

REPORT OF SCIENCE

AT

WILLIAMS COLLEGE

2011-2012

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

Williamstown, Massachusetts

2012

Cover Image:

This image depicts patterns of neuronal degeneration in the hippocampus resulting from transient global ischemia. The top image is from control animals and shows extensive damage throughout the hippocampus while the bottom image is from animals treated with estradiol, a hormone that significantly reduces the degree of damage and minimizes the negative cognitive consequences that normally result from this insult. This image appeared on the cover of *Brain Research*, volume 1443. See abstract from Professor Noah Sandstrom and four of his students on page 144.

The Science Executive Committee wishes to express its gratitude to the extensive efforts of all of the science departmental executive assistants in preparing this publication. Special thanks to Alicia Romac, Science Center Administrative Assistant for assembling this material in its final form.

Editor: Norman Bell
Coordinator of Science Facilities

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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 a 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.

MAJOR SCIENCE CENTER FUNDING

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 Paleanthropology (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 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 non-majors who want a more extensive introduction to computer science in general or who seek 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 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 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 ENVIS 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 ENVIS major and ENVI program, please visit: <http://catalog.williams.edu/catalog.php?&subjinfo=envis>

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 Transits: Venus's Atmosphere, the Size of the Solar System, and Planets Around other Stars

Transits of planets across the faces of their parent stars have been and continue to be a powerful method of astronomical discovery. The exceedingly rare transits of Venus—seen until recently only in 1639, 1761, 1769, 1874, and 1882—were, since the work of Edmond Halley, the main way foreseen of measuring the size and scale of the Solar System, leading to over 100 expeditions being sent around the world to study the 18th- and 19th-century transits. We will discuss not only the science but also the human stories involved. The transit method is being used in the 21st century by NASA's Kepler spacecraft to detect, so far, over 1000 planets around other stars, and the number is continually rising. Another spacecraft and ground-based telescopes are similarly studying transits of such "exoplanets." We will discuss the process and the results of these discovery searches. The discovery of these planetary systems, and consideration of the implications for our role in the Universe, is one of the most exciting topics in contemporary astronomy.

BIOL 11 Project BioEyes: Zebrafish Genetics and Development in the K-12 classroom

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.

BIOL 13 Ferment, Leaven and Curdle: Pickle, Bake, Cheese-Make!

In this class we will learn simple and effective techniques for creating fluffy focaccia, rich paneer and quick kimchee. Students will complete the course with an in-depth understanding of the importance of yeast, rennet and bacterial-mediated fermentation in food production. Theory will come to life through practical, hands-on investigation of these biological processes, as they are involved in baking, cheese making and pickling. Each class will involve a lesson, cooking practice and tasting!

CHEM 12 Spanish for the Health Sciences

The course is intended for those students with interest in the health sciences and with some knowledge of Spanish who want to develop their vocabulary and conversational skills. The course covers essential dialogs associated with health assessment interviews as well as extensive review of physiology, biochemistry, and public health issues affecting Spanish speaking communities in the United States.

CHEM 13 The Principles and Practice of Peptide Chemistry

The lecture covers the development of synthetic techniques since the time of Fisher and Curtius through current methodology in use today: methods of peptide bond formation and the problem of racemization, α -amino protecting groups, amino acid side chain protecting groups, solution and solid phase methodologies, orthogonal protection schemes with emphasis on Fmoc/t-Butyl strategies, and sequence specific problems. The laboratory portion of the course involves hands-on synthesis and characterization of model peptides using Fmoc/t-Butyl strategies.

CHEM 18 Introduction to Research in Biochemistry

An independent experimental project in biochemistry is carried out in collaboration with a member of the Department with expertise in biochemistry. Biochemistry is a branch of chemistry that deals with the molecular details of living systems including the interaction of biologically important molecules. In the Chemistry Department, studies are underway to investigate the structure/function relationship of proteins, the interaction between proteins and RNA

and DNA, and the molecular basis of bacterial gene regulation.

CSCI 11 Mixology

This course examines the history, science, and culture of mixed drinks. Students will learn about the origin of modern cocktails, the properties and mixing qualities of bitters, syrups, and fortified wines, the role of proportion, and the classification and appreciation of alcohol. Other topics include fermentation, modern mixology, glassware, and responsible consumption. The class will meet with local mixologists and tour a local distillery. *CSCI 15 Physical Computing: Playing with Technology (Same as Special 13)*

Get away from screen only computing, and interface digital and analogue technologies including objects, lights, motors, sensors, sound and cameras. Reading, research, presentations, workshops, design and practical exercises, Agile style sprints and scrums. Tools used will include Arduino micro-processor control boards, Processing and Flash. Skills learned may include soldering, simple programming, project management, and working together to articulate and solve problems.

ENVI 25 Sustainable Eleuthera: Farming, Subsistence, and Food Security

This course is a hands-on group research and community development project that will initiate a community garden, conduct community outreach about gardening and nutrition, and work with a local school on a garden-based learning project. The focus area is Weymms Bight, South Eleuthera, a low-income underserved settlement, which was formerly an agricultural area, but is now suffering from high unemployment, high rates of nutrition based diseases, and a shortage of fresh nutritious food.

GEOS 11 Mapping Data-a Spatial Approach to Research

While visual presentation of research data can be an effective means of getting your point across, the use of GIS (Geographic Information Systems) to perform spatial and temporal analyses can lead to the discovery of interesting correlations in your data.

Using appropriate software, this course will take you through basic skills and advanced GIS statistical analysis topics. In addition to lab exercises, you will use your own research topic/data to explore and visualize hidden potentials.

MATH 13 Visualization

The complexity and amount of information available to us is remarkable. But how do we make sense of all this data meaningfully? A revolution in visualization is taking place today, allowing us to comprehend and communicate by transforming massive quantities of information into meaningful, intuitive representations.

MATH 16 A Critical Study of the Coen Brothers

Over the past 25 years, Joel and Ethan Coen, known professionally as the Coen brothers, have established themselves as among the most important independent filmmakers of our time. They write, direct, and produce their own films and have won numerous critical distinctions for their work, including tying the existing record for the most Academy Award nominations for a single nominee for their 2007 blockbuster *No Country for Old Men*. Notorious for their dark humor and twisted plots based upon a simple storyline, their filmography pays tribute to nearly every classic American movie genre, with a particular recurring postmodern twist on film noir.

PHYS 10 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 7 well-equipped holography darkrooms available for student use. At the beginning of WSP, the class will meet for lecture and discussion three mornings a week and for lab 2 afternoons a week. Later classes will be mainly laboratory.

PHYS 12 Drawing as a Learnable Skill

Representational drawing is not merely a gift of birth, but a learnable skill. If you wanted to draw, but have never had the time to learn; or you enjoy drawing and wish to deepen your understanding and abilities, then this course is for you. This intensive course utilizes discoveries in brain research along with traditional drawing exercises to teach representational drawing. By using simple techniques and extensive exercises you will develop the perceptual shift from your symbol based left hemisphere to your visually based right hemisphere. This cognitive shift enables you to accurately see and realistically represent the physical world.

*PSYC 12 Alternative Birth Choices (Same as Women's,
Gender and Sexuality Studies)*

This course will consider the range of women's experiences surrounding pregnancy and childbirth. Among the topics we will cover are: alternative birthing choices (midwifery, homebirth, water-birth), the medicalization of childbirth, and attitudes regarding breastfeeding. We will view documentaries about pregnancy and childbirth, including films of labor and delivery; hear from a number of local professionals, such as a midwife, a doula, a childbirth educator, and a lactation consultant; and take a tour of a birthing center.



2012 Summer Science Research students take a break on the science quad lawn.

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 178 individuals at Williams in 2012. 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.

Funding Source*	Students
College funds	65
NSF grants to individual faculty	4
Arnold Bernhard Foundation Fellowships	14
American Physiological Society	1
Wege/Markgraf Fellowships	9
Lowe Fellowships	8
Markgraf Fellowships	5
Keck Northeast Astronomy Consortium	1
NIH grants to individual faculty	2
Class of 1951	3
MIT NASA Grant	1
Mellon Foundation	2
Somers Fellowship	2
Whitehead Scholarship	2
Keck Geoscience	1
Petroleum Research Fund	2
American Chemical Society	2
Bicentennial Psychology Scholarships	1
* Some students are supported by multiple grants.	



Zina Cigolle '12, Anna Hurlimann '12, and April Shen '13 at the Grace Hopper Celebration of Women in Computing in Portland, Oregon, which they attended along with Profs. Albrecht and Danyluk Nov. '11.

2012 Summer Science Students and their Faculty Advisors

Astronomy

Muzhou Lu
Eric Edelman
Markus Gonzales
Samuel Amdur

Jay Pasachoff
Jay Pasachoff
Jay Pasachoff
Marcos Peñaloza-Murillo

Christine Schindler
Shelby Shote
Kairav Sinha
Gordon David Smith
Hrishi Srinagesh
Marissa Thiel

Daniel Lynch
Steve Swoap
Wendy Raymond
Edwards
Robert Savage
Daniel Lynch

Biology

Tala Abujbara
Christie Black
Ryan Buchanan
Bryan Chow
Elizabeth Cornett
Amanda Correnti
Kang Daeun
Abigail Davies
Laura Donnelly
Katherine Dusenbury
Mike Essman
Jessica Fitts
Allison Graebner
Eric Hagen
Laurel Hamers
Betsy Hart
Karen He
Kathleen Higgins
Nina Horowitz
Vero Ignace
Yiqin Jiang
Brian Kirchner
Grace LaPier
Geordie Lonza
Rebecca Maher
Zach McKenzie
Tara Miller
Kim Oliva
Catherine Pang
Uttara Partap
Naomi Patterson
Emma Rickels
Sarah Rowe

Steve Swoap
Claire Ting
Hank Art
Marsha Altschuler
David Smith
Robert Savage
Martha Marvin
Lois Banta
Robert Savage
Claire Ting
Daniel Lynch
Tim Lebestky
Martha Marvin
Hank Art
Hank Art
Luana Maroja
Wendy Raymond
Daniel Lynch
Luana Maroja
Steve Swoap
Tim Lebestky
Tim Lebestky
Marsha Altschuler
Wendy Raymond
Steve Swoap
Tim Lebestky
Luana Maroja
Luana Maroja
Claire Ting
Steve Swoap
Lois Banta
Daniel Lynch
Hank Art

Evelyn Tran
Chalita Washington

Edwards
Wendy Raymond

Chemistry

Jamie Baik
Dylan Barber
Gordon Bauer
Kyle Bolo
Chelsea Boydston
Andrew Bravo
Craig Burt
Juno Cho
Chris Corbett
Kathryn Dryer
Richard Eiselen
Bryn Falahee
Fanny Trausel
Moses Flash
Emily Gao
Alejandro Gimenez
Michael Girouard
Michael Gold
Vera Gould
Sarah Guillot
Sora Kim
Ashley

Willis Koomson
Lovemore Makusha
Justin Mangope
Steve Mendoza

Jessica Monterrosa
Liliana Morris

Amy Gehring
Lee Park
David Richardson
Dieter Bingemann
Lee Park
David Richardson
Chris Goh
Chip Lovett
Lee Park
Chip Lovett
Chip Lovett
Jay Thoman
Jimmy Blair
Chris Goh
Amy Gehring
Lee Park
Chris Goh
Chris Goh
Lee Park
Chris Goh
Amy Gehring
Enrique Peacock-Lopez
Chip Lovett
Chip Lovett
Anne Skinner
Enrique Peacock-Lopez
Amy Gehring
Chris Goh

Zaw-htut Naing	Enrique Peacock-Lopez	Craig Corsi	Satyan Devadoss
Asvelt Nduwumwami	Chip Lovett	Irving Dai	Cesar Silva
Jared Nowell	Chip Lovett	Erick Davia	Cesar Silva
Georgiana Salant	Amy Gehring	Benjamin DeMeo	Colin Adams
Joon Hun Seong	Lee Park	Xavier Garcia	Cesar Silva
Khan Shairani	Dieter Bingemann	Whan Ghang	Frank Morgan
Kassandra Spiller	Chip Lovett	Shelby Heinecke	Cesar Silva
Felix Sun	Lee Park	Virginia Hogan	Steven Miller
Christian Torres	Chip Lovett	Daoji Huang	Satyan Devadoss
Emily Ury	Jay Thoman	Rachel Insoft	Steven Miller
Areli Valencia	Enrique Peacock-Lopez	Andrew Kelly	Frank Morgan
Scott Wieman	Jay Thoman	Michael Landry	Colin Adams
Nai Chien Yeat	Dieter Bingemann	Shiyu Li	Steven Miller
Peter Young	Jimmy Blair	Alex Lin	Colin Adams
Menghan Zhao	David Smith	Victor Luo	Steven Miller
		Zane Martin	Frank Morgan
		MurphyKate Monte	Colin Adams
		Margaret Nichols	Ollie Beazley
Computer Science		Tudor Padurariu	Cesar Silva
Guedis Cardenas	Morgan McGuire	Min Hae Park	Ollie Beazley
Michael Mara	Morgan McGuire	Xiao Lin Shi	Ollie Beazley
Mitchell Breitbart	Tom Murtagh	Dominic Spadecence	Satyan Devadoss
Abigail Zimmerman-Niefield	Tom Murtagh	Phillip Tosteson	Steven Miller
James Wilcox	Stephen Freund	Nicholas Triantafillou	Steven Miller
Parker Finch	Stephen Freund	Sarawathi Venkatesh	Colin Adams
Karlan Eberhardt	Jeannie Albrecht	Kevin Vissuet	Steven Miller
Donny Huang	Brent Heeringa	Steve Waruhui	Frank Morgan
Brianne Mirecki	Brent Heeringa	Emily Wickstrom	Cesar Silva
		Farrah Yhee	Colin Adams
Geoscience		Alexander Youcis	Ollie Beazley
Claudia Corona	David Dethier	Evangeline Zachos	Cesar Silva
Johanna Eidmann	Ronadh Cox		
Christopher Elliott	Ronadh Cox	Mystic	
Johnny Hinojosa	Wobus	Miranda Bona	Lisa Gilbert
Kalle Jahn	Ronadh Cox	Nuria Clodius	James Carlton
Gabriel Lewis	David Dethier	Zara Currimjee	James Carlton
Ian Nesbitt	David Dethier	Bryce Mitsunaga	Lisa Gilbert
Mathematics/Statistics		Physics	
Levent Alpoge	Steven Miller	Julian Hess	Daniel Aalberts
Ben Athiwarathku	Cesar Silva	Joseph Iafrate	Jeff Strait
Amanda Bower	Steven Miller	David Kealhofer	Tiku Majumder

Christina Knapp	Bill Wootters	Kimberly Holachek	Kate Stroud
Kamuela Lau	Michael Seifert	Alexander LaTourrette	Nate Kornell
Brandon Ling	Michael Seifert	Si Young Mah	Safa Zaki
Dylan Gilbert	David Tucker-Smith	Alexander Manter	Nate Kornell
Antonio Lorenzo	Tiku Majumder	Emily Norkett	Kate Stroud
Alice Sady	David Tucker-Smith	Ahini Patel	Steven Patel
Nathan Schine	Tiku Majumder	Natalie Plasencia	Paul Solomon
Roshan Sharma	Fred Strauch	Alexander Rich	Safa Zaki
Kirk Swanson	Tiku Majumder	Sarah Roseman	Amie Hane
Olivia Uhlman	Daniel Aalberts	Anuj Shah	Jennifer Crosby
Qiao Zhang	Fred Strauch	Daniel Silver	Susan Engel
Psychology		Meredith Sopher	Phebe Cramer
Elizabeth Albert	Paul Solomon	Effua Sosoo	Kate Stroud
Grace Bouton	Noah Sandstrom	Shanali Weeresinghe	Marlene Sandstrom
Julia Bender-Stern	Amie Hane	Elizabeth Visconti	Kenneth Savitsky
Eric Dietsche	Noah Sandstrom	Emmanuel Whyte	Laurie Heatherington
Sierra Germeyan	Betty Zimmerberg		

Summer Research Colloquia 2012

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:

Steve Miller, Mathematics and Statistics	Cookie Monster Meets the Fibonacci Numbers. Mmmmmmm -- Theorems!
Jay Pasachoff, Astronomy	The recent transit of Venus
Steven Fein, Psychology	Frack Us? Political Ideology and the War on Science
Frank Morgan, Mathematics and Statistics	Tilings and Isoperimetric Problems
David Tucker-Smith, Physics Department	Big News from the LHC
Prof. Satyan Devadoss, Mathematics and Statistics	Posets and Polytopes
Hank Art, Biology Department	This is not your grandfather's (or even father's) Hopkins Forest: 75 years of changes in the permanent plots.
Luana Maroja, Biology Department	"A hopeful monster? Hybridization and mimicry in but- terflies"
Phoebe Cohen, Geoscience Department	"Life Before Animals: The Diversification of Eukaryotes in Precambrian Oceans"

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 2011-2012.

Presenter	Title
Tiku Majumder	Intro & Welcome
Colin Adams	A Discussion of the Proposed Tenure Appeals Reforms.
Brent Heeringa	“How to host a profitable fundraiser (with slightly fussy participants)”
Heather Williams	“Cultural evolution: is bird song like language?”
Steve Swoap	“Some mammals are really cool.”
Frank Morgan	“Pentagonal tilings”
Steven Souza	“You can observe a lot by watching.”
Cesar Silva	“Notions of Chaos in Dynamical Systems”
Paul Karabinos and Michael Taylor	“Applications of Gigapan Photography in Research and Teaching”
Hank Art	“Tales from an Enigmatic Woodlot”
Tim Lebetzky	“Be my fruitfly valentine?”
Marcos Peñaloza-Murillo Fulbright) Solar Eclipse	“An Approach of Williams College to Atmospheric Science Through its (visiting Meteorological Observations in Africa and China”
Markes Johnson	“Charles Darwin, Pleistocene rhodoliths (Coralline algae), and the Cape Verde Islands”
Satyan Devadoss	“Packings and Partitions”
Safa Zaki	What can we learn from deficits in face processing?
Susan Engel	K-12 Schools- Are We Measuring the Right Thing?
Michael Seifert	“Topological defects”
Chip Lovett	“Searching for Drugs in a Library”
Jon Snow	“The A, Bee, Cs of Gene Regulation”
Jay Pasachoff “	The June 5 transit of Venus”
Amie Hane	Dandelions, Orchids, and the Search for a Phenotype

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

Samanta Avila	Kim Kiplagat	Ogechukwu Uwanaka	Paul Park
Bethany Berry	Logan Lawson	Roger Vargas	Wendy Raymond
Jorge Castro	Juana Manzanares-Torres	Edgar Vega	David Richardson
Melissa Cendejas	Miguel Mendez	Venson Williams	Cesar Silva
Christina Chen	Lauren Moseley		
Tendai Chisowa	Ashley Ngo	Faculty	Tutors
Naomi Fields	Megan Steele	Charles M. Lovett, Dir	Valencia Areli '14
Dylan Freas	Isabella Tillman	Olga R. Beaver	Flash Moses '15
Omar Gouda	Hector Trujillo	Cassandra Cleghorn	Jared Nowell '15
Jackie Harris	Angelica Tucker	Lee Park	Ignace Vero '15

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 2011-2012 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 Assistant Professor Fred Strauch of the Physics Department at Williams College present two colloquia on quantum information theory. His first talk focused on quantum entanglement, in which particles remain linked even when separated; the second highlighted his work toward the realization of entanglement in superconducting circuits.

In April, Mea Cook, Assistant Professor of Geosciences, presented two talks on the role of oceans in climate change. In these lectures, she focused on her research using deep-sea sediments to reconstruct patterns of

ocean circulation and greenhouse gas production. 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 Celeste Thoman Venolia.

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 48 newly elected associate members from the class of 2012 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 2012

Astrophysics

Matthew W. Hosek

Biology

Ellen M. Beauchamp

Jack E. Berry

Katelyn M. Foley

Adena E. Hernandez

Paloma Marian

Gregory S. McElroy

Daniel C. Nachun

Bonnie K. Patchen

Mark W. Springel

Tarjinder Singh

Sameer Aryal

Chemistry

Grace C. Babula

Daniel A. Gross

Andrew F. Kung

Emma M. Pelegri-O'Day

Zachary D. Remillard

Cameron R. Rogers

Nicole L. Wise

Matthew N. Zhou

Computer Science

Chansoo Lee

Michael T. Mara

Diogenes A. Nunez

Antal B. Spector-Zabusky

Geosciences

Kathryn M. Kumamoto

Nari V. Miller

Mathematics & Statistics

Ji Ahn

Praphruepong Athiwaratkun

Thomas N. Crawford

Noah N. Goldberg

Stephanie A. Jensen

Brian T. Li

Connor M. Stern

Gregory A. White

Liyang Zhang

Neuroscience

Gregory C. Johnson

Physics

Joel T. Clemmer

Julian M. Hess

Murat Kologlu

Margaret G. Robinson

Tori F. Borish

Taryn R. Siegel

Anders E. Schneider

Psychology

Chelsey S. Barrios

Amber M. Cardoos

Aaron C. Lim

Jordan L. Mickens

Helena E. Nannes

Noah E. Schoenholtz

In Memoriam

Our friend and colleague **Dr David Park**, Webster Atwell Class of 1921 Professor of Physics, Emeritus, died on January 19, 2012 at age 92. Dr Park served Williams College and the Physics Department for over 60 years. He was a brilliant scholar, a natural teacher, and an inspiration and mentor to his colleagues and students.

Longtime administrative assistant, **Nancy Barber**, died on July 2, 2011 at the age of 76. Nancy worked in the Chemistry Department for over 25 years and will be missed by all who knew her.

ASTRONOMY DEPARTMENT

Faculty of the Astronomy Department were Jay M. Pasachoff, Field Memorial Professor of Astronomy, Chair, and Director of the Hopkins Observatory; Karen B. Kwitter, Ebenezer Fitch Professor of Astronomy; and Steven P. Souza, Instructor in Astronomy and Observatory Supervisor. Bryce A. Babcock, retired as Staff Physicist and Coordinator of Science Facilities, is Associate of the Hopkins Observatory. Marcos Peñaloza-Murillo, Professor of Physics at the Universidad de los Andes in Mérida, Venezuela, arrived for the calendar year as a Fulbright Scholar.

Jay Pasachoff devoted a major effort this year to the June 5 transit of Venus across the face of the Sun, the second of the twenty-first century pair and only the sixth such transit ever observed and the last to be seen before the year 2117. The scientific efforts were devoted both to using the transit in liaison with a spacecraft in orbit around Venus to study Venus's atmosphere and to observing the transit in our solar system in detail as an analogue to the thousands of exoplanet transits that are now being observed.

In addition to preparing for the scientific observations Pasachoff also arranged public outreach to alert the general public of the significance of and interest in the transit of Venus. He published a "Comment" in *Nature* before the transit and an Op-Ed piece in *The New York Times* on the morning of the transit, as well as an Academic Minute for radio and for the web.

Pasachoff was joined by Babcock, Muzhou Lu '13, Glenn Schneider from the University of Arizona, and others at the Mees Solar Observatory of the University of Hawaii for observations on the day of the transit. They collaborated in a Venus Twilight Experiment, which sent 9 coronagraphs to observe Venus's atmosphere from a variety of sites around the world, elaborating on the observations that Pasachoff and Schneider had made for the 2004 transit with NASA's Transition Region and Coronal Explorer spacecraft. Pasachoff's expedition to Haleakala was sponsored in part by a grant from the Committee for Research and Exploration of the National Geographic Society.

Pasachoff had also obtained commitments of telescope time at Sacramento Peak Observatory, New Mexico (where the IBIS imaging spectrograph at the Dunn Solar Telescope, was operated by Kevin Reardon '92), at Kitt Peak, Arizona, and at the Big Bear Solar Observatory, California, and with spacecrafts including NASA's Solar Dynamics Observatory, the Solar Optical Telescope

(where Emma Lehman '10 had been on the staff) 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 reported on preliminary results at a public lecture sponsored by the Keck Observatory in Hawaii. Pasachoff gave an invited lecture that included preliminary results at the 220th meeting of the American Astronomical Society in Anchorage, Alaska. He subsequently prepared the 365daysofastronomy.org summary of the transit and the *Sky & Telescope* article about the observations as well as a McGraw-Hill Yearbook entry on the 2012 transit.

Pasachoff and William Sheehan, a historian of science in Minnesota, analyzed early reports of the discovery of the transit of Venus, comparing them with what we now know Venus's atmosphere looks. They showed that Mikhail Lomonosov, the Russian scientist who is generally credited with the discovery of the Cytherean atmosphere, did not, in fact, detect the atmosphere. Their report was published in the *Journal for the History and Heritage of Astronomy*.

At the October 2011 meeting of the Division of Planetary Sciences of the American Astronomical Society held in Nantes, France, Pasachoff, Babcock, and Souza participated with MIT colleagues in the report of observations of the occultation of a star by Pluto in May 2011 using the 0.6-m DFM telescope on the roof of the Thompson Physics Laboratory. On May 22, 2011, Souza had 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. Present for the observations were Pasachoff, Babcock, Matt Hosek '12 and Shubhanga Pandey '13. The results were used to refine the model of Pluto's and Charon's orbits and to improve the predictions of the observations from two other telescopes.

A new 3-year NASA Planetary Astronomy grant was received by Pasachoff for continuing the stellar occultation work, especially in view of the flyby of Pluto by NASA's New Horizons spacecraft in 2015. See <http://www.stellaroccultations.info> for more information.

Pasachoff collaborated with others 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.

Pasachoff continued work on the interstellar medium, especially through considerations of the cosmic deuterium abundance.

Pasachoff took 8 students to observe the annular solar eclipse of May 20, 2012, from the western United States, where the end of the annular eclipse was visible. The exchange student Eric Edelman (Wesleyan '13), the Keck Northeast Astronomy Consortium Summer Fellow used his new grant from the Solar Research Program of the National Science Foundation for studies of the two central solar eclipses of 2012. Pasachoff worked with the Jet Propulsion Laboratory, the New Jersey Institute of Technology and the National Radio Astronomy Observatory in planning and making radio-telescope observations of the May 20 annular solar eclipse with the Jansky Very Large Array near Socorro, New Mexico. Additional support for student participation was received from the Massachusetts Space Grant Consortium, sponsored by NASA.

Pasachoff, Kwitter, and Souza all attended the Keck Northeast Astronomy Consortium (KNAC) Faculty Meeting at Haverford College in July 2011, and the KNAC Student Symposium at Wellesley College in September 2011.

Peñaloza-Murillo had participated in two previous total solar eclipse observations with Pasachoff, in 2001 in Zambia and in 2009 in China. As an atmospheric physicist, he is interested in the response of the Earth's atmosphere to the cooling that takes place when the Moon blocks the incoming sunlight. He worked with Teddy Amdur '15 during the spring and summer of 2012 on the project. He sent measuring instruments with Markus Gonzales '13 to the Jansky Very Large Array as part of the Williams College observations of the May 20 annular eclipse.

Kwitter continued her research into the chemical composition of planetary nebulae (PNe). These ejected shells of dying sun-like stars contain products of nuclear processing—helium, nitrogen, carbon—inside their parent stars, and so are valuable probes into the chemical enrichment history of the Milky Way and other galaxies. Kwitter's research concentrates on PNe in the Milky Way and in the neighboring Andromeda Galaxy (M31), 2.5 million light-years away, and a near twin.

In the summer of 2011 Kwitter supervised three students:

Matt Hosek '12, Aven King '12, and Alice Sady '13. These students learned to use CLOUDY (Ferland et al. 1998) to create computer models of planetary nebulae in M31, that yield information about the stars at their centers. Their work is acknowledged in a paper published in July 2012 in the *Astrophysical Journal*.

Kwitter and colleagues Dick Henry (U. Oklahoma) and Bruce Balick (U. Washington) (KHB) are continuing their collaborative research on PNe in M31. The spectra they obtained of 16 M31 planetary nebulae (taken with Emma Lehman '10 at the 8.1-meter Gemini-North telescope on Mauna Kea) were part of the input for the models that Matt, Aven and Alice worked on. KHB have applied for additional time in Fall 2012 with Gemini-North to observe ten more planetary nebulae in M31, which would help in defining M31's oxygen gradient (the rate at which the oxygen abundance declines with distance from the center of the galaxy).

KHB and a group of colleagues were awarded time with the Hubble Space Telescope to observe Milky Way PNe 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 PN parent stars.

With colleagues from U. Texas, Rice, U. Oklahoma and U. Kansas, Kwitter is participating in a project using the VIRUS-P integral-field spectrograph on the 2.7-m telescope at McDonald Observatory in west Texas. Matt Hosek '12 analyzed VIRUS-P spectra of the Eskimo Nebula, NGC 2392, for his senior honors thesis, discovering evidence for variable dust extinction across the face of the nebula. He and Kwitter traveled to McDonald in April 2012 to take further observations.

In July 2011, Kwitter gave the invited talk on chemical abundances at International Astronomical Union Symposium #283 in Tenerife, Canary Islands, "Planetary Nebulae – An Eye to the Future." Her talk was entitled "Reuse, Reduce, Recycle: Planetary Nebulae as Green Galactic Citizens." At the Symposium, Kwitter was elected to the IAU's Working Group on Planetary Nebulae. In September, Kwitter attended the KNAC Student Research Symposium at Wellesley College.

Souza conducts and supervises the astronomy observing program, and all indoor labs and daytime observing. He hosted numerous observatory visitors, including planetarium groups, student previews and prospectives, and groups from the American Museum of Natural History, the Williams College Summer Science Program, and the Massachusetts Teachers Association.

On June 5, 2012, Souza organized on-campus viewing of the transit of Venus at our TPL rooftop observatory, assisted by Joe Iafrate '14, and K. Kwitter. Using solar-filter cardboard glasses and 3 telescopes outfitted with safe-viewing filters, more than 50 visitors patiently waited out the clouds to catch the rare sight of Venus in front of the Sun.

Souza continues to maintain and improve the observatory. With students Allen Davis '14 and Yaron Teich, (Vassar '13, Keck Northeast Astronomy Consortium exchange student), he cleaned and recollimated the 0.6-m telescope main mirror. He implemented a telescope/camera system for planetary imaging, and with help from Larry George and Michael Taylor he automated one of the small domes to complete a remotely-operated widefield imaging system. He upgraded all observatory and lab PCs and Macs, acted as department liaison with OIT and Facilities, and served as a first-year advisor and as a member of the Information Technology Committee.

Souza attended the Keck Northeast Astronomy Consortium (KNAC) Faculty Meeting in July 2011, and the KNAC Student Symposium in September 2011. He also attended a symposium honoring Prof. Michal Simon at Stonybrook University in June 2011, at which he presented a talk entitled "Interstellar C2, the Meatball, and the Purple Cow."

Souza's research effort to monitor variations in H-alpha emission in massive stars in open clusters continued. In the summer of 2011, with Allen Davis '14 and Yaron Teich (Vassar '13) worked to improve the data reduction process and analyze the data for two clusters. Souza received a \$4600 grant from the American Astronomical Society for new optical filters for the project, and presented a Science Lunch talk on his work.

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 Vice-Chair (2011-2013) 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 American Astronomical Society to the American Association for the Advancement of Science's Astronomy Division.

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 final meeting in Washington, DC. (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. (<http://aer.noao.edu>).

Pasachoff, a Fellow of the Society for Skeptical Inquiry, is on the editorial board of the Skeptical Inquirer. In a related course at Williams, he will again give his seminar on Science, Pseudoscience, and the Two Cultures in spring 2013.

One of Pasachoff's eclipse images, with data taken in conjunction with Muzhou Lu '13 and Craig Malamut '13 (Wesleyan) and processed by Hana Druckmüllerová, appears in a photography exhibit, Starstruck, at Bates College; it opened in June 2012.

Class of 1960 Scholars in Astronomy

Matthew W. Hosek

DEPARTMENT COLLOQUIA

[Colloquia are held jointly with the Physics Department. See Physics section for listings.]

OFF-CAMPUS COLLOQUIA

Karen B. Kwitter

“Reuse, Reduce, Recycle – Planetary Nebulae as Green Galactic Citizens”

Invited talk at IAU Symposium #283

“Planetary Nebulae: An Eye to the Future”

Tenerife, Canary Islands, July 2011

Jay M. Pasachoff

“Transits of Venus in Public Education and Contemporary Research”

AAS Division of Planetary Sciences meeting, October 2011

Online video at <http://transitofvenus.nl/wp/2011/10/16/four-giants-talk-about-transits/>,

Pasachoff, Jay M., Steven P. Souza, Bryce A. Babcock, Shubhanga Pandey, Matthew W. Hosek, Michael J. Person, Amanda A.S. Gulbis, Amanda S. Bosh, Carlos A. Zuluaga, Eileen V. Ryan, and William H. Ryan

“The 22 May 2011 Pluto Occultation Observed”

AAS Division of Planetary Sciences meeting, October 2011, Nantes

Pasachoff, J. M., B. A. Babcock, S. Pandey, D. Amrhein, M. J. Person, A. A. S. Gulbis, A. S. Bosh, C. A. Zuluaga, S. Sallum, D. J. Tholen, R. Lucas, M. Kakkala, J. Ciotti, S. Plunkett, N. Hiraoka, W. Best, E. J. Pilger, M. Miceli and S. E. Levine

“The Double-Double Pluto-Charon and Pluto-Hydra Predicted Stellar Occultations of June 2011”

AAS Division of Planetary Sciences meeting, October 2011, Nantes

Zuluaga, C. A., M. J. Person, A. S. Bosh, S. E. Levine, A. A. S. Gulbis, A. M. Zangari, J. M. Pasachoff, B. A. Babcock, S. Pandey, D. Amrhein, S. Sallum, E. W. Dunham, D. J. Tholen, P. Collins, T. Bida, B. Taylor, R. Lucas, M. Kakkala, J. Ciotti, S. Plunkett, N. Hiraoka, W. Best, E. J. Pilger, M. Miceli, A. Springmann, M. Hicks, B. Thackeray, J. Emery, S. Rapoport, I. Ritchie, M. Pearson, A. Mattingly, J. Brimacombe, D. Gault, R. Jones, R. Nolthenius, J. Broughton, T. Barry

“The measured Pluto-Charon offset from the stellar occultations of 23 June 2011”

AAS Division of Planetary Sciences meeting, October 2011, Nantes

Rusin, V., M. Saniga, J. M. Pasachoff, M. Druckmüller, and M. Belik

“Ten years of the high-resolution imaging process of the eclipse white-light corona”

AGU Fall Meeting, October 2011

POSTGRADUATE PLANS OF ASTRONOMY DEPARTMENT MAJORS

Matthew W. Hosek

Grad school in Astronomy, University of Hawaii at Manoa

Aven King

Scuba shop instructor

Ben Oliva

unknown

Taryn Siegel

Epic (healthcare software in Wisconsin)



Biology Department

Working with the many inter-disciplinary 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 21 honors students working in faculty labs this past year. Of these, 11 were inducted into the Sigma Xi Honors Society. For the academic year 2012-2013, the department has 26 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, Anna Szymanski received a Stratton Fellowship to further her studies. The department also has approximately 40 students doing summer research, either here at Williams or off campus. Emma Rickles '14 and Kathleen Higgins '14 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. Uttara Partap '13 from the Swoap lab received an undergraduate research fellowship from the American Physiological Society for 2012.

On December 2, 2011, a number of BIOL and/or BIMO alumni (Ellen Crocker '06, Esa Seegulam '06, Erica Dwyer '03, and Erin Troy '01) returned to campus to share their post-graduate research experiences with students. Through a poster presentation and panel discussion they gave current students an opportunity to learn firsthand about life as a graduate student.

Each year at graduation, the Biology Department awards prizes to several outstanding majors from the class of 2012. Jack Berry and Hannah Wilson each received the Benedict Prize in Biology. Sara Dorsey received the Dwight Botanical Prize. Tarjinder Singh received the Conant-Harrington Prize for exemplary performance in the biology major, and Lauren Goldstein-Kral received the William C. Grant, Jr. Prize for demonstrating excellence in a broad range of areas in biology.

Professor **Marsha Altschuler** continued her research on chromosome copy number control in the ciliate *Tetrahymena thermophila* assisted by independent study students Tom Kuriakose '12 in the Fall and Bryan Chow '13 in the Spring.

Professor **Hank Art** has been on a full-year sabbatical during academic year 2011-2012 working on the 75-years of data collected in the Hopkins Memorial Forest permanent plot system. The summer of 2011 marked the completion of re-inventorying the permanent plot system in the Hopkins Memorial Forest, a research collaboration with a group of 11 undergraduates: Abigail Martin '11, Eric Outtersen '12, Claudia Corona '12, Amelia Simmons '13, Mark Lyons '13, Sarah Rowe '13, and Gordon Smith '13, Julio Luquin '13, Wade Davis '14, Julieanne Fontana '15, and K.B. DiAngelo '13, each of whom worked 10 weeks on the project.

This research segued into my sabbatical that has been spent working with Chris Warren (OIT) on building up the web-based Hopkins Forest database and query retrieval system, Sharron Macklin on establishing the Hopkins Forest Geographic Information System, and with Paul Smernoff, Networks & Systems Administrator on a file sharing system for the 25-member Hopkins Forest Alumni Research Network to produce papers using the 75-year data collection.

Professor Art offered a summer 3-day course for K-12 teachers in the Hopkins Memorial Forest in July, 2011 as part of the Museum Institute for the Teaching of Science Program offered through the Berkshire Museum. The course was based on how to tell the integrated "forest" from the individual "trees" and involved 12 teachers from schools across Berkshire County.

Professor Art also led two Alumni Travel ecological field trips, one to Southeast Alaska – Glacier Bay in August, 2011, and one to the Serengeti and the great migration in January, 2012.

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 students Greg McElroy '12 and Lauren Goldstein-Kral '12, along with Naomi Patterson '15 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. Connor Dempsey '13, Nicole Lou '13, and Audrey Kwon '13 also contributed to this research project over the summer of 2011. At the

annual international Crown Gall Conference, held this year in Madison, WI, Janis Bravo presented a poster, and Lois Banta presented a talk on this research. During the academic year, Grace LaPier '13 and Abbi Davies '13 used site-directed mutagenesis to create new T6SS mutants. Independent Study student Hannah Wilson '12 concluded the lab's exploration of a novel mechanism for transcriptional regulation of a subset of the *virB* genes, which encode a multi-protein complex responsible for the delivery of the DNA and several virulence factor proteins to host cells.

During the fall semester, Professor Banta taught the lab-intensive capstone course for the Genomics, Proteomics, and Bioinformatics program. The course focuses on one model system, the Ras/MAPK signal transduction pathway, and its role in the development of colon cancer. Highlights of the course this year included using quantitative real-time PCR to probe the contributions of inflammation to human colon cancer. In the spring term, Professor Banta taught an upper-level elective in Microbiology. The students in this course over the past few years are among the first undergraduates in the nation to carry out a metagenomics project, surveying the full spectrum of bacteria found in a given ecological niche; the class this year focused on pond sludge from Woods Hole, MA and from local agricultural sites.

During this academic year, Professor Banta served as a panelist for the National Science Foundation, and as a reviewer for *Journal of Bacteriology*, *The Plant Cell*, and *Molecular Plant Physiology*. She was named to the Editorial board for the journal *Frontiers in Plant-Microbe Interaction*. Within Williams, she served on the Biochemistry/Molecular Biology advisory committee, the Bioinformatics, Genomics and Proteomics advisory committee, the Environmental Studies advisory committee, and as departmental seminar coordinator; she also served as coordinator for the Global Health track of the International Studies Area of Concentration and for the 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 with colleagues to further develop the biology lab program. The infamous "Fly Lab" in the Genetics course has been redesigned: in the past, this lab had students map known eye color mutations in the fruit fly, *Drosophila melanogaster*. While this was an effective teaching tool for the fundamentals of genetics, it involved students analyzing very well-characterized mutations, so little new information was uncovered. This past year, the lab was redesigned to include original research. Students mapped wavy, a mutation affecting

the morphology of the fly wing. While this mutation has been known and maintained since the 1930s, it has not been determined which gene is affected by the mutation. The location of the gene has been narrowed down to about 500,000bp of DNA on the X-chromosome, and this fall, we hope to identify the wavy gene within that region.

In addition to course development, Dean continues to use fly genetics to research how metabolism affects seizure disorders. Daniel Nachun '12, used a new neurophysiology technique in the lab. This technique is being used to top off their findings for a manuscript. Nachun will be attending the Neuroscience Ph.D. Program at UCLA this fall.

In the summer of 2012, Professor **Joan Edwards** worked with Emily Ury '13, Rebecca Shoer '13 and Emily Levy '13 to develop a way to track pollinators in the field at Isle Royale Wilderness National Park. The project involved determining the flowerscape by mapping all flowering plants in a 24 x 24 m plot. They then observed how pollinators forage on this flowerscape. Initial results show that all insects specialize on one flower species at a time and that larger insects travel more rapidly between flowers and go longer distances than smaller insects.

During the academic year, Professor Edwards worked with Evelyn Tran '14, Cara Pardon '15, and Aaron Taylor '16 to study the explosive seed dispersal in *Oxalis* species. They were able to get close-up high-speed images (filmed at 50,000fps) and start to collect comparative data among the many species of *Oxalis*. Prof. Edwards also worked collaboratively with Prof. Luana Maroja to study the genetic structure of arctic plants, which have their core populations in the arctic but have disjunct southern populations on Isle Royale. Three honors students (Hannah Matheny '12, Tarjinder Singh '12 and Oscar Calzada '12) worked on identifying microsatellites for these plants and measuring heterozygosity and population structure.

Professor Edwards taught a senior tutorial in Conservation Biology (Biology 424) in the fall and Field Botany and Plant Systematics (Biology 220) in the spring.

Assistant Professor **Tim Lebestky** joined the department in the summer of 2011. The Lebestky lab utilizes the genetic model system of *Drosophila melanogaster* for the study of behavioral genetics and molecular neurobiology techniques to understand arousal and sensory integration. Animals use their senses to learn about their immediate environment, parse the relevant information, and react in a meaningful way. These concepts also translate into human biology, as imbalances in arousal and sensory

gating are linked to pathologies, such as insomnia, attentional disorders, autism, and anxiety. Dr. Lebestky chaperoned two undergraduates on a week-long research trip to UCLA (Jack E. Berry '12 and Chansoo Lee '12). Students learned biology techniques and computer-programming strategies for creating visual stimuli patterns for *Drosophila* behavior experiments (August 2011). He also mentored 3 honors thesis students (Sameer Aryal '12, Jack Berry '12, Nathaniel Kastan '12), one independent study student (Chansoo Lee '12), two volunteer researchers (Jenni Ginsberg '13, Zach McKenzie '14), and one Summer Science Student in the fall semester (Racquel Gibson '15). Dr. Lebestky gave two invited lectures at the University of Kansas and also Brandeis University. He also submitted a manuscript to *Genetics*, and attended two meetings, the *Drosophila* Neuroscience Conference, and also the New Neuroscience Faculty Symposium at Cold Spring Harbor Labs. In the Fall semester, Dr. Lebestky created a new course: Biol 407, the Neurobiology of Emotion, and then taught Biol 310, Neural Development and Plasticity in the Spring of 2012. Both the lab and lecture portions of the Biol310 course represent a new version of the course, with all new lab experiments and new directions for lectures on neural plasticity.

During this past year Professor **Dan Lynch** was on leave during the fall semester. In the spring he taught BIMO/BIOL/CHEM 322 Biochemistry II Metabolism lecture and two laboratory sections while a third lab section was taught by Visiting Assistant Professor Jon Snow.

Lynch continued his research on plant sphingolipid biochemistry but he switched from working with the flowering plant *Arabidopsis thaliana* to the moss *Physcomitrella patens*. The moss provide certain advantages over *Arabidopsis* in studies of sphingolipid metabolism and function. Students working in the lab included Mike Essman '13, a thesis research student in the biology department who began his project during winter study to generate and characterize moss plants with decreased levels of phytosphingosine, the predominant long-chain base in the moss. In addition, Karyn Moss '12 completed a senior thesis project working with professors Lynch and Swoap to characterize the lipid profiles in selected fat depots of calorically restricted mice. Lynch served as a review panel member at the NSF in the fall and as a reviewer for manuscripts submitted to several scientific journals

Luana Maroja has two additional lines of research this year. The first, in collaboration with K. Wallin from U. of Vermont, is related to the impact of winter climate change in Northeastern forest; more specifically how the

invertebrate fauna is affected by reduced snow pack in winter. With two students (K. Oliva '15 and N. Horowitz '14) Maroja has developed microsatellite genetic markers for a tiny snail abundant in our forests and will investigate the population genetics of the species. The second project is part of a collaboration with Prof. Joan Edwards that aims at combining population dynamics with population genetics to investigate the effects of isolation and climate change (past and current) in the populations of arctic plants on Isle Royale in Lake Superior. With the help of three students (O. Calzada '12, H. Matheny '12 and T. Singh '12) Maroja also developed microsatellites for these endangered plants.

In addition to these new lines of investigation, Maroja has also completed part of her postdoctoral work on the *Heliconius* butterfly genome, which shows that hybridization was responsible for the spread of adaptive coloration genes and was published in the journal *Nature*. During the summer, Maroja presented a lecture at the Science lunches reporting these results. Maroja participated in the Evolution 2012 conference in Ottawa in July, taking four students (Hart '14, Horowitz '14, T. Miller '15, and Oliva '15) who presented three posters.

In Fall 2011, Maroja taught Genetics 202 for the 1st time and together with D. Dean she has changed the fly lab, which now is an original research project that includes modern genetic techniques, such as the use of p-elements to map unknown traits. She wrote an academic manuscript describing the lab she developed for her evolution class that has been accepted for publication in *Evolution: Outreach and Education*. Also in the fall, Maroja participated in an NSF grant review panel on Evolutionary Biology and presented an invited graduate student seminar at the University of Vermont.

Martha Marvin continues to investigate the role of small heat shock proteins in embryonic development of the zebrafish, in an ongoing collaboration with former Williams professor Lara Hutson. This family of proteins protects embryos from environmental stress, but also serve essential developmental roles. Dr. Marvin is particularly interested in the role of a tissue called the yolk syncytial layer; it does not directly give rise to the brain, heart or viscera but is essential to pattern and guide the development of these embryonic tissues. A specialized region of the YSL, Kupffer's vesicle, contains cilia that move fluid in one direction to break the embryo's bilateral symmetry. Paloma Marin '12 demonstrated that reducing Hspb7 causes the loss of a cilia component that is essential for their movement. Mark Springel '12 showed that loss of Hspb7 in the yolk syncytial layer

causes severe and prolonged heart defects, including malformed valves and small ventricular chambers, due to defective migration of the layer of cells that will form the heart.

Dr. Marvin teaches the laboratories for Neuroscience 201 and also taught a lab section of Physiology, BIOL 205. She advised two honors students this year. She also co-taught a Winter Study course called Project BioEyes, which trains Williams students to teach genetics and development, and also engages local 4th 11th grade students to scientific investigation.

Assistant Professor **Manuel Morales** taught Animal Behavior during the spring semesters of 2011 and 2012. A highlight for students is the all-day field trip to the Bronx Zoo. Morales was on leave during the Fall 2011 Semester.

In the summer of 2012, Professor **David Smith** worked with Emily Ury '13, Rebecca Shoer '13 and Emily Levy '13 to continue his 30+ years of observations of the boreal chorus frog population on Isle Royale National Park. To date the project shows the frog populations have regular fluctuations and Prof. Smith's research examines what factors may drive the population changes.

Professor Smith taught Ecology (BIOL203) in the fall and The Organism (BIOL102) in the spring.

Associate Professor **Claire Ting** taught a capstone course in the fall semester on Life at Extremes: Molecular Mechanisms (BIOL414), which explored the physiological and molecular survival kits organisms have evolved that permit them to acclimate to environmental stresses and to thrive in extreme environments, such as the deep sea. In the spring semester she taught the Biology Department core course, The Organism (BIOL102). Through lectures, discussions of original research papers, and laboratories, this large, introductory course encouraged students to explore how one cell becomes a multicellular organism through the process of development and how evolution results in the rich biological diversity on earth.

During the year, Professor Ting continued to pursue her National Science Foundation funded research on photosynthesis in the ecologically important marine cyanobacterium *Prochlorococcus*. This blue-green bacterium is one of the most abundant photosynthetic organisms on the planet and is an important carbon sink. Research in her laboratory aims to establish how differences at the genomic level translate into physiological advantages in photosynthetic capacity

and in tolerance to environmental stress. In addition to laboratory work, her group has conducted field work in the Sargasso Sea, which is an open ocean region where *Prochlorococcus* thrives. This past year her laboratory continued to work with the bacterioplankton samples they collected from Sargasso Sea waters for metagenomic and metatranscriptomic analyses. Undergraduate students who participated in research in her laboratory this past year included Ellen Beauchamp '12 (NSF summer research assistant, honors thesis student), Melany Funes '14 (NSF summer research assistant), Adena Hernandez '12 (honors thesis student), and Alyson Barrett '14 (research assistant). In addition, Christie Black '15 and Catherine Pang '14 joined the Ting Laboratory as Biological Research students during Winter Study, and continued as research assistants during the spring. Kris Anderson continued as an NSF-funded research technician in the laboratory. With support from the National Science Foundation, Ellen Beauchamp '12 and Melany Funes '14 joined Professor Ting at the Department of Energy Joint Genome Institute (DOE JGI) User Meeting on Genomics of Energy and Environment in Walnut Creek, California and participated in a *Prochlorococcus* Team Meeting in Asilomar, California during the spring semester.

In order to raise awareness about current environmental issues associated with the oceans and its inhabitants, and about the challenges associated with stewardship of the oceans, Professor Ting organized a Williams College Oceans Symposium during the spring semester. This interdisciplinary symposium, which was sponsored by the Center for Environmental Studies, included seven events that took place throughout the spring semester and encouraged interactions across disciplines and between the College and wider community.

Heather Williams continued her work on the cultural evolution of song in two Savannah sparrow populations, one in Williamstown and one on Kent Island in the Bay of Fundy. She presented some of this work at a Science Center lunch in the fall. She supervised three summer research students. Ryan Buchanan '14 used surgical techniques to place implants containing muscimol over a brain area important for the production of learned bird song. Ai Tran '12 investigated changes in circulating hormones in young male songbirds raised without song tutors. Kate Foley '12 asked whether song syntax is innate or learned. She continued her summer work as an honors thesis and used operant learning techniques to train naive young males with artificially generated variable syntax songs to try to determine whether young zebra finches can learn a variable syntax or whether the species-typical

fixed syntax has an innate basis. Williams served on a panel for the National Science Foundation and as part of a committee that reviewed the Neuroscience program at Mount Holyoke College, and as a peer reviewer for 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'. Sonja Boatman '12 and Melinda Wang '14 worked as

Research Assistants studying vestibular and lateral line efferent neurons in the goldfish. Zottoli was a co-author on a paper entitled: "Regeneration in the era of functional genomics and gene network analysis," that was published in the *Biological Bulletin*. Professor Zottoli continues to conduct summer research at the Marine Biological Laboratory in Woods Hole, MA where he is an Adjunct Scientist in the Cellular Dynamics Program. Professor Zottoli continues as a Life Trustee of The Grass Foundation.

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. Pam Silver from Harvard Medical School and Dr. Jerry Wilkinson from the University of Maryland to be Class of 1960 Scholar speakers.

Class of 1960 Scholars in Biology

Sora Kim
Henry Su

Marissa Thiel
Geordie Lonza

Christine Schindler
Grace LaPier

Elizabeth Hwang



Biology Department, Front row (left to right): Martha Marvin, Manuel Morales, Joan Edwards, Steve Swoap, Chair, 2nd row: Debra Rogers-Gillig, Lois Banta, Marsha Altschuler, Jon Snow. Back row: Dan Lynch, Hank Art, Heather Williams, Steve Zottoli, Bill DeWitt, Audrey Werner, Tim Lebestky, Derek Dean, Claire Ting, Jenna MacIntire, Luana Maroja, Rob Savage, David Smith, Wendy Raymond and Dawn Jamros.

BIOLOGY DEPARTMENT COLLOQUIA

- Larry Zipursky, UCLA, HHMI, Co-sponsored with Neuroscience
“Cell Recognition, Molecular Specificity and Constructing Neural Circuits”
- Warren Abrahamson, Bucknell University
“Host Plants, Herbivores, & Natural Enemies: A Medley of Questions and Approaches”
- Pam Silver, Harvard Medical School 1960s Scholar Lecture
“A Chemical Biology Approach to Understand Host-Parasite Interactions”
- Zhen Yan, University of Virginia
“Molecular and Signaling Mechanisms of Skeletal Muscle Adaptation”
- Jerry Yin, University of Wisconsin, Madison
“Memor, Sleep, Sick Flies and Fiesty Badgers - Really?”
- Kerry Woods, Bennington College
“Imagined Forests: Preconceptions and Realities of Old-Growth”
- Margaret Rubega, University of Connecticut
“Feeding Mechanics in Birds: We Know Less Than You Think”
- Wendy Garrett, Harvard School of Public Health
“Disease-associated and Beneficial Gut Microbiota in Colitis and Colorectal Cancer”
- Miriam Cremer, Basic Health International
“Cervical Cancer Prevention in Rural El Salvador”
- Jerry Wilkinson, University of Maryland 1960s Scholar Lecture
“Sexual Selection, Genomic Conflict and Reproductive Isolation in Stalk-Eyed Flies”
- Rachel Brewster, University of Maryland Baltimore County
“Getting the Brain Into Shape: Mechanisms of Neural Tube Morphogenesis”

OFF-CAMPUS COLLOQUIA

- Hank Art. Seventh Annual Forest Summit
“Woodlot History in the Hopkins Memorial Forest, Williamstown, MA”
Holyoke Comm. College, October, 2011
- Lois M. Banta, Janis E. Bravo, Lauren Goldstein-Kral ('12), Audrey Kwon ('13), Nicole Lou ('13), Connor Dempsey ('13), Greg McElroy ('12), Helen Cha ('11), and Rosalia Deeken.
Modulation of Basal Defenses in *Arabidopsis thaliana* by *Agrobacterium tumefaciens*. Oral presentation at the 32nd Annual Crown Gall Conference (Madison, WI, Nov. 2011)
- Janis E. Bravo, Audrey Kwon ('13), Nicole Lou ('13), Rosalia Deeken, and Lois M. Banta.
Effect of the *A. tumefaciens* Type 6 Secretion System on Basal Defense Responses in *Arabidopsis thaliana*.
Poster presentation at the 32nd Annual Crown Gall Conference (Madison, WI, Nov. 2011)
- Joan Edwards,
“Conserving our Native Flowers and Pollinators”
Berkshire Botanical Gardens, 12 November, 2011.
“Botanical Explosions: the Evolutionary Impact of Ultra-fast Plants”
Bennington College, 29 March, 2012.
- Elizabeth Hart ('14), J. Jing ('14), Z.M. McKenzie ('14), L.S. Maroja.
Song differences, male courtship intensity and cuticular hydrocarbons in a cricket hybrid zone..
EVOLUTION 2012 - Ottawa, Canada. Poster presented by student.

- Kim Oliva ('15), Nina Horowitz ('14), H. Yurchenco, P. Templer, K.F. Wallin, L.S. Maroja (LPA1).
Effects of Winter Climate Change on Terrestrial Snails (*Zonitoides arboreus*) in a Northern Forest Ecosystem.,
EVOLUTION 2012 - Ottawa, Canada. Poster presented by students.
- T. Miller ('15), L.S. Maroja, D.C. Smith, E. Maclary.
Don't put all your eggs in one basket: chorus frogs distribute offspring in multiple pools..
EVOLUTION 2012 - Ottawa, Canada. Poster presented by student.
- Dean D.M. and L.S. Maroja.
Adapting the fly lab for primary research in the genetics classroom.
53rd Annual *Drosophila* Research Conference March 7-11, 2012. Poster presented by Dean.
- Davey J.W., Baxter S.W., Maroja L.S. , Kapan D.D., Jiggins C.D., Blaxter M.
Scaffolding the *Heliconius melpomene* genome with RAD Sequencing.
International Conference on Quantitative Genetics in Edinburgh. Presentation by Davey.
- Maroja L.S.
Invited graduate student seminar.
Barriers to Gene Exchange, Hybrid Zones and Speciation.”
University of Vermont. September 9, 2011.
- Lahvic, J., Davis, L., Hutson, L.D. and Marvin, M.J.
HspB7 and HspB12 Are Necessary for Normal Left-Right Asymmetry.
9th International Conference on Zebrafish Development and Genetics, Madison, WI. June, 2010 (poster)
- Lahvic J. and Marvin, M.J.
HspB7 and HspB12 are necessary for normal left-right asymmetry.
North East Society for Developmental Biology, Woods Hole, MA, April 2010. (talk, delivered by Jamie Lahvic)
- Marin P. and Marvin, M.J.
Small heat shock protein Hspb7 is required for function and morphogenesis of Kupffer's Vesicle cilia.
North East Society for Developmental Biology, Woods Hole, MA, April 2012. (poster)
- Springel, M.W. and Marvin, M.J.
Cardiac morphogenesis in zebrafish depends upon the small heat shock protein Hspb7.
North East Society for Developmental Biology, Woods Hole, MA, April 2012. (poster)
- Springel, M.W., Ji, Y., Zuflacht, J., Marin, P., Lahvic, J., Hutson, L.D., Amack, J., and Marvin, M.J.
Cardiac laterality, migration and morphogenesis depend upon small heat shock proteins.
10th International Conference on Zebrafish Development and Genetics, Madison, WI. June, 2012 (poster)
- Morales, M.A.
Invited talk
Department of Ecology and Evolutionary Biology, University of Connecticut, March 2012.
- Morales, M.A. 2011.
Phenology of mutualism: altitudinal variation in survival and benefit of an ant-tended treehopper.
96th Annual Meeting of the Ecological Society of America.
- Morales, M.A and A. F. G. Zink.
2012. Mechanism of aggregation in an ant-tended treehopper.
97th Annual Meeting of the Ecological Society of America.

POSTGRADUATE PLANS OF BIOLOGY DEPARTMENT MAJORS

Isaac Abodunrin, Jr.	Unknown
Sameer Aryal	Unknown
Amlak Bantikassegn	Research Assistant, Yale University.
Francesca Barrett	Research Assistant, Zon Lab, Boston Children's Hospital
Ellen Beauchamp	Research Technician at Dana-Farber Cancer Institute in Boston, MA and then I plan to apply to graduate school in 2 years
Stella Berke**	Working in strategy consulting in Boston, MA at a small firm called OC&C
Jack Berry	Working as a research technician in the department of neurosurgery at Stanford Medical School
Sonja Boatman	Unknown
Meghan Breen	Unknown
Austin Brown	Unknown
Olivia Delia	Leading a high school backpacking trip for Overland in the Spanish Pyrenees and Swiss Alps, and in the fall heading to France to teach middle school and/or high school English
Elizabeth Dorr	Working as an admissions counselor for Sea Education Association/SEA Semester in Woods Hole, MA.
KB DiAngelo	Unknown
Sara Dorsey	Unknown
Holly Dwyer	Unknown
Amanda Esteves-Kraus	Teaching biology at the Hackley School in Westchester, NY.
Katelyn Foley	Working at Mass General Hospital.
TiaMoya Ford	Unknown
Lauren Goldstein-Kral	Working for Teach for America in Hartford, CT.
Kelsey Ham	Unknown
Adena Hernandez	Unknown
Gregory Johnson**	Research Assistant in Developmental Neuroscience Beth Israel Deaconess Medical Center Boston, MA.
Nathaniel Kastan	Working in Dr. Greenberg's neuro lab at Harvard Medical School.
Thomas Kuriakose	High school math in Mississippi with the Mississippi Teacher Corps
Donna Lee	M.D. at University of Rochester School of Medicine and Dentistry
Stephen Maier, II	Unknown
Paloma Marin	Teach for America teaching science in a low-income, urban school in Los Angeles. I was selected to be a 2012 Amgen fellow (funded by the biotechnology company of the same name), a fellowship awarded to 100 math and science major accepted corps members. I plan to do TFA for 2 years before applying to medical school
Hannah Matheny	I accepted a six-month Fellowship position with the Clinic for the Rehabilitation of Wildlife (C.R.O.W) on Sanibel Island, Florida. I am planning on applying to veterinary school this summer for matriculation in the fall of 2013
Gregory McElroy	Working as a research assistant at Boston University in the Pulmonary Center

Nikola Mirkovic**	Post-bac premedical program at William Patterson University; coaching high school football and wrestling
Sylvia Molina	Research Assistant in the University of New Mexico.
Kathleen Morrison	Unknown
Karyn Moss	Unknown
Daniel Nachun**	Attending a Ph.D. program in Neuroscience at University of California, LA
Bonnie Patchen	Unknown
Nina Piazza	I am going to spend a year teaching science, music, and English at a rural elementary school in Yongfeng, China, after which I will be attending medical school at the University of Rochester.
Estefany Reyes	Working as a research assistant in the lab of Dr. Mark Boldin at the Beckman Research Institute (Part of the City of Hope Cancer Hospital) in Duarte, CA.
Nicole Shannon	Unknown
Kate Shaper**	Teaching AP Biology and AP English to high school students at the ChenYin Private Academy in Shanghai, China
Tarjinder Singh	Hershel-Smith Fellow, completing a MPhil in Biological Sciences at the University of Cambridge
Meera Sivalingam	Unknown
Mark Springel**	Working as a Research Assistant at Children's Hospital, Boston MA
Hannah Systrom	Unknown
Anny Szymanski	Pursuing a Master's in Marine Biology at the University of Alaska in Fairbanks, AK
Ai Tran	Unknown
Heather Valenzuela	Unknown
Marsha Villarroel	Unknown
Emily Wendell	Unknown
Hannah Wilson	Teaching and doing public health work in Africa.
Rachel Zipursky	Unknown

****Neuroscience**



A view from inside the Morley Science Lab greenhouse.

CHEMISTRY DEPARTMENT

The Chemistry Department had an eventful 2011-2012 academic year. We had 28 senior majors this year with an impressive 20 completing senior thesis projects. We are very pleased to announce a new face to the Chemistry Department. **Dr. Jimmy Blair**, a bioorganic chemist, starts his appointment in July 2012. He will teach Organic Chemistry: Intermediate Level (CHEM 251) in the fall semester and a new course in the spring of 2013, Chemical Biology: Discoveries at the Interface (CHEM 326). We are delighted that Dr. Blair will begin his academic career as a faculty member in our department.

We are particularly proud of our students and their accomplishments. Each year, individual students are recognized with departmental awards. In the class of 2012, the John Sabin Adriance prize went to Christopher Valle for outstanding work throughout his chemistry career. The James F. Skinner prize was awarded to Cameron Rogers for his distinguished achievement in chemistry and his future promise as a researcher. The Leverett Mears prize went to Roop Dutta in recognition of both his abilities in chemistry and future in medicine. Emma Pelegri-O'Day was awarded the American Chemical Society Connecticut Valley Section Award for her sustained scholastic excellence. Matthew Zhou was awarded the American Institute of Chemists Student Award for outstanding scholastic achievement. Zachary Remillard received the Frank C. Goodrich 1945 Award for demonstrated excellence in chemistry research. Rachel Patel was the recipient of the ACS Division of Inorganic Chemistry Undergraduate Award in Inorganic Chemistry, and Michelle McRae was awarded the American Chemistry Society Analytical Division Award. Our newest award, the Skinner Award for Travel to a Professional Meeting, was given to Grace Babula. Over the course of the academic year, a number of awards were presented to chemistry students for outstanding scholarship. Grace Kim '15 and Claire Lidston '15 received the CRC Awards as the outstanding students in CHEM 151 and CHEM 155, respectively. Christian Gronbeck '15 was presented with the Raymond Chang First-Year Chemistry Award for his exceptional work in CHEM 153. Recognized for their achievement in organic chemistry, Craig Burt '14 received the Polymer Chemistry Award and Chau Vo '14 was the recipient of the Harold H. Warren Prize.

Associate Professor **Dieter Bingemann**, with the help of independent study student Jiji Ahn '12 and research assistants Bryn Falahee '13 and Chiara Del Piccolo '14, continued his search for the fundamental reason behind

the dramatic slowdown of the motion in glasses at their arresting point. 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 domains at the molecular level.

The team found in experiments and molecular dynamics simulations that even though the overall dynamics slows dramatically, the molecules in the material still experience about the same number of very short waits between structural rearrangements. Below the glass transition, however, a very small number of extremely long waiting periods without any rearrangements emerges which is solely responsible for the dramatic effect in the sample. Bingemann presented these results from both the single molecule experiments and computer simulations at the Gordon Conferences "Chemistry and Physics of Liquids" and "Soft Condensed Matter Physics" in August 2011.

Back in the classroom, Bingemann taught Physical Chemistry: Structure and Dynamics (CHEM 361), one of the upper-level physical chemistry courses in the Department, in the fall, using a new project-based approach, which borrows heavily from tutorials, which was favorably received by the students. In the spring, he taught Instrumental Methods of Analysis (CHEM 364) a hands-on upper level introduction to various state-of-the-art instrumental methods using the same project-based teaching approach. Also in the Spring, Bingemann team-taught Introduction to Environmental Science Methods (ENVI 102) with Professor Mea Cook of the Geosciences Department.

Associate Professor **Amy Gehring** spent her tenth year at Williams returning to her teaching roots and enjoyed working with the same courses that she did in her very first year. These were all courses in our upper-level biochemistry offerings including Biochemistry I—Structure and Function of Biological Molecules (CHEM 321) in the fall and Enzyme Kinetics and Reaction Mechanisms (CHEM 324) and Topics in Biochemistry and Molecular Biology (BIMO 401) in the spring. BIMO 401 is a seminar style course and is the capstone for the Biochemistry and Molecular Biology (BIMO) program. Gehring continued to serve as chair of the BIMO program, with duties that included hosting two seminars by Professor Gökhan Hotamisligil (Harvard School of Public Health) and Professor Lenny Guarente (MIT).

Research continued in the Gehring lab to understand the

molecular details of the life cycle of the model antibiotic-producing soil bacterium, *Streptomyces coelicolor*. During the summer of 2011, Gehring was joined in this work by Matt Madden '12, Erin McGonagle '12, Hetal Ray '12, Jennifer Rodriguez '12, Sora Kim '13, and Jessica Monterrosa Mena '14. Erin, Hetal and Jennifer continued during the academic year as thesis students, studying conditions for the overproduction of antibiotics, the role of secreted proteins in the bacterium's life cycle, and the control of sporulation, respectively. They were joined in the fall by fellow thesis student, Kenny Murgo '12, who worked together with Sora over the year to demonstrate the biochemical function of a potential antibiotic biosynthesis regulatory enzyme.

In July, Gehring will attend the Gordon Research Conference on Microbial Stress Response and present a poster detailing Kenny and Sora's research. Also participating in research at various times during the academic year were Jessica, Lauren Agoubi '13, Emily Gao '13, Sola Haye '14, Georgiana Salant '14, and Ashley Kim '15. For both the summer and during the academic year as a thesis student, Mike Alcala '12 pursued a collaborative project with Professor Peacock-Lopez using fluorescence microscopy to visualize oscillations in gene expression in the bacterium *E. coli* with a minimal 2-gene system; he was joined in this work by Areli Valencia '14. With all of these students involved with research, it was certainly a busy and productive year in the lab! 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*, and *Process Biochemistry*.

Christopher Goh spent his AP leave in the laboratory of Geoff Coates in the chemistry department at Cornell University, thanks in part to the generous support of a Hellman Foundation Fellowship. With the help of Skype and occasional trips back to Williams, Goh was also able to oversee the senior thesis of Zac Remillard '12. Zac was able to present his thesis work at the National American Chemical Society Conference in San Diego, CA, in March this year, and later at the ACS-Connecticut Valley Undergraduate Symposium. At the latter, Zac was the recipient of an award for best oral presentation. The research group also received an ACS-PRF grant to start a new project on developing homogeneous iron catalysts to promote rapid and selective epoxidations of alkenes. The targeted epoxidation products have potential use as building blocks for new polymeric materials.

Professor **Sarah Goh** taught Organic Chemistry:

Intermediate Level (CHEM 251) in the fall semester. As part of the Bronfman ventilation renovation over the summer and fall, the laboratory got a facelift, and Michelle McRae '12 and Matt Zhou '12 were the first to work in the "new" space. Michelle synthesized polymer micelles displaying mannose sugars and investigated their recognition with sugar-binding receptors. Matt used controlled radical polymerization techniques to tune the lower critical solution temperature of N-isopropyl acrylamide/N,N-dimethyl acrylamide block copolymers. Each of these polymer families can be used as a drug delivery vehicle, capitalizing on targeting agents (such as sugars) or manipulating aggregation properties. Matt and Michelle finished up their calendar year theses during winter study 2012. In the spring, Prof. Goh headed to Ithaca, NY, for a relaxing and reflective sabbatical, returning to Williamstown in time for graduation. She also served as a reviewer for the National Science Foundation, Molecular Foundry at Lawrence Berkeley National Laboratory, Petroleum Research Fund, *Journal of Polymer Science*, and Roberts and Company Publishers.

Professor **Lawrence J. Kaplan** returned from a sabbatical and taught Biophysical Chemistry (CHEM 367) in the fall, Science for Kids (CHEM 11) with Professor Richardson during Winter Study, and Chemistry and Crime (CHEM 113), for the first time since 2005, in the spring semester.

He continues to administer the Center for Workshops in the Chemical Sciences with colleagues at Georgia State University, Georgia Institute of Technology and Millersville University. Since its founding eleven years ago, the CWCS has received major grants from the National Science Foundation and continues with the current collaborative grants to Williams, Georgia Tech, and Georgia State for \$3,908,665 for five years. As a result of this current NSF grant the CWCS was rebranded the Chemistry Collaborations, Workshops and Communities of Scholars (cCWCS). The cCWCS 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. The website for the Forensic Science Scholars Community, launched in 2010 has

been significantly expanded with many more members and more educational resources.

Kaplan taught a weeklong workshop in forensic science during the summer of 2012 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. Deb Morandi and Tony Truran, both in the Chemistry Department, assisted Kaplan in the organization and instruction of the workshop.

Kaplan served as reviewer for the *Journal of Chemical Education*.

During the past year Professor Lovett 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 **Charles Lovett** continued his research on the *Bacillus subtilis* SOS response to DNA damage, which comprises a set of DNA damage-inducible genes (SOS genes) that code for DNA repair and cellular survival functions. During the past 27 years Lovett, with students working in his lab, have discovered more than 30 SOS genes and characterized their genetic regulation in response to DNA damage. Based on recent evidence implicating the SOS response in the development of antibiotic resistance in bacteria, research in the Lovett lab has focused on finding SOS response inhibitors. Lovett's NIH-funded project entitled, "The binding of the LexA protein to the RecA protein nucleoprotein filament," involves characterizing the molecular details of SOS induction in order to design such inhibitors. Last year the project was expanded to include searching a library of 14,400 bioactive compounds for SOS response inhibitors using a high-throughput screen developed by Williams students in the summer of 2011. Summer students, working as full time research assistants, included Roop Dutta '12, Willis Koomson '14, Andrew Kung '12, Asvelt Nduwumwami '13, Emily Niehaus '12, and Peter Young '13. Roop, Andrew, and Emily, along with Clarissa Andre '12 and Christian Torres '12 continued as honors thesis students during the academic year. Professor Lovett also supervised winter study as well as work study research students Moses Flash '15, Tiantian He '15, Willis Koomson '14, Jared Nowell '15, and Amanda Walker '15.

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

Lee Park's work on the design of partially fluorinated conjugated compounds for use as organic electronic materials continued this year with the help of a large group of students. Between summer 2011 and May 2012, the following students helped out in the lab, as summer research assistants, thesis students, or simply by volunteering time in lab: Grace Babula '12, Chesea Boydston '15, Peter Clement '13, Chris Corbett '13, Alejandro Gimenez '13, Dan Gross '12, Mindy Lee '12, Cameron Rogers '12, Joon-Hun Seong '14, Erica Wu '13, and Johan Postema, a summer exchange student from the University of Leiden. Over the year the group has been working on synthesizing and characterizing both polymeric and oligomeric materials, looking at absorption, emission, and self assembly properties of these materials. We have made good progress and our work for the year culminated in two poster presentations at the National American Chemical Society Conference in San Diego in March; Park took 6 students Grace, Chelsea, Mindy, Dan, Cameron, and Chris to the meeting, and a good time was had by all. The group for summer 2012 includes Dylan Baker '15, Chesea Boydston '15, Chris Corbett '13, Alejandro Gimenez '13, Vera Gould '14, Joon-Hun Seong '14, and Felix Sun '14 – we're looking forward to a productive summer and next year!

Park taught Inorganic/Organometallic Chemistry (CHEM 335) to a larger than usual group with an enrollment of 23 students and Materials Chemistry (CHEM 336) with 15 students this year. For the Materials Chemistry course, she offered for the second time the new lab program on nanofabrication strategies. She also began offering a series of new problem solving sessions for introductory students that we hope will provide students with some fundamental strategies in approaching a range of different kinds of problems that they might encounter in courses and labs.

Park also continues to serve on 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, the Keck foundation) as well as manuscripts for various journals. At Williams she completed her service on the Committee for Appointments and Promotions, and is gearing up to serve as Chair of the Committee on Educational Policy next year.

In 2011-2012 Professor **Peacock-López** taught Current Topics in Chemistry (CHEM 155) in the fall, and Foundations of Modern Chemical Science (CHEM 256) in the spring. During January, he taught Spanish for the Health Sciences (CHEM 12). In collaboration with Professor Amy Gehring, Professor Peacock-López served as co-advisor to Michael Alcala '12. Michael was motivated by previous work on repressilator dynamics, considered a relatively simple synthetic transcriptional network in *E. coli* by developing a two-gene plasmid, which represents the smallest artificial gene network. Recently, Mimi Lu '09 and Steve A. Mendoza '13 analyzed two-gene networks and observed complex dynamics under certain physical conditions. Based on the theoretical observations, Mr. Alcala has designed and constructed the Minimal 2-Gene Oscillator, a two-gene transcriptional activator-repressor artificial genetic network based on the design of a previous artificial genetic network—the Repressilator (Elowitz, 2000)—that shows oscillatory behavior. In this case, Mr. Alcala constructed a simpler model by using both a transcriptional repressor gene (tetR-lite) and a transcriptional activator gene (melR-lite), instead of three transcriptional repressor genes, and attempt to show that oscillatory behavior occurs when the half-lives of the gene products are of about the same magnitude as their mRNAs. Time-lapse fluorescence microscopy experiments monitoring the expression of a GFP variant over time suggests that the network displays oscillatory behavior under certain conditions.

During the academic year, Laura Dos Reis '12 considered regulated glucose transport to model metabolite concentrations in glycolysis. In her work, Dos Reis developed and studied a three variable model, where she considered glucose transport and hexokinase inhibition by gluco-6-phosphate. For the three-variable model, she 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; 21 students) organized and taught chemistry labs at Williams College. As in previous years, Dr. Tony Truran helped with running the experiments. These honors chemistry students attended five labs during the year to perform

some of the experiments from the Williams introductory chemistry lab program and a newly developed organic synthesis. 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 the National Science Foundation, *Mathematical Biosciences*, *Journal of Chemical Physics*, *Physica A*, and *Chaos*.

During the 2011-2012 academic year, Professor **David Richardson** enjoyed a mini-sabbatical in the fall semester, remaining on campus. Professor Richardson's research lab remained active throughout the year. Together with Professor Jay Thoman he supervised the senior honors thesis research of Emma Pelegri-O'Day '12, which was directed at the development of new methods for the synthesis of deuterofluorocarbons. He also supervised the efforts of two work-study students, Vanessa Soetanto '12 and Asvelt Nduwumwami '14. Vanessa continued the Richardson lab's collaboration with Dr. Andria Agusta, of the Indonesian Institute of Biological Sciences, and with Professor Chip Lovett on a project involving the isolation of new antibiotics from medicinally active South East Asian plants. Asvelt worked on the same project, focusing on APCI-HPLC/MS method development. In a second collaboration with Professor Jay Thoman he also supervised the summer 2011 research of Ariana Chiapella (MCLA '12) and Olivia Gannon (Bennington College '12) directed at measuring PCB levels in sediments and macro-invertebrates from the Hoosic River. Finally, he also supervised the research of work-study student Zachary MacKenzie '14 in a collaboration with Professor Luana Maroja of the Biology Department involving cuticular hydrocarbons from crickets.

Professor Richardson continued his supervision and maintenance of the Department's 500 MHz nuclear magnetic resonance spectrometer and he wrote a user's manual for the Department's 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*, and as a textbook reviewer for Roberts & Co. He also served on the Science Building Steering Committee at the Massachusetts College of Liberal Arts.

In January 2012, Professor Richardson resumed his teaching responsibilities, teaching Science for Kids (CHEM 11) together with Professor Larry Kaplan. In the spring semester he taught Organic Chemistry: Introductory Level (CHEM 156) along with one of the course's laboratory sections. During July 2011 he taught the chemistry laboratory portion of the Williams College Summer Science Program and, together with Professor Chip Lovett, he hosted the Department's Summer Science Camp program for local 4th and 5th graders. He also served on the Boards of the New England Tropical Conservatory and the South Williamstown Community Association.

Anne R. Skinner, senior lecturer emerita, attended the 2012 annual meeting of the Paleoanthropology Society and presented her results on a project aimed at dating the changes in the course of the ancient Thames River: "Dating of Submerged Landscapes by Electron Spin Resonance". At the 77th annual meeting of the Society for American Archaeology she discussed "ESR Dating at Grotte de Contrebandiers, Témara, Morocco". She is continuing her research on a variety of sites and will present two invited lectures at the upcoming Society of Africanist Archaeology meeting in Toronto. This summer she traveled to Tanzania on a grant from the Canadian scientific research agency, to study Iron Age rockshelters.

During summer 2011, Nikki Wise '12 conducted research which involved dating materials from the Kharga Oasis in Egypt. Nikki then spent the academic year completing her thesis on additional samples from the Dakhleh Oasis in an effort to date a new type of stone tools.

Professor **Tom Smith** spent his fourteenth 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 Rachel Patel '12 worked toward the synthesis of a new marine natural product, enigmazole A. On leave from the classroom this year, Professor Smith published the results of project on tetanolide C that had been in the works for the past five years.

Jay Thoman taught Concepts of Chemistry: Advanced Section (CHEM 153) in the fall and Physical Chemistry: Thermodynamics (CHEM 366) in the spring. On campus, he also taught the laboratory component of AP Chemistry for Mount Greylock Regional High

School. With David Richardson, he served as thesis co-advisor to Emma Pelegri-O'Day '12, who was very successful in developing and extending methods for synthesizing deuterated fluorocarbon molecules from iodofluorocarbon precursors. Emma demonstrated that the general method developed for iodoperdeutero compounds could be extended in a selective and controlled manner to reactant molecules with hydrogen atoms and also to iodopentafluorobenzene. Emma also developed local ^{19}F NMR methods for decoupling ^1H and ^{13}C resonances.

In service outside of the college, Thoman served as a reviewer for the *Journal of Physical Chemistry* and for the Department of Energy. He continues to serve as Chair of the Review Committee for the Chemistry GRE.

During summer 2011, Thoman worked with Annie Moriondo '14 and Liam Abbott '13 to probe the structure and dynamics of hydrofluorocarbon molecules using cavity ringdown laser spectroscopy. Annie and Liam improved the experimental apparatus and probed the temperature dependence of the CH-stretching overtone spectrum of a series of small gas-phase hydrofluorocarbon molecules. This project continued during the academic year by work-study student Richard Eiselen '14.

Also during summer 2011, Thoman and Dave Richardson sponsored two students on an ongoing project investigating PCB pollutants in the Hoosac River and its environs. Olivia Gannon from Bennington College and Arianna Chiapella from MCLA made excellent progress in analysis method development, making a brand new piece of "drying" equipment (obtained by Geosciences Professor Mea Cook) work for our experiment, and making a merely one-year-old piece of equipment work about 3 times faster. They also collected many crayfish from the Hoosic River, and processed about half of them to quantify the concentration of PCBs. This work follows the summer 2010 project of Emily Ury '13 and Alex Lou '13, who analyzed Hoosac River sediment for PCB concentration, and collected benthic invertebrates for later analysis.

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 Craig Hawker from University of California, Santa Barbara and Professor Geoffrey Hutchison '99 from the University of Pittsburgh were the 1960 Scholar speakers this year. Nine students were selected by the faculty to be Class of 1960 Scholars during 2012 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 2012 are:

Class of 1960 Scholars in Chemistry

Emily Gao	Mika Nakashige
Michael Girouard	Scott Symonds
Sarah Guillot	Erica Wu
Lovemore Makusha	Nai Chien Yeat
Menghan Zhao	

During the summer of 2012, approximately 45 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, Bernhard Summer Fellows Program, the College Divisional Research Funding Committee, the J.A. Lowe III '73 summer research fund, 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.

CHEMISTRY COLLOQUIA

Professor Ronald Christensen, Bowdoin College

“The Long and Short of Polyenes: The Optical Spectroscopy of Linearly Conjugated Systems”

Professor Craig Hawker, University of California-Santa Barbara, Class of 1960 Scholars Program

“Tricking Nature: Generating Complex Nanoscale Patterns Through Bottom-Up Self-Assembly”

Professor Gökhan Hotamisligil, Harvard School of Public Health (Co-sponsored with BIMO and Biology)

“Treasure Hunting in Fat to Treat the Plague of Metabolic Diseases”

Professor Geoffrey Hutchison '99, University of Pittsburgh, Class of 1960 Scholars Program

“Rational Design of Molecular Materials: Molecular Springs, Solar Cells and More”

Professor Kristi Kiick, University of Delaware

“Multivalent Polymers in the Design of Hybrid Biomaterials”

Professor Lee Park, Williams College, Williams Thinking Lecture

“Designing Nanoarchitectures”

Dr. Thomas Pinnavaia, Michigan State University

“Porous Silicates”

Professor Kate Queeney '92, Smith College

“How Does Your Biofilm Grow”

Dr. Debra Rolison, Naval Research Laboratory (Co-sponsored with Physics and Astronomy)

“Integrating the Multifunction Necessary for Electrochemical Power into Energy and Size Scalable Ultraporous Nanoarchitectures”

Professor Jay Thoman, Williams College

“Hodge Markgraf and Jenny Holzer’s 715 Molecules”

Dr. Leo Tsai '98, Beth Israel Deaconess Medical Center

“An Introduction to Diagnostic Radiology”

OFF-CAMPUS COLLOQUIA

Grace Babula '12, Chelsea D. Boydston '15, Peter L. Clement '13, Christopher J. Corbett '13, Alejandro R. Gimenez '13, Mindy C. Lee '12, Lee Y. Park

“Optical and Electronic Properties of Discrete Phenylenevinylene-based Oligomers”

243rd ACS National Meeting & Exposition, San Diego, CA, March 2012

Dieter Bingemann

“Describing Glass Dynamics as a Sequence of Local Relaxation Events”

University of Pennsylvania, January 2012

Dieter Bingemann

“How Individual Structural Rearrangement Events Lead to the Complex Dynamics in Glasses”

University of Wisconsin, May 2012

Daniel Gross '12, Cameron R. Rogers '12, Katrina A. Tulla '11, Erica L. Wu '13, Lee Y. Park

“Partially Fluorinated Sidechains in Influencing Polymer Film Morphology, Absorption and Fluorescence Behavior”

243rd ACS National Meeting & Exposition, San Diego, CA, March 2012

Lee Y. Park

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

Wellesley College, December 2011

Zachary D. Remillard '12, Sara A. Turner '11, Emily Gao '13, Desire T. Gijima '10, A. Chandrasekaran, Robert D. Pike, Christopher Goh

“Copper Complexes of Tridentate Pyridine-imine and Pyridine-amine Ligands as Catalysts for Atom Transfer Radical Polymerizations”

243rd ACS National Meeting & Exposition, San Diego, CA, March 2012, INOR-525

Zachary D. Remillard '12, Sara A. Turner '11, Emily Gao '13, Desire T. Gijima '10, A. Chandrasekaran, Dmitri Royman, Robert D. Pike, Christopher Goh

“Structures and Properties of Copper(I) Complexes of Tridentate Heteroaromatic-imine and Heteroaromatic-amine Ligands”

243rd ACS National Meeting & Exposition, San Diego, CA, March 2012, INOR-271

POSTGRADUATE PLANS OF CHEMISTRY DEPARTMENT MAJORS

Michael Alcala	Research Assistant, Harvard School of Public Health, then to medical school
Clarissa Andre	Unknown
Grace Babula	Unknown
Oscar Calzada	Research Associate, Boston Children's Hospital, then to medical school
Roop Dutta	M.D., Tufts University School of Medicine
Daniel Gross	Unknown
Kathryn Kumamoto	Ph.D. in Geology, Stanford University
Andrew Kung	Unknown
Mindy Lee	Economics research, then to graduate school
Natalia Loewen	Work in San Francisco area, then to graduate school
Mathew Madden	Science teacher, Teach For America, Atlanta, GA, then medical school
Erin McGonagle	Luce Fellowship, Angkor Hospital for Children, Cambodia, then to medical school
Michelle McRae	Associate Consultant, Bain & Company, New York, NY
Nari Miller	Graduate school
Kenneth Murgo	Research with an orthopedic surgeon, then to medical school

Emily Niehaus	Clinical research, then to medical school
Rachel Patel	M.D., University of Massachusetts Medical School
Emma Pelegri-O'Day	Fulbright Research Fellowship, Germany
Hetal Ray	Research Assistant, Multiple Sclerosis Research Center of New York
Zachary Remillard	Research Assistant, Reluceo, Inc., Plymouth, MN
Marissa Robertson	Unknown
Jennifer Rodriguez	Work for Basic Health International, El Salvador, then to medical school
Cameron Rogers	Ph.D. in Chemistry, University of California-Berkeley
Christopher Valle	M.D., Feinberg School of Medicine, Northwestern University
Marsha Villarroel	Unknown
Norman Walczak	University of Texas at Austin Law School
Nicole Wise	Work, then to graduate school
Matthew Zhou	Ph.D. in Chemistry, University of California-Berkeley



Professor Chip Lovett explains a technique to a group of Summer Science Research students.

COMPUTER SCIENCE DEPARTMENT

The Computer Science Department continues to be an exciting and vibrant academic community. We are particularly pleased to report that Assistant Professors Brent Heeringa and Morgan McGuire were both promoted to the ranks of Associate Professor as of July 1, 2012. After six years serving as Provost of the College, Prof. Bill Lenhart spent the last year on sabbatical in France. Although still on sabbatical from teaching for one more academic year, he joined us back on campus this summer. Our students kept our computing lab lively around the clock this past year, and many continue to participate with the faculty on a variety of research projects. Antal Spector-Zabusky '12 was awarded honorable mention in the annual undergraduate research awards competition sponsored by the Computing Research Association for research performed under the supervision of Professor Freund. Professor Freund also began his term as Department Chair this past year. Lorraine Robinson, our long-time administrative assistant, retired in June. We wish her all the best for the future.

Computers and computation are pervasive in our society. They play enormously important roles 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 we attempt to meet these varying interests through 1) its major program; 2) a selection of courses intended for those who are interested primarily in an introduction to computer science; and 3) recommended course sequences for non-majors who want a more extensive introduction to computer science, or who seek to develop specific expertise in computing for applications in other disciplines.

The computer science major 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 the student whose future career 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, digital design, distributed systems, advanced algorithms, theory of computation, computer graphics, artificial intelligence, machine learning, operating systems, and compiler design. For those students interested in learning

more about important new ideas and developments in computer science, but who are not necessarily interested in developing extensive programming skills, the department offers three courses. Creating Games (CSCI 107) introduces important concepts in computer science through the design and analysis of games. Artificial Intelligence: Image and Reality (CSCI 108) provides an introduction to the field of artificial intelligence, and The Art and Science of Computer Graphics (CSCI 109) introduces students to the techniques of computer graphics.

Prof. **Jeannie Albrecht** spent the fall semester on sabbatical at the University of Massachusetts, Amherst. There she became involved in a research project involving green computing. Specifically, Albrecht and her colleagues at UMass are investigating how to use computing to decrease the energy impact of society. The problem is highly relevant to today's technological trends. The first part of the project involved the instrumentation of Albrecht's house with power meters. Power data is now gathered every second about the entire house, and a weather station is used to correlate the energy usage with the outdoor temperature, humidity, and wind conditions. The next step in the project was to explore ways to flatten the peak energy usage of the house by scheduling "background" appliances (such as dehumidifiers, air conditioners, refrigerators, etc.) during non-peak times of the day. Albrecht and her colleagues have recently published three papers that describe their vision and document their initial results. They are currently looking at how to use batteries and renewable energy sources most effectively given the data that has been collected. The project is joint work with Prof. Prashant Shenoy, Prof. David Irwin, Aditya Mishra, and Sean Barker '09 at UMass.

During the past year, Albrecht 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>). A journal article on Gush (and the project's predecessor, Plush) recently appeared in the Association for Computing Machinery's Transactions on Internet Technology (TOIT) journal. Pamela Mishkin '15 worked with Albrecht this spring on enhancements to Gush that provide a better user experience.

Related to her involvement with GENI, Albrecht recently traveled to RIT with Karlan Eberhardt '13 to teach other researchers how to use Gush as part of

the GENI Summer Camp. Albrecht received a grant from the National Science Foundation to organize a workshop in July in conjunction with the next GENI Conference that will focus on redefining Distributed Systems education. Approximately 20-30 attendees from a variety of academic institutions will attend and discuss how to incorporate new networking technologies into undergraduate courses.

Prof. **Duane Bailey** worked with Juan Mena '15 on developing a database of sliding piece puzzles, along with their rankings and solutions. The work is based on the old but standard catalog of Hordern. The hope is to develop a better understanding of the structure of the state spaces of these human-oriented search problems to identify what makes search easy or difficult, fun or tedious. Bailey and Mena worked with Tracy Baker-White on developing a decoding device that aids in the understanding of the mysterious messages that appear in the work of Charles Dellschau, a German-American folk artist who drew pictures of fanciful airships designed by the Sonora Aero Club in the early 1900s.

Bailey was invited to the 10th Gathering for Gardner. There, he and his former student, Feng Zhu '02 (now teaching at USC's Marshall School of Business), presented work on the development of a porous structure that tiles the plane non-periodically.

Last summer Bailey gave a Williams summer science research talk, "In Search of a Programmable Tattoo". The hope was to understand the technologies that might have to be developed to support robust computation in irregularly structured biological media. Bailey's work with Kathryn Lindsey '07 (now at Cornell Math) demonstrates that traditional automata can perform robust computations in aperiodic environments.

Bailey with students Donny Huang '13, Peter Mertz '12, Nehemiah Paramore '14, Cody Skinner '13, and James Wilcox '13, constructed a 40th anniversary CMOS version of the first microprocessor, the Intel 4004. The original device was one of a set of chips that made up the Busicom 141-PF. The Williams processor, if fabricated, would take up less than a square millimeter of silicon.

Prof. **Andrea Danyluk** was happy to teach Artificial Intelligence (CSCI 373) this year, for the first time since 2007. She revised the course substantially, introducing new topics and all new lectures, as well as a series of assignments developed at UC Berkeley.

Danyluk continues her research in the area of machine learning. She supervised a year-long student research project this year. Chansoo Lee '12 worked with her on the problem of object identification, a specialized type of

image recognition in which the category is known and the goal is to recognize an object's exact identity. This task is related to, though clearly different from, the task of object classification, in which the goal is to identify the category to which an object belongs. Both tasks typically involve the application of machine learning algorithms, which are presented with input images along with their correct labels (i.e., either the exact identity or class). While there exist several algorithms for object identification that have met with reasonable success, there is room for improvement. Active learning is an approach in which the learning algorithm selects the training examples that it determines will be most helpful for improving its performance. Most typically, active learning is useful when there exists an abundance of input examples that have not yet been labeled. By identifying those examples that will be most useful, the learning algorithm focuses the attention of the human expert who must provide the labels for training purposes. Much less frequently, the active learning system can be used to identify examples for which it would be useful to have the human expert identify the most salient features. This has previously been done in the context of classification problems - not object identification problems. Chansoo worked toward developing an active learning algorithm that could work successfully within the object identification framework. This would have clear benefit for Prof. Danyluk's research project on the identification of individual spotted salamanders.

In addition, Danyluk co-authored a paper with Nick Arnosti '11, based on one half of his honors thesis work last year. The paper will be presented at the International Conference on Machine Learning in Edinburgh.

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. Her commitment to increasing the number of women and underrepresented minorities in computing research is also at work at Williams. This year she helped to bring Gioia DeCari to campus to perform "Truth Values: One Girl's Romp Through M.I.T.'s Male Math Maze" and organized a panel that followed the show.

She continues her 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. They have published their "Strawman Report" and are now working on the next phase. Danyluk also continues her work with the Liberal Arts Computer Science Consortium.

Prof. **Stephen Freund** is currently serving as Chair of the Computer Science Department. He has also continued his work on tools to help programmers find defects in software. His current focus is on how to make it easier for programmers to write error-free programs that take advantage of multicore processors. He presented work on this topic at the International Conference on Run-time Verification and at the Workshop on Foundations of Object-Oriented Languages, as well as at several academic institutions, including University of Washington and University of Massachusetts, Amherst. Freund also received an NSF grant to fund his research on this topic for the next three years.

Last summer, Freund worked with Antal Spector-Zabuksy '12 on a visualization tool for illustrating the behavior of concurrent programs under relaxed memory models. The intended use of the tool is to enable programmers (or instructors in the classroom) to visually and interactively explore how a program's run-time behavior may be impacted by scheduler and memory-model.

Freund organized the Workshop on Formal Techniques for Java-like Languages in Lancaster, UK last summer. He also served on the program committee for several workshops and conferences, including the ACM Conference on Programming Language Design and Implementation. He is 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 sixth year as Assistant Professor in the Computer Science Department at Williams College. Heeringa taught a tutorial in Advanced Algorithms in the fall, a course on Mixology during winter study, and Algorithm Design and Analysis in the spring.

Together with Louis Theran (Temple, FU Berlin), Justin Malestein (Temple), and Matthew Berardi (Temple), Heeringa studied computational problem in rigidity theory. Periodic frameworks, in which the lattice can flex, arise in the study of zeolites, a class of microporous crystals with a wide variety of industrial applications, most notably in petroleum refining. Heeringa helped develop algorithms for determining rigidity in generic periodic frameworks. This work appeared at the 2011 Canadian Conference on Computational Geometry (CCCG).

Heeringa also continued his collaboration with Glencora Borradaile (Oregon State University). In collaboration with Alan Fern (OSU), Xiaoli Fern (OSU), and Javad Azimi (OSU) Heeringa and Borradaile worked on

problems in active learning — an area of machine learning that specializes in minimizing the labeling efforts required to learn accurate classifiers. Most work in active learning focuses on sequentially selecting one unlabeled example at a time. Heeringa and his coauthors developed a new algorithm for batch active learning. This work was accepted at the 2012 International Conference on Machine Learning (ICML).

Heeringa worked with Donny Huang '13 on fundamental problems in data structures relating to the efficiency and optimality of binary search trees.

Heeringa reviewed papers for Information Processing Letters, the Conference on Implementation and Application of Automata, and Siam Journal on Computing. In addition he traveled to Toronto for the Canadian Conference on Computational Geometry, to Brooklyn for the Symposium on Algorithms and Data Structures, and gave an invited talk at Carleton College in Northfield, Minnesota.

All of Heeringa's research is supported by an award from the National Science Foundation.

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.

This was the first year of an increased cap allowing 24 students per year to enroll in the Creating Games (CSCI 107) interdisciplinary course in the CS and Art departments. To scale the hands-on course up to this size, McGuire worked with teaching assistant Lily Riopelle '14, Coordinator of Mellon Academic Programs Elizabeth Gallerani and interim director Katy Kline in the museum, and Michael Taylor in the science shop. The students each produced three significant computer or video games from scratch and studied topics as diverse as gender roles in narrative and computability in mathematics. Many reported this to be one of the most challenging and rewarding experiences in their Williams career. To support the course, McGuire developed the codeheart.js open source framework for learning to program web and mobile apps, which is now available to the general public at <http://codeheartjs.com>.

McGuire published The Graphics Codex, a new electronic book on computer graphics for iPhone, iPad, and iOS <http://graphicscodex.com>. Next semester, OIT will issue tablets to students registered for Computer

Graphics (CSCI 371) so that they can use this in the classroom. This leverages the digital format in new ways for interactive examples, continuous updates, and densely hyperlinked references. The primary goal of this new book is accessibility — the form factor means that it is always with students in the lab or classroom, it brings the resources of the ACM Digital Library to students by directly linking topics to primary sources and seminal papers, and online distribution means that the e-book costs students only 5% as much as a typical computer science textbook.

McGuire served as editor in chief of the *Journal of Graphics Tools* and as section editor on computational photography for ACM Queue and published several peer-reviewed papers on new special effects in computer graphics. The most recent of these is “Scalable Ambient Obscurance”, coauthored with thesis student Michael Mara ’12. Mara’s thesis is on new algorithms and system infrastructure to enable cinema-quality 3D images for mobile applications. The key to this work is

computing scene illumination on a server in the cloud and streaming it as video to a 3D-enabled client. Mara and McGuire will be collaborating on this project at NVIDIA Research, where Mara will complete a post-baccalaureate research internship.

Prof. **Tom Murtagh** began a new project investigating techniques for more effectively utilizing flash memory in file systems. Flash memories in use today typically include controllers that enable them to emulate hard disk drives. This has hastened deployment, but prevents operating system software from optimizing file system organization for the underlying characteristics of flash devices. Together with Abigail Zimmerman-Niefield ’15, Murtagh is working on designing a file system interface to an underlying storage device that will support data layout optimizations on both flash memories and disk drives.

Murtagh attended the 2012 USENIX Annual Technical Conference and the Workshop on Hot Topics in Storage and File Systems in June, 2012.



2012 Summer Science Research students enjoying the Tuesday lunch speaker.

Each year the department participates in a special lectureship program funded through the generosity of the Class of 1960. This spring, we welcomed Dr. David Ferrucci from IBM as our distinguished guest for this program. Dr. Ferrucci leads the Semantic Analysis and Integration Department at IBM's T.J. Watson's Research Center, where he focuses on technologies for automatically discovering knowledge in natural language content and using it to enable better decision making. Among his accomplishments are the design and implementation of the Watson computer system that can rival human champions at the game of Jeopardy!. Dr. Ferrucci gave several talks and met with faculty and students during his visit. 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

Zina Cigolle	Joshua Geller	Michael Mara	Antal Spector-Zabusky
Karlan Eberhardt	Donny Huang	Brianne Mirecki	Alexander Wheelock
Carson Eisenach	Chansoo Lee	Diogenes Nunez	James Wilcox
Thomas Gaidus	T. Andrew Lorenzen	Lily Riopelle	

Computer Science Department Colloquia

Prof. Jeffrey S. Chase, Duke University

"Reflections on Trusting Trust, Part 2: The Cloud"

Computer Science Faculty

"Everything you need to know about graduate schools including: Deadlines, personal statements, finding an Advisor, Research, Application Process, Choosing the Right School"

Prof. John W. Byers, Boston University

"Daily Deals: Prediction, Social Diffusion, and Reputational Ramifications"

Mark Terrano, Hidden Path Entertainment

"Games and Immersion"

Christopher Cyll '04 and Michael Gnozzio '07, Adverplex, Inc.

"Building a Profitable Website: Algorithmic Marketing, Quality Modeling, and Other Things You Need to Run an Internet Startup"

Prof. David Liben-Nowell, Carleton College

"You Can Pick Your (Best) Friends"

Michael Hay, PhD, Cornell University

"Analyzing Private Network Data"

Josh Ain '03, Google

"Finding Structure in Webpages"

Prof. Daniel Scharstein, Middlebury College

"Benchmarking Stereo Vision and Optical Flow Algorithms"

Matthew Ginsberg, Co-Founder and CEO, On Time Systems Inc.

"Dr. Fill: Crosswords and An Implemented Solver for Singly Weighted CSPs"

Prof. Samuel Z. Guyer, Tufts University

"Tools for Improving Software Right Now"

Ben Ransford, Ph.D. Candidate, SPQR Lab, University of Massachusetts, Amherst

"Transiently Powered Computers"

Brent Yorgey '04, Ph.D. Candidate, University of Pennsylvania

"Embedded, Functional, Compositional Drawing"

Dr. David Ferrucci, IBM Fellow and Watson Principal Investigator, IBM Research

"Beyond Jeopardy! The Future of Watson"

Prof. Emery Berger, University of Massachusetts, Amherst
“Programming with People: Integrating Human-Based and Digital Computation”

Duane Bailey
“In Search of a Programmable Tattoo”
Summer Science Talk, Williams College, August, 2011

Brent Heeringa
“How to Host a Profitable Fundraiser (with Slightly Fussy Participants)”
Science Lunch, Williams College, October, 2011

Department Student Colloquia

Thomas Gaidus’13	“An Introduction to Android Application Development Through Google Code University”
Donny Huang’13	“Parallel Spatial Partitioning Algorithms”
Chansoo Lee’12	“Active Learning with Feature Feedback for Object Identification”
T. Andrew Lorenzen’12	“Researching for Fiksu”
Michael Mara’12	“CloudLight: A Distributed Global Illumination System for Real-Time Rendering”
Antal Spector-Zabulsky’12	“Dynamic Race Condition Detection via Synchronization Specification Automata”
James Wilcox’13	“Securing Internet Meta-Architectures”

Off-Campus Colloquia

Jeannie Albrecht
“Selected Project Highlights: An Overview of Gush”
GENI Engineering Conference 11, July 2011
“Tutorial Session: Experiment Control Using Gush,”
GENI Engineering Conference 11, July 2011
“Experiment Control Using Gush”
GENI Summer Camp at RIT, May 2012

Andrea Danyluk
“Identification of Individual Spotted Salamanders”
Middlebury College, Middlebury, VT, September 2011
“Undergraduate Research Experience Internships”
Grace Hopper Celebration of Women in Computing, Portland, OR, November 2011

Stephen Freund
“Cooperative Concurrency for a Multicore World”
University of Washington, Seattle, WA, November 2011
“Cooperative Concurrency for a Multicore World”
University of Massachusetts, Amherst, MA, February 2012

Brent Heeringa
“The 1-neighbour Knapsack Problem”
International Workshop on Combinatorial Algorithms, June, 2011
“The Line-leaf Tree: A Dynamic Data Structure for Tree-like Partial Orders”
Carleton College, April, 2012

Morgan McGuire

“Stochastic Rasterization”
GPU Technology Conference, San Jose, CA, May 15, 2012

Postgraduate Plans of Computer Science Majors

Zina H. Cigolle	Amazon.
Chuan Ji	Google.
Chansoo Lee	Graduate school at University of Michigan, MI.
T. Andrew Lorenzen	Google.
Michael T. Mara	Graphics research at NVIDIA.
Peter S. Mertz	Geophysical consulting in Connecticut.
Diogenes A. Nunez	Graduate school at Tufts University, MA.
Eric D. Outterson	Undecided.
Jonathan R. Schmeling	Undecided.
Gregory S. Sherid	Undecided.
Antal B. Spector-Zabusky	Graduate school at University of Pennsylvania, PA.



Students demonstrating games designed as part of Creating Games (CS 107) In photo, left to right. Bridget Malicki, Cole Leiter, Wade Phenicie, Margaret Lanphier and Walter Filkins

GEOSCIENCES DEPARTMENT

After thirty-five years on the Williams College faculty, Markes Johnson is retiring, from his formal teaching duties. He, Gudveig Baarli, and David Backus will continue their collaborative work on Baja California and other projects from their new offices in Mather House. Fortunately, we will still be able to offer courses and research opportunities in paleontology since **Phoebe Cohen** joined our department on July 1. Phoebe received her Ph.D. from Harvard University and researched the evolution of Neoproterozoic eukaryotes. She was most recently a postdoctoral associate at the Massachusetts Institute of Technology where she divided her time between research and the Education and Public Outreach group at the NASA MIT Astrobiology Advent of Complex Life team.

Another major change in the Geosciences Department is the addition of Steve Albino as a technical assistant to help the faculty teach, train students, and conduct research. Steve, has extensive GIS experience, a degree in Geology, and a seemingly inexhaustible list of skills.

Mea Cook gave an invited lecture at the American Geophysical Union fall meeting in San Francisco, California, in a session on Bering Sea paleoceanography. She also attended an Integrated Ocean Drilling Program (IODP) post-cruise meeting in Salamanca, Spain, for participants in Expedition 323 to the Bering Sea. At these two conferences, she presented the work she did over the last two years with nine students determining the age of sediments from two IODP sites in the Bering Sea, and reconstructing ocean circulation during the end of the last ice age using radiocarbon measurements from those sediments. Mea's honors student, Nari Miller, studied the organic and inorganic geochemistry of sediments from the penultimate ice age to investigate rapid climate and ocean circulation changes in the Bering Sea.

Professor **Rónadh Cox** continued her field research on enigmatic boulder ridges on shore-hugging cliffs in the Aran Islands with Leaf Elliot '13 and Kalle Jahn '14. She and her students have been using field observations and GIS analysis to track movement of the boulder ridges since a detailed 1839 Ordnance Survey map was made.

Cox had two field seasons in summer of 2011. She spent the month of June measuring boulder movements on the Aran Islands, with Dave Rapp '13 and Miranda Bona '13 and then spent a few weeks in Madagascar collecting samples to help evaluate regional erosion

rates: river sand samples for cosmogenic isotope analysis, and charcoal for ^{14}C age dating. She was joined in the field by Ny Riavo Voarintsoa, a Malagasy student who spent the 2010-2011 academic year at Williams, taking Geosciences classes and working in Rónadh's lab on GIS analysis of lavaka erosion. Both field seasons were successful. The Aran Islands group documented movement of a number of large boulders at considerable distances from the sea shore and at elevations of metres to 10s of metres above mean sea level, including a 10-ton block that had moved several metres since June 2010: these observations underscore previous findings that storm waves are moving these large blocks on a regular basis, in spite of their size and their distance above sea level. The sample set from the Madagascar expedition is currently being analysed in the UVM lab of Paul Bierman '85, with the assistantship of James McCarthy '11.

In January, Rónadh became a Science Editor for the journal *Geology*. The journal has 5 science editors, who handle more than 1000 manuscript submissions per year, covering the whole range of geological topics. Reading such large numbers of papers on lots of different subjects is fascinating, if time consuming! Professor Cox will assume the duties of Chair of the Geosciences Department as of August 2012.

Plans for summer 2012 include another season in the west of Ireland. In addition to returning to the Aran Islands to the boulder-monitoring sites, Rónadh will work with two students, Leaf Elliot '13 and Kalle Jahn '14 at two new sites: Annagh Head, in Co. Mayo (on the mainland), and the Inishkea Islands (off the coast of Mayo). They will be joined by Physics prof. Ward Lopes, who will lend his expertise to the group's attempts to understand the mechanisms by which storm waves can move large boulders. Back at Williams later in the summer, Johanna Eidmann '14 will work in Rónadh's lab pushing forward the GIS analysis of lavaka evolution in Madagascar, trying to quantify rates of lavaka formation and evolution by comparing old air photos with recent orthoimagery.

David Dethier continued his NSF-sponsored research in the Colorado Front Range, focused mainly on the measurement of geomorphic and geochemical 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, University of

Connecticut) a Keck Geology Consortium project involving 4 students in the Boulder Creek area. There were no Williams students on the project this year. 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 ^{10}Be techniques. Dethier continued to work in the City of Boulder watershed and adjacent areas 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 mainly alpine study areas.

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 27 years of monitoring are available at <http://oit.williams.edu/weather/>; archived watershed data (streamflow and temperature, stream chemistry and bulk precipitation chemistry) are at: <http://oit.williams.edu/weather/watershed/>.

Assistant Professor **Lisa Gilbert**, at Williams-Mystic continues her studies of seafloor formation and evolution. Gilbert traveled to the Annual Meeting of the Geological Society of America in Minneapolis to present work she has been doing with colleague Matt Salisbury (Geological Survey of Canada) on the velocity structure of oceanic crust. Their work appeared in the journal *Geochemistry, Geophysics, Geosystems*. This year she began a new project on the permeability of oceanic crust, using innovative techniques to estimate hydrothermal circulation within samples of the seafloor. This spring, Grace LaPier '13 and Connor Dempsey '13 assisted with laboratory measurements. This summer, Miranda Bona '13 began her honors thesis work related to this project. Bryce Mitsunaga '13 is working with her on the properties of seafloor rocks using samples from seamounts of different ages to understand the physical evolution of potential upflow zones for hydrothermal circulation in old oceanic crust.

Gilbert traveled to the Northeast Section Meeting of the Geological Society of America in Hartford with two of her fall Williams-Mystic students, Zara Currimjee '13 and Nuria Clodius (Mt Holyoke '13). The students presented results of an on-going collaborative study at Barn Island Marsh in CT. Anna Szymanski '12 and Abigail Martin '11 were co-authors.

Markes Johnson was named the Charles L. MacMillan Emeritus Professor of Natural Science at the conclusion of the 2011-2012 academic year, bringing to a close 35 years of service to the Geosciences Department and the College. Although he will no longer be active in the classroom, Prof. Johnson expects to remain busy working on research articles and book manuscripts from a campus office in Mather House. The Iberian research group, to which he and spouse Gudveig Baarli (Williams Research Scientist) belong, has another field season ahead in 2013 under a grant awarded from the Spanish Ministry of Science and Technology for research on rocky shores in the Canary Islands (Spain) and Cape Verde Islands (former possession of Portugal). Markes and Gudveig participated in fieldwork with the group on three islands (Santiago, Maio, and São Nicolau) during Spring Break in March 2012.

During the 2012 Winter Study Period, Research Scientist David Backus and Markes Johnson collaborated on studies related to a Pliocene fan delta preserved on Isla del Carmen in comparison with the modern delta at Loreto, Baja California Sur, Mexico. Preparation of research materials related to ongoing projects in Mexico and the Cape Verde Islands promises to keep Markes, Gudveig, and David involved with geological studies for quite some time.

Academically, the highlight of the year came with publication of the Springer book, *Earth and Life*, with a lengthy (65-page) chapter by Markes and Gudveig on the "Development of Intertidal Biotas through Phanerozoic Time."

During the course of the academic year, Prof. Johnson wrote peer reviews on manuscripts submitted to *Palaeogeography, Palaeoclimatology, Palaeoecology*; *Journal of Coastal Research*; *Sedimentology*, and *Naturwissenschaften*. He also performed reviews on grant proposals for the Natural Sciences and Engineering Research Council of Canada and the DFG (German Research Foundation).

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. He taught a new tutorial called *Evolution of and on Volcanic Islands*. During the two-week spring break Karabinos led a course field trip to the big island of Hawaii supported by the Freeman Foote Travel Fund for the Sciences and the Geosciences Department.

Professor 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.

Karabinos was awarded a National Science Foundation grant: "Structural Geology and Tectonics Forum in Williamstown, MA" for \$35,100. The conference lasted seven days from June 12 to 18, and included three days of technical sessions and four days of field trips, short courses, and workshops. It was attended by 115 structural geologists from the United States, Canada, and Europe. Approximately one third of the participants were graduate students. Karabinos also gave a presentation at the meeting on how to use Google SketchUp for teaching structural geology. He also led a field trip to the Berkshire massif in western Massachusetts.

Karabinos led a field trip to the Chester dome in southeastern Vermont. at the New England Intercollegiate Geologic Conference in Middlebury, Vermont, in October.

Karabinos attended the National Meeting of the Geological Society of America in Minneapolis, Minnesota, in October, 2010, where he gave an invited presentation at a theme session titled Virtual Reality in Geoscience Education I (Digital Posters). He gave another presentation in a theme session called Multidisciplinary Studies of Fault System Deformation. At the meeting, Karabinos was elected a Fellow of the Geological Society of America.

During his 45th year of teaching at Williams, Prof. **Bud Wobus** attended the annual meeting of the Geological Society of America in Minneapolis in October. While at GSA he represented the department at the semi-annual board meeting of the Keck Geology Consortium and organized a reunion of some 25-30 alumni and faculty at the meeting. Later in the fall he led his annual hike on the geology of Stone Hill for the Williamstown Rural Lands Foundation, with about 30 participants. In December he hosted a reunion of alumni attending the American Geophysical Union meeting in San Francisco, including several new alums working in the Bay Area.

During January he was the faculty leader of an 18-day trip for alumni to Argentine and Chilean Patagonia, giving several evening lectures and "on-the-road"

seminars using the geological guidebook he prepared for the trip. Just after spring vacation he participated in the 25th annual Keck Geology Symposium at Amherst College, where he gave a talk at the Silver Anniversary banquet recalling the founding and early years of the Consortium. His honors student, Katie Kumamoto '12, presented a short talk and poster and contributed a paper to the Symposium proceedings about her Keck-sponsored field and lab research studying the Hrafnfjörður volcano in the West fjords region of Iceland.

For alumni reunion in June he inaugurated a new campus tour, "Williams Rocks – What Williams is Built In, On, and Of" to introduce walkers to the geological history of the area as illustrated by campus outcrops and building materials. This summer he will visit a Keck project in the Powder River Volcanic Field of NE Oregon where his next honors student, Johnny Ray Hirojosa '13, will be working.

Geosciences faculty, students, and alumni published widely in scientific journals and presented numerous talks at the National Geological Society of America meeting in Minneapolis, Minnesota, and the American Geophysical Union Meeting in San Francisco, California. Kathryn Kumamoto '12 gave a research presentation at the Keck Symposium hosted by Amherst College.

The David Major Fund in Geology offered field camp scholarships to three of our majors during summer 2011. Caleb Lucy '11 and James McCarthy '11 attended the Indiana University field camp and Lisa Merkhofer '11 attended the YBRA field camp run by the Univ. of Houston. The Keck Geology Consortium supported field work by Katie Kumamoto '12 in Iceland. The McAleenan Family Fund in Geology supported James McCarthy's attendance at the National Meeting of the Geological Society of America in Minneapolis, Minnesota, in October and Nari Miller's attendance of the American Geophysical Union conference in San Francisco, California in December. Johanna Eldmann '13 received an NAGT field camp scholarship to attend the Lehigh field camp this summer.

Two honors students presented their research results on May 1. Katie Kumamoto won the Freeman Foote prize for best thesis presentation. Katie also won the Mineralogical Society of America prize, and Nari Miller received the David Major Prize in Geology. Katie Kumamoto and Nari Miller were inducted into Sigma Xi. Katie was a runner-up in the NSF fellowship competition.

The Geosciences Department continued to participate in the Class of 1960 Scholars Program. The lecture series was organized by Paul Karabinos and was integrated with the tutorial Evolution of and on Volcanic Islands.

Class of 1960 Scholars in Geology

Miranda L. Bona	Thomas J. Gaidus	Ian M. Nesbitt
Peter L. Clement	Kalle L. Jahn	Sarah E. Rowe
Johanna S. Eldmann	Kathryn M. Kumamoto	Gordon P. Smith
Christopher M. Elliott	Elena Luethi	Oona G. Watlkins

Geosciences Colloquia

- Dr. Keith Klepeis, University of Vermont
 Sperry Lecture Speaker and Geosciences Class of 1960 Scholar Speaker
 “The Patagonian Andes: Formation of a Collisional-Style Mountain Range in a Back-Arc Setting”
 “What Lies Beneath? A View of New Zealand’s Mountain Ranges from Deep Beneath the Earth’s Surface”
- Dr. Michael Williams, Univ. of Massachusetts, Amherst
 Geosciences Class of 1960 Scholar Speaker
 “Structural Processes in the Lower Crust: New Tools and New Interpretations from North America’s Largest Sample of Continental Lower Crust”
- Dr. Mea Cook, Williams College
 “The Ocean’s Role in Past and Future Climate Changes”
 “Reconstructing Ocean Circulation and Greenhouse Gases Using Deep-Sea Sediments”
- Dr. Rónadh Cox, Williams College
 “Giant Boulders on Irish Cliffs: How Did They Get There?”
 “Boulder Ideas: Storm Waves can Move Megagravel on Cliff Tops of the Aran Islands, Ireland”
- Dr. Daniel Ksepka, North Carolina State University
 “March of the Fossil Penguins: Applying New Methods to Avian Paleontology”
- Dr. Phoebe Cohen, MIT
 “Tracing the History of Eukaryotes in Precambrian Seas”
- Dr. Paul Harnik, The National Evolutionary Synthesis Center
 “The Ecology of Extinction in Ancient and Modern Seas”
- Dr. Markes E. Johnson, Williams College
 “Charles Darwin, Pleistocene Rhodoliths, and the Cape Verde Islands”



Caleb Lucey '11 and Erik Anderson '12 working on a project at Chard Pond

Geosciences Student Colloquia

Kathryn M. Kumamoto '12

“Magmatic Processes of the Hrafnfjörður Central Volcano, Northwest Iceland

Nari V. Miller '12

Evidence for Methane Release from Laminated Bering Sea Sediments During the Penultimate Glaciation”

Off-Campus Colloquia

Mea Cook

“Understanding Climate Change: Tracing Productivity and Ocean Circulation in the NW Pacific Using Benthic Foraminifera and Radiocarbon”

Williams-Mystic, Mystic Seaport

“Tracing Productivity and Ocean Circulation in the NW Pacific Using Benthic Foraminifera and Radiocarbon”

Lafayette College

“Methane and Climate changes During the Last Glaciation”

Middlebury College

“The Ocean’s Role in Past and Future Climate Changes”

Thomas Jefferson High School for Science and Technology

Rónadh Cox

“Inquiry-Based Science”

Museum Institute for Teaching Science, Summer Institute

“Regional Erosion Rates in Madagascar via Cosmogenic Isotope Analysis”

University of Witwatersrand, Johannesburg, South Africa

“Boulder Ideas: Wave-Emplaced Megagravel on the Aran Islands, Ireland”

“Comets Cause Chaos, by Jupiter! Crust-Penetrating Impacts at Europa”

University of Illinois, Champaign-Urbana

“Storm Waves Move Large Boulder Ridges on the Aran Islands, Ireland

Geological Society of America Annual Meeting, Minneapolis, MN

“Crust-Breaching Impacts at Europa: Hydrocode Models and Geomorphologic Constraints on Ice Thickness”

Geological Society of America Annual Meeting, Minneapolis, MN

Postgraduate Plans of Geosciences Majors

Erik M. Anderson

Unknown

Kathryn M. Kumamoto

Ph.D. program in Geology at Stanford University

Nari V. Miller

Geosciences field camp; travel for one year; graduate school

MATHEMATICS AND STATISTICS DEPARTMENT

The Mathematics and Statistics department had another great year. Professor Susan Loepp was awarded the 2012 Haimo Award for Distinguished College or University Teaching by the Mathematical Association of America, a national teaching prize. Professor Steven Miller was promoted to Associate Professor. Other accomplishments of our faculty are listed below. Our student team received an Honorable Mention and placed in the top ten out of 460 teams from 572 colleges and universities in the December 2011 William Lowell Putnam Mathematical Competition. This year we had 67 new mathematics majors, and 33 students in our SMALL summer research program, both records. This summer marks the end of Professor Silva's tenure as chair of the department. Professor Johnson will serve as the new chair.

Wendy Wang from Pennsylvania State University was hired as a new Assistant Professor of statistics. We also appointed Mark Mixer and Matt Gardner Spencer as new Visiting Assistant Professors of Mathematics. Four members of our department were on leave this past year. Ollie Beaver spent the fall at Williams. Edward Burger spent the year at Baylor University. Bernhard Klingenberg spent the fall at the University of Salzburg in Austria and the spring at the Institute of Statistics at the TU Graz in Austria. Susan Loepp spent the year at Williams. Steven Miller spent the year at Smith and Mount Holyoke. Ollie Beaver returned to teaching this spring and we look forward to the return of the others in the Fall of 2012. Next year Professors Colin Adams, Thomas Garrity and Mihai Stoiciu will be on leave for the year, and Professor Ed Burger will be on leave in the spring.

We are very proud of the accomplishments of our majors. The Rosenberg Prize for outstanding senior was awarded to Liyang Zhang '12. Erik Levinsohn '12 and Niralee Shah '12 received the Goldberg Prize for the best colloquium; this year the department awarded honorable mention in the Goldberg prize to Patrick Aquino '12, Carolyn Geller '12, David Gold '12, Stephanie Jensen '12, Andrew Nguyen '12, Sidney Luc Robinson '12, Tarjinder Singh '12, and Matthew Staiger '12. Patrick Aquino '12 was awarded the Morgan Prize for teaching, and Gregory White '12 was awarded the Morgan Prize in applied mathematics. Hannah Hausman '12 received the Robert M. Kozelka Award for outstanding students of statistics. The Witte Problem Solving Prize went to the members of this year's Putnam Team: Carlos Dominguez '13, Jared Hallett '14 and Liyang Zhang '12. Jared Hallett '14

first, and Craig Corsi '14 and Yang Lu '14 second, were awarded the Benedict Prize for outstanding sophomore. Connor Stern '12 was awarded the Wyskiel Prize for a student who chooses a career in teaching. Finally, Liyang Zhang '12 was awarded the colloquium attendance prize for seniors. Tara Deonauth '13 and Christina Knapp '13 were awarded the colloquium attendance prize for non-seniors.

The members of our Students of Mathematics and Statistics Advisory Board (SMASAB), were Alexander Greaves-Tunnell '13, Jared Hallett '14, Hannah Hausman '12, Christina Knapp '13, Stephanie Jensen '12, and Chansoo Lee '12. They provided sage advice including help in our hiring process, in addition to organizing the department's ice cream socials. This year one of our majors, Liyang Zhang '12 was awarded Honorable Mention in the National Science Foundation graduate fellowships in mathematics.

In summer 2011, **Colin Adams** spoke at the meeting on "Knots: Form and Function" at the Centro De Research di Giorgio in Pisa, Italy. Over the academic year, 2011-12, he gave a variety of talks. In particular, Tom Garrity and Colin Adams performed and recorded the Derivative vs. Integral Debate at Williams Family Days, with President Falk as moderator. The DVD is now on sale through the Mathematical Association of America. During spring break, Adams and Tom Garrity traveled to Wisconsin to give their humorous math debates at a variety of schools.

Adams published four papers, three with students from the SMALL program. He also worked with Tom Crawford '12 who wrote a thesis on finding knots with disjoint totally knotted Seifert surfaces. He continued to serve as a co-principal investigator on a grant that supports undergraduate math conferences around the country. In the spring he taught knot theory to a record 45 students. In summer 2012, he worked with six students and a Korean postdoc on original research as part of the SMALL program.

In summer 2011, Professor **Ollie Beaver** taught in and coordinated the mathematics component of Williams 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 in Boston and was an invited panelist on the National Science Foundation Panel for Graduate Fellowships in Mathematical Sciences.

Professor **Elizabeth Beazley** has now completed her second year at Williams, and she has continued to find the Williams math department an exciting place to grow her research program. Following a workshop on “Algebraic Combinatorixx” at the Banff International Research Station in Alberta, Canada, she has initiated several research collaborations in the areas of quantum and equivariant Schubert calculus, including one which grew out of a Class of 60s visit to Williamstown in March 2012. She had one paper appear this year in the January edition of the *Journal of Algebra* titled “Affine Deligne-Lusztig varieties associated to additive affine Weyl group elements.” In addition, her paper “Maximal Newton polygons via the quantum Bruhat graph” was accepted to the Formal Power Series and Algebraic Combinatorics conference to be held in Nagoya, Japan in July 2012, resulting in a conference proceedings publication in *Discrete Mathematics and Theoretical Computer Science*. She was also especially pleased to take eight Williams undergraduates to two research conferences in September 2012 at Brown University and Smith College.

Professor **Edward Burger** spent the academic year 2011–2012 at Baylor University as Vice Provost for Strategic Educational Initiatives and Visiting Professor of Mathematics. He also served as an educational consultant for both The University of Texas at Austin and Winston-Salem State University. In the summer of 2011, Burger was a faculty member of Williams’ Summer Humanities and Social Sciences Program.

Burger’s appearance on the Today Show series “The Science of the Winter Olympics” (co-sponsored by the NSF), earned him a 2011 Telly Award (and the entire series won an Emmy Award). Also in 2011 he received a Distinguished Achievement Award from the Association of Educational Publishers, recognizing Fuse—his mathematics video textbooks for mobile devices, published by Houghton Mifflin Harcourt. In 2012 Burger was featured in three episodes of the NBC-TV/NSF series “The Science of NHL Hockey” (Vectors, Statistics & Averages, and Kinematics) shown on the Today Show as well as throughout the NHL 2012 season.

In 2012 Burger published A Generalization of a Theorem of Lekkerkerker to Ostrowski’s Decomposition of Natural Numbers with undergraduate co-authors David C. Clyde, Cory H. Colbert, Gea Hyun Shin ’11, and Zhaoning Wang ’11 in *Acta Arithmetica*. With Michael Starbird, he completed a book on teaching, learning, and creativity entitled, *The 5 Elements of Effective Thinking*, to be published by Princeton University

Press. Burger and Starbird also completed work on the fourth edition of their textbook, *The Heart of Mathematics: An invitation to effective thinking*. Also in 2012, he starred in *Math on the Spot*, the first math video app developed exclusively for the Apple iPhone, published by Houghton Mifflin Harcourt.

Burger delivered over 40 addresses in the past year including five keynote addresses at MAA and NCTM Sectional Meetings, one of the keynote addresses at the MAA 2011 MathFest in Lexington, KY, the closing keynote address at the 2012 NCTM Annual Conference in Philadelphia, PA, the 2011 Robert L. Moore Lecture at The University of Texas in Austin, and the “Charge” address at the Phi Beta Kappa induction ceremony at Baylor University. He also addressed all first-year cadets at West Point Academy at the opening of the 2011–2012 academic year, and spoke at the Benjamin Franklin Society in Vero Beach, FL.

Professor **Satyan Devadoss** continued his research in the areas of discrete topology and geometry, on which he gave several invited talks from coast-to-coast, along with giving a two-day short-course on this subject at the national meeting for mathematicians in Boston. Several of his papers appeared in print this year, including one on the shape of associativity (*Canadian Notes*), one on the structure of trees (*European Conference on Computational Geometry*), and one on the nature of infinity (*Esopus Magazine*).

On the Williams front, Professor Devadoss gave several talks, to alums, students, and to general audiences. He supervised a SMALL research group on Geometric Origami in summer 2011, taking students to Toronto for a computational geometry conference. Devadoss advised Brian Li’s senior thesis on Polygonal Linkages, taught his first tutorial on Phylogenetics, and offered a winter study course on Visualization (of the Williams curriculum). With faculty, he served as an official mentor, along with participating in his first Oakley center seminar (on Charles Taylor’s *A Secular Age*, the hardest reading imaginable). He’s looking forward to the next year.

Professor **Richard De Veaux** continued his work in data mining and gave a variety of talks, invited talks, keynote addresses and workshops on teaching and data mining throughout the United States and Europe. He advised Ville Satop ’12 on his thesis. He was elected to the Board of Directors of the American Statistical Association in May 2012 for a three year term.

Professor **Thomas Garrity** has continued his research in number theory. His article, “Using Mathematical

Maturity to Shape Our Teaching, Our Careers and Our Departments” appeared in the *Notices of the American Mathematical Society*. His DVD debate “Derivative vs. Integral: The Final Smackdown”, with Colin Adams and moderated by Adam Falk, was released through the Mathematical Association of America. In July 2011 he spoke to students at the Hampshire College Summer Studies in Mathematics. In September, he gave a colloquium at Bennington College. In March 2012, with Colin Adams, he gave various versions of their debates at the University of Wisconsin at Madison, at Ripon College and at the Madison Area Technical College. He gave a colloquium and a faculty seminar at TCU in April 2012. In May 2012, Colin Adams and he gave a debate at Framingham State University. In the summer of 2011 he led a group of seven students (Krishna Dasaratha from Harvard, Laure Flapan from Yale, Chansoo Lee ‘12 from Williams, Cornelia Mihaila from Wellesley, Nicholas Neumann-Chun ‘13 from Williams, Sarah Peluse from Lake Forest and the University of Chicago and Matt Stoffregen from the University of Pittsburgh) in SMALL. A number of papers will eventually result from this work.

Garritty advised two thesis students last year, Stephanie Jensen ‘12 and Noah Goldberg ‘12.

His book *Algebraic Geometry: A Problem Solving Approach*, with co-authors Richard Belshoff, Lynette Boos, Ryan Brown, Jim Drouihlet, Carl Lienert, David Murphy, Junalyn Navarra-Madsen, Pedro Poitevin, Shawn Robinson, Brian A. Snyder and Caryn Werner has been accepted for publication by the American Mathematical Society. This book is both innovative in its presentation of algebraic geometry and in how it was written (explaining in part the large number of co-authors). He has joined the steering committee for the Park City Mathematics Institute. Finally, he continues as 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 optimal control problems.

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** spent the fall as a Visiting Professor at the University of Salzburg, Austria and the Spring as a Visiting Professor at the Institute

of Statistics at the TU Graz, Austria. Over the year, he was invited to give short courses on Applied Statistics, Categorical Data Analysis, and Mathematical Statistics and he organized a special course on Ordinal Categorical Data. He presented his newest methodological results in the analysis of correlated binary data at the Austrian Statistics Days 2011. In addition, he offered consulting services to medical faculty at the Medical University of Graz, Austria. His paper on simultaneous inference for proportions appeared in the journal *Computational Statistics & Data Analysis*.

Professor **Susan Loepp** was a recipient of the 2012 Mathematical Association of America’s Deborah and Franklin Tepper Haimo Award for Distinguished College or University Teaching of Mathematics. In January, she accepted the award and gave a talk at the National Mathematics meetings in Boston. In addition, in January, 2012, Loepp began a 5-year term as an associate editor for the *Mathematical Monthly*.

In summer, 2011, Loepp served as the SMALL director and advised the SMALL 2011 Commutative Algebra group. The group members, Ji Won Ahn ‘12, Elizabeth Ferme, Feiqi Jiang, and Gian Thi Huong Tran proved several original results in commutative algebra. They have written a manuscript based on their results and have submitted the paper to a refereed research journal in mathematics. Ji Won and Feiqi presented their results at the undergraduate research poster session at the National Mathematics meetings, and won an “Outstanding Presentation” award by placing in the top 15% of the poster presentations. In the spring of 2012, the paper written by the 2009 SMALL Commutative Algebra group, Nick Arnosti ‘11, Rachel Karpman, Caitlin Levenson, and Jake Levinson ‘11, appeared in the *Journal of Commutative Algebra*.

Last summer Professor **Steven Miller** supervised 9 summer REU students in the SMALL program. This led to 3 accepted papers, 3 submitted papers, 4 works in progress, and 25 talks by his students at various conferences, including an honorable mention at the Young Mathematicians Conference at Ohio State. His former thesis student, Jake Levinson ‘11, received first place there for his thesis work.

Miller was on sabbatical last year, and is glad to be back. He continued his research in number theory, random matrix theory and probability, had 8 papers appear and several more accepted, and gave 19 talks. He also designed some new classes at Smith and Mount Holyoke; one of these, Advanced Applied Linear Algebra, will be taught at Williams in the Fall of 2012.

Miller continues to be active in educational outreach activities. His math riddles page, <http://mathriddles.williams.edu>, is one of the top hits when googling ‘math riddles’, and is used by teachers in classes from K-12 all over the world. He gave a course on cryptography and Benford’s law to junior high and high school teachers in the Teachers As Scholars program, and gave talks at junior high and high schools.

Professor **Frank Morgan** has a new blog at the Huffington Post. He is continuing his study of minimal surfaces and densities with a number of collaborators and his undergraduate research Geometry Group. A joint paper with eight students on “Optimal Pentagonal Tiling” appeared in Notices of the American Mathematical Society, May 2012.

Professor **Allison Pacelli** was on maternity leave during the fall semester, and was thrilled to welcome her new son Andy into the world last July. Pacelli returned to campus this spring, teaching a senior seminar in Algebraic Number Theory and a tutorial in Galois Theory.

Professor **Cesar Silva** completed his third year as chair of the department. He continued his research in ergodic theory. He supervised the thesis of Praphruepong (Ben) Athiwaratkun ‘12, and the research in the spring of Christina Knapp ‘13 concerning a survey paper on the uncountability of the unit interval. Silva taught Calculus II in the fall, and Ergodic Theory in the spring, where he used his book on the subject. In December he participated in the MathBlast Williams workshop for 10th graders from Mount Greylock Regional High School and BART where he presented “Fractals and Natural Shapes.” He published a paper in *Colloquium Mathematicum* based on research with his students and had another paper submitted for publication. He was

invited to present a lecture at a conference in memory of Jal Choksi at McGill University in June.

In the summer he supervised a research group in ergodic theory whose members were Ke Cai, Jared Hallett ‘14, Lucas Manuelli and Sun Wei.

Professor **Mihai Stoiciu** taught “Groups and Characters” and “Differential Geometry” during the Fall Semester and two sections of “Applied Real Analysis” during the Spring Semester of the Academic Year 2011-2012. Stoiciu supervised Gregory White ‘12, who wrote an undergraduate thesis titled “Stochastic Calculus and Applications to Mathematical Finance” and Liyang Zhang ‘12 whose thesis was titled “Spectral Theory for Matrix Orthogonal Polynomials on the Unit Circle.”

During the year, Stoiciu continued his research on spectral properties of random and deterministic operators, working with collaborators from UK and US. His paper “Some Spectral Applications of McMullen’s Hausdorff Dimension Algorithm,” written with collaborators from Durham University, UK, was accepted for publication in the journal “Conformal Geometry and Dynamics.” He was invited to present his research at the AMS Special Session on “Spectral Theory” in Tampa, FL and was an invited participant in the “Arizona School of Analysis and Mathematical Physics” at the University of Arizona in Tucson.

In October 2011 Stoiciu gave the plenary address at Mid-Hudson Mathematics Conference for Undergraduates at Bard College, Annandale-on-Hudson, NY. At Williams College, Stoiciu gave two talks at the Osher Lifelong Learning Institute in the “Frontiers of Science” Program, a talk for high school students at the Williams MathBlast 2011, and a faculty seminar on his recent research in spectral theory.

Mathematics Colloquia

Kobi Abayomi, Georgia Institute of Technology

“Statistics for Re-identification in Networked Data Models”

Colin Adams, Williams College

“The Geometric Degree of Knots”

“Triple Crossing Number of Knots”

Ivana Alexandrova, University of Albany

“Aharonov-Bohm Effect in Resonances of Magnetic Schrodinger Operators with Potentials with Supports at Large Separation”

Olga R. Beaver, Williams College

“Gleason’s Theorem Revisited”

Elizabeth Beazley, Williams College

“An Introduction to Quantum Schubert Calculus”

Ivor Cribben, Columbia University

“Dynamic Connectivity Regression: Determining State-Related Changes in Brain Connectivity”

Satyan Devadoss, Williams College

“Phylogenetic Trees and Origami Foldings”

“Packings, Partitions, and the Water Cube”

“Collapsing Spaces of Trees”

Thomas Garrity, Williams College

“On the Topological Hypothesis for Phase Transition in Statistical Mechanics”

Gyo Taek Jin, Korean Advanced Institute of Science and Technology

“Quadriseccant Approximation of Knots”

Stewart Johnson, Williams College

“The Return of the Banana Path”

Christine Kohnen, Duke University

“Disclosure Limitation: The Statistical Game of Protecting Waldo”

Susan Loepp, Williams College

“Completions of Local Rings”

“Completions and Complete Intersections”

Bethany McLean ‘92, famously exposed Enron, now at Vanity Fair and TV personality

“Why It’s Smart to be a Math Major Even if You’re Not Good at Math”

Christopher McMahan, University of South Carolina

“Topics in Heterogeneous Group Testing”

Steven Miller, Williams College

“Biases: From Benford’s Law to Additive Number Theory Via the IRS and Physics”

Luke Miratrix, University of California, Berkeley

“Adjusting Treatment Effect Estimates by Post-Stratification in Randomized Experiments”

Frank Morgan, Williams College

“Tilings, Densities, and Asia”

“Existence of Isoperimetric Regions with Density”

“Different Definitions of the Area Enclosed by a Closed Curve in \mathbb{R}^n ”

“Stokes Theorem” “Soap Bubbles and Mathematics”

Allison Pacelli, Williams College

“Class Numbers & Class Field Towers”

Jennifer Quinn '85, University of Washington, Tacoma
 "Digraphs and Determinants"

Stephen Sawin, Fairfield University
 "South-Pointing Chariot: An Invitation to Geometry"

Jeffrey Schenker, Michigan State University
 "The Problem of Quantum Diffusion"

Cesar Silva, Williams College
 "Mixing Notions in Ergodic Theory"
 "Sub-Sigma-Algebras of Standard Spaces in Ergodic Theory"

Aaron Smith, Stanford University
 "Markov Chain Monte Carlo and (nearly) Exact Tests"

Rebecca Steorts, University of Florida
 "Bayes and Empirical Bayes Benchmarking for Small Area Estimation"

Mihai Stoiciu, Williams College
 "Spectral Applications of McMullen's Hausdorff Dimension Algorithm"

Kaisa Taipale, St. Olaf College
 "A Conjectural Quantum Puzzle Rule"

Qing Wang, Pennsylvania State University
 "Topics in U-Statistics and Risk Estimation"

Mathematics Student Colloquia by 2012 Graduates

Ji Won Ahn '12	"Mathematics of Doodling"
Patrick Aquino '12	"The Jordan Curve Theorem: A Simple Proof"
Prapthetpong Athiwaratkun '12	"Local Solvability: The Lewy Example"
Eileen Becker '12	"The abc Conjecture and Its Interesting Consequences"
Victoria Borish '12	"Knotty Problems in Quantum Theory"
Luke Breckenridge '12	"Thinking Outside the Box"
Hayley Brooks '12	"A Drunk and His Dog: Cointegration and Developing Successful Investment Strategies"
Jack Chen '12	"Bold Play: Go Big or Go Home"
Felipe Colina '12	"Re-focusing with Fourier"
Thomas Crawford '12	"Tropical Geometry"
Austin Davis '12	"Little Boat, Big Trouble: The Jealous Husbands Problem"
Laura Dos Reis '12	"Modeling the Spread of HIV in a Population with an Imperfect Vaccine"
Walter Filkins '12	"Encoding and Decoding Fractals"
Westcott Gail '12	"Newton's Method and Beyond: From Convergence to Super Hayley"
Carolyn Geller '12	"The Mathematics of Choosing a Spouse"
David Gold '12	"Spacetime and Complex Geometry"
Noah Goldberg '12	"A Priests' Puzzle (and its Mathematical Solution)"
Benjamin Halbower '12	"Chaos: Examining the Lorentz Water Wheel"
Hannah Hausman '12	"The Kakeya Needle Problem"
Stephanie Jensen '12	"Hyperbolic Geometry and Gieseking's Manifold"

Samuel Jonynas '12	"Sylow's First Theorem for Finite Groups"
Aayush Khadka '12	"Benford's Law and Its Applications"
Murat Kologlu '12	"Functions that Blow Up: Several Variable Complex Analysis and Harthogs' Theorem"
Josephat Koima '12	"Resultants of Polynomials"
Andrew Kung '12	"Are Your Friends Making You an Alcoholic?"
Pawel Langer '12	"15-Puzzle Impossible?!"
Chansoo Lee '12	"Finding Roots of Polynomials"
Erik Levinsohn '12	"Dude, Where's My Convex Hull?"
Brian Li '12	"Carpenter's Rules and Convexifying Polygons with Visibilities"
Timothy Lorenzen '12	"Do Traveling Salesmen Like Minesweeper?"
Shuai Ma '12	"Irrationality of Pi"
Michael Mara '12	"True Lovers are Intrinsically Linked, But What About Graphs?"
Andrew Nguyen '12	"Lost in Manhattan: The Problem of Self-Avoiding Walks"
Quoc Anh Nguyen '12	"A Beautiful Mind Meets The Beautiful Game: A Game Theoretic Approach to Soccer"
Theo Patsalos-Fox '12	"Sidestepping Difficult Differential Equations with Picard's Theorem"
Katherine Rieger '12	"Hip Hip Beret!"
Sidney Luc Robinson '12	"Applications of Generating Functions"
David Samuelson '12	"The Burnside Counting Theorem"
Matthew Schuck '12	"Fractals and Hausdorff Dimension"
Niralee Shah '12	"Hearing the Shape of a Drum"
Kevin Shallcross '12	"Group Theoretical Approaches to Understanding the Rubik's Cube"
Shara Singh '12	"Mathematics of Sudoku Puzzles"
Tarjinder Singh '12	"A Discussion of Markov Chains and Hidden Markov Models With Application to Gene Prediction and Motif Discovery"
Matthew Staiger '12	"Sticking it to Negami's Upper Bound on Stick Number for Knots"
Connor Stern '12	"Buffon's Needle Problem"
Katherine Stevenson '12	"Shape Ninja: The Art of Slicing Polyhedra"
Daniel Tessier '12	"Using Straight Lines to Divide the Projective Plane"
Philip Vu '11	"The In-Between Worlds: Understanding Non-integer Dimensions with the Hausdorff Measure"
Norman Walczak '12	"Hold the Applause: Pulse-Coupled Biological Oscillators"
Diqian Wang '12	"Where Do You Draw the Line?"
Stephen Weiss '12	"The Projective Plane as Unifier for Conics"
William Weiss '12	"The End of Tarantino: How to Win a Mexican Standoff"
Gregory White '12	"Regularity of Area-Minimizing Hypersurfaces"
Matthew Wyatt '12	"Hausdorff's Moment Problem"
Liyang Zhang '12	"Grassmannian Variety"

Off-Campus Colloquia

Colin Adams

“Superinvariants and Indicatrices of Knots”

Centro De Research di Giorgio, Pisa, Italy

“The Great Calculus Debate”

University of Wisconsin

Ripon College

“The Great Pi/e Debate”

Madison area Technical College, Madison, WI

Framingham State University

“Blown Away: What Knot to Do When Sailing”

James Madison University

Kennesaw State University

“Making Math Fun”

Kennesaw State University

“Real Estate in Hyperbolic Space: Investment Opportunities for the Passive-Aggressive Investor”

Park City Mathematics Institute, Park City, UT

“Hyperbolic Knots”

Joint Mathematics Meetings, Boston, MA

“Mathematically Bent Theater”

Joint Mathematics Meetings, Boston, MA

Elizabeth Beazley

“Affine Flag Varieties in Positive Characteristic”

Brown University

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

Dartmouth College

“Quantum Cohomology and the Poset of Newton Polygons”

Universite du Quebec a Montreal

“Infinite Shuffling Between Matrix Varieties and Newton Polygons”

Haverford College

Satyan Devadoss

“Colloquium”

Vassar College

“Geometry Seminar”

Georgia Institute of Technology

“Phylogenetic Networks”

Mathematical Biosciences Institute

“Plenary Speaker”

Discrete Math Day Conference

Renaissance Weekend

“Veritas Forum”

Dartmouth College

Georgia Institute of Technology

University of Arizona

“Discrete and Computational Geometry”

MAA Two-Day Short-Course

Richard De Veaux

“The Seven Deadly Sins of Data Mining”

Cardinal Health Research Symposium, Chicago, IL

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

Detroit, MI

Dallas, TX

Chicago, IL

New York, NY

Atlanta, GA

Los Angeles, CA

“Presentational Skills Workshop”

“Is the t-test Really Dead?”

Joint Statistical Meetings, Miami, FL

“Data Visualization for Large Data Sets

Workshop, Proctor and Gamble, Cincinnati, OH

“Data Mining: Fool’s Gold or the Mother Lode?”

Law Review Symposium, Thomas Cooley Law School, Lansing, MI

Math Association of America, Distinguished Lecture Series, Washington, DC

University of Kansas, Lawrence, KS

Pond Lecture, Chicago, IL

Pond Lecture, Milwaukee, WI

“Data Mining for Quality”

Fall Technical Conference, American Society for Quality, Kansas City, MO

“Robust Boosting”

Decision Sciences Institute, Boston, MA

“The Challenges of Big Data”

NSF Workshop, Bangalore, India

“Data Visualization for the Business Statistics Course”

Decision Sciences Institute, Columbia, SC

“Statistics and Data Mining for Computer Scientists, Engineers, Blacksmiths and Lawyers Workshop”

ITI, Cavtat, Croatia

Thomas Garrity

“On Writing Numbers”

Bennington College

Texas Christian University

“Derivative vs. Integral: The Final Smackdown”

with Colin Adams, University of Wisconsin, Madison

Ripon College

“On the Arrogance of Mathematicians”

Hampshire College

“The Great Pi/E Debate”

with Colin Adams, Madison Area Technical College

Framingham State University

“On a Thermodynamic Classification of Real Numbers”

Texas Christian University

Susan Loepp

“Where Algebra and Analysis Meet: What is the Distance Between Two Polynomials?”

Fairfield University

“The Key to Sending Secret Messages”

“Protecting your Personal Information: An Introduction to Encryption”

Frank S. Brennenman Lecture Series, Tabor College

“Teaching, Mentoring, and Advising Undergraduate Research: Lessons Learned on the Streets”

Haimo Award Talk, Joint Mathematics Meetings, Boston, MA

Steven Miller

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

CANT 2011

Amherst College

University of Connecticut

Colby College

“Theory and Applications of Benford’s Law, or: Why the IRS Should Care About Number Theory!”

Hampshire College

“Finite Conductor Models for Zeros Near the Central Point of Elliptic Curve L-Functions”

University of Maine

Brown University

“Pythagoras at the Bat”

University of Massachusetts, Amherst

Fitchburg State University

Boston College

“Benford’s Law, Values of L-Functions and the $3x + 1$ Problem, or: Why the IRS Should Care About Number Theory”

University of Massachusetts, Amherst

“Benford’s Law, or Why the IRS Cares About Number Theory”

Mount Holyoke College

“Eigenvalue Statistics for Toeplitz and Circulant Ensembles, Analysis and Probability Seminar

University of Connecticut

“Distribution of Summands in Generalized Zeckendorf Decompositions”

George Washington University

“To Infinity and Beyond: Gaps Between Summands in Zeckendorf Decompositions”

CANT 2012

“Moment Formulas for Ensembles of Classical Compact Groups”

Joint Mathematics Meetings, Boston, MA

“Models for Engaging Undergraduate Students in Research”

with Dave Damiano, Dean Evasius, Joe Gallian, Ivelisse Rubio, Jake Levinson ’11, and Gina-Marie Pomann

Joint Mathematics Meetings, Boston, MA

“Distribution of Missing Sums in Sumsets”

CANT 2012

Frank Morgan

“SurpriZing Science: AmaZing Bubbles”

With the SMALL Geometry Group, Spring Street, Williamstown, MA

“Soap Bubbles and Mathematics”

St. Michael’s College

Pine Cobble High School, Williamstown, MA

MathCounts, Hartford, CT

CUNY, Staten Island

Tufts University
 MIT '87 Reunion Dinner
 Edinburgh, ICMS Isoperimetric Problems, at Dynamic Earth for 60 high school students
 "Existence of Isoperimetric Regions in R^n With Density"
 Joint Mathematics Meetings, Boston, MA
 "Densities from Geometry to the Poincaré Conjecture"
 Washington State University
 MAA Meeting, University of Portland
 "Optimal Pentagonal Tilings"
 MAA Meeting, University of Portland
 "Optimal Tilings"
 Undergraduate Prize Lecture, Northwestern University
 Bridgewater State University
 "The Isoperimetric Problem With Density"
 Lehigh University

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

"Panel Presentation"
 The Hotchkiss School, Lakeville, CT
 "Métricas Compatibles y Sensitividad Medible"
 IMCA, Lima, Peru
 "Cantor's Set Throughout Real Analysis"
 Joint Mathematics Meetings, Boston MA
 "On μ -Compatible Metrics and Measurable Sensitivity"
 Joint Mathematics Meetings, Boston, MA
 "On Measurable Sensitivity for Nonsingular and Measure-Preserving Maps"
 McGill University

Mihai Stoiciu

"Mid-Hudson Mathematics Conference, Plenary Address"
 Bard College
 "Spectral Theory"
 University of South Florida

Postgraduate Plans of Mathematics Majors

Ji Won Ahn	Attending medical school at Washington University School of Medicine in St. Louis
Praphruepong Athiwaratkun	Working with Exeter Group in Boston
Victoria Borish	Researching at the Institute for Quantum Optics and Quantum Communication in Vienna, Austria.
Hayley Brooks	Pursuing a business with another Williams senior that facilitates fundraising in elementary schools via an online platform.
Thomas Crawford	Attending math graduate school at Boston University
Austin Davis	Teaching English at Phillips Andover as a Teaching Fellow and pursuing a Master's Degree in English over the summers through the Bread Loaf School of English.
Westcott Gail	Working as an Investment Banking Analyst at Deutsche Bank in New York
Carolyn Geller	Working as an Analyst in the Health and Benefits Consulting Department at Mercer in New York
David Gold	Working at Mighty Food Farm in Pownal, VT.
Hannah Hausman	Doing a two-year fellowship at the Carnegie Foundation for the Advancement in
Chansoo Lee	Pursuing a Ph.D. in Computer Science at the University of Michigan
Erik Levinsohn	Teaching high school math at the BART Charter School in Adams, MA
Brian Li	Research at the National Institute of Health while applying to medical school
Andrew Liu	Investment Fellowship with T. Rowe Price in Baltimore, Maryland
Andrew Lorenzen	Working as a Software Engineer at Google in Mountain View
Andrew Nguyen	Working at an economic consulting firm in New York
Theo Patsalos-Fox	Working at Boston Consulting Group
Katherine Rieger	Working at Vanguard Group participating in the Vanguard Accelerated Development Program in Philadelphia, PA.
Niralee Shah	Mathematics Teaching Fellow at King's Academy in Madaba, Jordan
Shara Singh	Working at the Williams College Investment Office
Tarjinder Singh	Pursuing a Master's Degree (MPhil. in Biological Sciences) at the University of Cambridge
Connor Stern	Teaching secondary math for Teach for America in Camden, NJ
Katherine Stevenson	Working for ITT Exelis, a government contractor, at the Goddard Space Flight Center in Greenbelt, MD, on NASA's Space Communications Network Services doing satellite communications work.
Stephen Weiss	Working at Exeter Group in Boston
Gregory White	Working as an Associate Consultant at Bain & Company in New York City
Matthew Wyatt	Working in the Model Review Group at JPMorgan in New York City, a subset of the Quantitative Research Division.
Liyang Zhang	Pursuing a Ph.D. in Mathematics at Yale University

PHYSICS DEPARTMENT

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.”

Eighteen Physics and Astrophysics majors graduated in June. Four will start graduate work in science or math, three science research, two high school physics teaching, two work in alternative energy, two work on healthcare software proving again what good preparation these majors are for many professions.

The department continues to actively engage students in research. Last summer 18 students were on campus doing physics research with a similar number this summer. Eight seniors completed honors research projects.

Prof. **Tucker-Smith** gave a Faculty Lecture about the search for the Higgs at the LHC. Prof. Strauch gave two Sigma Xi Lectures about quantum entanglement. The Physics and Astronomy colloquium program was excellent this year, and included four alumni – Josh Cooperman '05, Patty Liao '09, Tim McConnochie '98, and David Butts '06 who presented their work and met with students to talk about the paths they've taken in their careers. We also co-hosted Gioia De Cari who performed her one-woman play “Truth Values” about women in science.

Professor and Chair **Daniel Aalberts** taught Introductory Mechanics (PHYS 131) to 72 students in the fall and Statistical Mechanics and Thermodynamics (PHYS 302) in the spring.

In the Aalberts Lab, thesis student Julian Hess '13 enhanced an algorithm for RNA binding to include mean unfolding costs at the target while Joel Clemmer '12 developed measures for the information of RNA folds. Jeff Meng '11 returned to write a paper based

on his thesis work modeling stretched loops related to small RNA-mRNA binding. Scientific Programmer Bill Jannen '09 worked on an algorithm to cluster related RNA structures. Aalberts also collaborates with John Hunt (Columbia Univ) on methods to enhance gene expression. This summer, he will continue research with Julian Hess '13 and develop his new course (PHYS 231T Facts of Life) with Olivia Uhlmann '13.

During summer 2011 Professor **Kevin Jones**, along with Christina Knapp '13 and David Kealhofer '13, worked on a quantum optics experiment at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. The students were supported by a grant from NIST's Summer Undergraduate Research Fellowship program and Jones was supported as a Guest Researcher by a different NIST grant. The research group which hosted their visit is headed by Dr. William Phillips (1997 Nobel Laureate). The Williams contingent worked closely with Dr. Paul Lett and other NIST scientists on an experiment to produce quantum states of light, i.e. light beams that have properties that cannot be produced by any classical optics device. David and Christina constructed a diode laser system for doing four-wave mixing (a non-linear optics process) in cesium vapor. By the end of the summer they were able to demonstrate a four-wave mixing signal, verifying that the laser systems that they had constructed had the necessary power and spectral properties for the project. Jones will be continuing this project in summer 2012.

Jones, with NIST coauthors, published a paper in the journal *Optics Express* reporting on the development of a source for a particular quantum state of light, “multi-spatial mode squeezed vacuum,” of potential interest for quantum imaging applications. Jones and colleagues are working on a manuscript, describing their development of a noiseless amplifier for optical images. It has long been appreciated that quantum states of light have interesting properties for image and information processing, but actually producing and manipulating these states has been a significant experimental challenge. Jones continues to collaborate with the NIST group on new projects in this area.

For the past year, **Ward Lopes** has been on sabbatical as part of his Assistant Professor Leave. During part of the time, he traveled to the University of Illinois to continue working on a collaboration he has with Paul Selvin's lab. With the rest of his time, Ward has been at Williams continuing work on experiments and computations that had been started in his lab. Since the last report on Science, Ward has been coauthor on two published papers and he is currently writing two more.

During the 2011-12 academic year, Prof. **Tiku Majumder** continued 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, and has focused on numerous facilities, development, and admissions projects which relate to the Science Center. He also taught Physics 301, Quantum Mechanics, and its associated advanced laboratory, to a large group of 21 students in the fall of 2011. He continues to pursue diode laser and atomic physics experiments in his research lab, teaming up with senior thesis students Anders (Andy) Schneider '12 and Taryn Siegel '12, and current postdoc Dr. Gambhir Ranjit. Gambhir was hired with funds from Majumder's \$300,000 NSF grant, which also supports summer research students as well as the purchase of numerous new pieces of scientific equipment.

The Majumder lab continues to pursue very high precision measurements of atomic structure of the heavy metal elements 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. The two current experimental projects in the Majumder lab involve the use of various semiconductor diode laser systems and atomic sources of thallium (in heated vapor cells) and indium (in a high-vacuum atomic beam apparatus). Taryn Siegel '12 completed her thesis this spring which involved setting up a two-laser (IR, UV) spectroscopy system to observe and measure two-step spectroscopy in thallium atoms contained in a 600 °C quartz thallium cell. Taryn was able to lock the UV

laser used for the first-step excitation, and scan the IR laser to obtain initial hyperfine spectra for the second-step excitation.

Andy Schneider '12 also completed his thesis work this spring, following up on the development work of his predecessor in the lab, Tony Lorenzo '11. Andy worked to optimize the indium atomic beam system and the 410 nm laser frequency-modulation spectroscopy setup, and was able to collect and analyze our first indium Stark shift data by applying 10-12 kV/cm electric fields to the atomic beam. Andy is headed to Houston to begin a two-year high school teaching position prior to attending graduate school in physics. Tony Lorenzo spent this post-graduate year working in the Williams physics department as a lab instructor, and is now headed to the Optical Sciences Ph.D. program at U. Arizona.

In June, Prof. Majumder and Dr. **Ranjit** attended the APS Division of Atomic, Molecular, and Optical physics meeting in Anaheim, CA, presenting two well-received posters, which presented the work of both thesis students this year. Incoming thesis students David Kealhofer '13 and Nathan Schine '13 will have the task of collecting and analyzing substantial amounts of data from both the beam and cell experiments. The group expects to complete and publish the results of both measurements this year.

Over the past year, Visiting Assistant Professor **Michael Seifert** has continued his research into possible violations of Lorentz symmetry. Lorentz symmetry is thought to be a fundamental symmetry of nature, describing how space and time are related to each other; Seifert's research studies how a breaking of this symmetry could be mathematically modeled and experimentally detected. His current projects deal primarily with the consequences of Lorentz symmetry violation in the context of gravitational phenomena, and with a class of solutions called "topological defects" that can arise when symmetries of nature are broken. In the summer of 2012, Seifert will act as a summer research supervisor for Kamuela Lau '14 and Brandon Ling '15, who will be conducting research into the properties of topological defect solutions in the context of Lorentz symmetry violation.

During the 2011-12 academic year, Seifert taught Electromagnetic Theory (PHYS 411), an advanced tutorial class, and Electromagnetism and the Structure of Matter (PHYS 132), the second semester of a two-semester introductory sequence. Seifert also began to develop a new Winter Study course, Quantum Mechanics and the Nature of Reality, to be offered in January 2013

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. Joseph Iafrate '14 will work with Strait during the summer of 2012 extending this project.

Strait serves as pre-engineering advisor, department webmaster, and College Marshal, the faculty member responsible for coordinating the Convocation and Commencement ceremonies.

Assistant Professor **Frederick Strauch** was on leave during the 2011-2012 year. He continued his theoretical work in superconducting quantum circuits, quantum algorithms, and other applications to quantum information processing, in collaboration with Kurt Jacobs at the University of Massachusetts Boston and Ray Simmonds of the National Institute of Standards and Technology in Boulder, CO, supported by a continuing grant of \$233,186 from the National Science Foundation.

During the year Strauch consulted with MITRE corporation for the Intelligence Advanced Research Projects Activity (IARPA) program for Quantum Computer Science. This multi-year project poses several challenge problems to determine the resource requirements to run quantum algorithms on potential physical implementations. Strauch's involvement over the past year includes the preparation of specification

for a superconducting quantum computer, running a small technical workshop in December 2011 at the University of Southern California, and helping to organize and run a general workshop for the program in Minneapolis in May 2012.

Strauch also engaged in a number of trips to conferences, workshop, and research institutions. His first trip, in November 2011, was to Valencia, Spain to give an invited talk for the International Workshop on Theoretical Aspects of the Discrete Time Quantum Walk. Strauch returned to deliver two Sigma Xi lectures to the Williams community on his research in entanglement in superconducting circuits, an opportunity he enjoyed immensely. He subsequently traveled to the annual meeting of SQuInt (Southwest Quantum Information and Technology network) in Albuquerque, NM and visited NIST in Boulder, CO in February 2012, presenting a talk on his research in controlling superconducting resonators. He finished his travels by returning to Boston for a contributed talk to the March Meeting of the American Physical Society.

Strauch continues to publish in Physical Review Letters, Physical Review A (with Douglas Onyango '11), and hopes to finish several manuscripts before returning to the classroom in the Fall. During the summer of 2012, he will be working with Nathan Saffold '14, Roshan Sharma '13, and Qiao Zhang '13.

Associate Professor **David Tucker-Smith** continued his research in theoretical particle physics. With his students and colleagues, Tucker-Smith studies how models of new physics can be tested at the Large Hadron Collider (LHC) and other experiments. In the summer of 2011, Tucker-Smith worked with Dylan Gilbert '13 and Margot Robinson '12 on strategies for searching for a new gauge boson that couples preferentially to bottom quarks, and with Murat Kologlu '12 he investigated new physics explanations of the anomalously large top forward-backward asymmetry measured at the Tevatron. Murat and Margot continued their research during the academic year for their senior honors theses. Murat will begin Caltech's physics PhD program in the fall, while Margot will pursue an M.P.H at the University of Washington. In the coming year Dylan Gilbert '13 will continue on as a thesis student

under Tucker-Smith's supervision, along with Alice Sady '13, who will return from studying abroad in Geneva and doing research at CERN.

In the fall semester of 2011 Tucker-Smith taught Newton, Einstein, and Beyond (PHYS 107), a course intended for non-scientists, and in the spring semester he taught Mathematical Methods for Scientists (PHYS 210), and an introduction to Einstein's general relativity, Gravity (PHYS 418). In March Tucker-Smith participated in a workshop on Monte Carlo tools for new physics at the LHC, at Cornell University.

Professor **Bill Wootters** worked this year with thesis student Tori Borish '12 on the "ubit" model of quantum mechanics. Normally quantum mechanics is expressed in terms of complex numbers; the ubit model provides a way of re-expressing the theory using only real numbers. The resulting difference in perspective suggests certain slight modifications of standard quantum theory, some of which had been studied numerically by Antoniya Aleksandrova '11. Tori's main objective, on which she made excellent progress, was to understand these

effects analytically by means of perturbation theory.

In the summer of 2011, in addition to pursuing the ubit project Wootters worked with Roshan Sharma '13 on the problem of finding and characterizing "minimum uncertainty states" in the quantum mechanics of discrete systems, an investigation that was continued by Ilya Amburg '14 during the academic year. During the winter study period of 2012, Christina Knapp '13 began a project on quantum entanglement and composite bosons that she plans to continue for her senior thesis. That project extends a line of research initially explored a few years ago by Chris Chudzicki '10 and Jimi Oke '10.

Wootters gave talks on the ubit model at a few institutions, including the Institute of Mathematical Sciences in Chennai, India, which he visited during spring break. He also gave an invited talk at the American Physical Society's March meeting in Boston as part of a session on teaching quantum information science at liberal arts colleges

Class of 1960 Scholars in Physics

Victoria F. Borish
Joel T. Clemmer

Julian M. Hess
Murat Kologlu
Taryn R. Siegel

Margaret G. Robinson
Anders E. Schneider

Physics Department Colloquia

[Colloquia are held jointly with the Astronomy Department.]

Joshua Cooperman '05, University of California, Davis

"Causal Dynamical Triangulations: How to Simulate Quantum Gravity on Your Laptop "

Patty Liao '09, University of Michigan

"Physics-Engineering Continuum: Focus on Energy Applications"

Louisa Gilder, author of The Age of Entanglement

"The Early History of Entanglement: EPR Before 1935"

Daniel Reich, Johns Hopkins University

"Probing Sub-Cellular Force Dynamics and Soft Matter Using Magnetic Nanowires "

Eric Dufresne, Yale University

"Electrostatics Meets Entropy"

Zosia Krusberg, Vassar College

“The Phenomenology of Maverick Dark Matter”

Kourosh Zarringhalam, Boston College

“Recent Results on the Thermodynamics and Kinetics of RNA Secondary Structure ”

Leon Golub, Smithsonian Astrophysical Observatory

“A New View of the Solar Corona ”

Timothy McConnochie '98, NASA Goddard Space Flight Center

“Observing the Dynamics of the Mars Polar Vortex ”

Debra Rolison, Naval Research Lab

“Integrating the Multifunction Necessary for Electrochemical Power into Energy and Size-Scalable Ultraporous Nanoarchitectures ”

Anne Goodsell, Middlebury College

“Exciting Physics with Excited Atoms ”

Thomas Baumgarte, Bowdoin College

“Binary Black Hole Mergers ”

David Butts '06, Draper Laboratory

“Inertial Sensing with Cold Atoms ”

Off-Campus Colloquia

Daniel P. Aalberts

“RNAbows: an intuitive tool for RNA structure visualization”

poster presentation at the RNA Symposium, U Albany, 2011

(with Bill Jannen '09)

“Computing Effective Free Energy to Bind an Oligo to an mRNA

the Bindigo-MFT algorithm poster presentation at the RNA Symposium, U Albany, 2011

(with Julian Hess '13)

“Base Pairing Probability and Composition Asymmetry in RNA”

poster presentation at the RNA Symposium, U Albany, 2011

(with Joel Clemmer '12)

“Intuitive ways of visualizing RNA folds and landscapes”

Joint Physics and Biology Colloquium, Boston College

Tiku Majumder

“Precise Atomic Beam Measurement of the Stark Shift within the $5P_{1/2}$ to $6S_{1/2}$ Transition In Using FM

Spectroscopy ” poster presentation at the APS Division of Atomic, Molecular, and Optical Physics Meeting, Anaheim, CA, June 4 – June 9, 2012

(with Gambhir Ranjit, A. Schneider '12, and N. Schine '13)

“Measuring Hyperfine Structure and Isotope Shift in the Thallium $7S_{1/2}$ to $7P_{1/2}$ Transition Using Two-Color

Spectroscopy” poster presentation at the APS Division of Atomic, Molecular, and Optical Physics Meeting, Anaheim, CA, June 4 – June 9, 2012

(with Gambhir Ranjit, and T. Siegel '12)

“Heavy Metal, Cheap Lasers and Tests of Fundamental Physics ”

Bowdoin college, invited department colloquium

Michael Seifert

“Lorentz Symmetry and How to Break It ”
Hamilton College, invited department colloquium

Fred Strauch

“Quantum Walks in Discrete and Continuous Time ”
International Workshop on Theoretical Aspects of the Discrete Time Quantum Walk
Valencia, Spain

Fred Strauch

“Entanglement State Synthesis for Superconducting Resonator Qudits ”
Southwest Quantum Information and Technology Workshop
Albuquerque, NM

Bill Wootters

“Keeping It Real: Quantum Mechanics without Complex Numbers”
Department of Physics, University at Albany
“Theoretical Research Fostered by an Undergraduate Environment”
APS March Meeting, Boston
“Qualitative Distinctions between Standard Quantum Theory and Its Real-Vector-Space Analogue”
Institute of Mathematical Sciences, Chennai, India
“Quantum Mechanics as a Real Vector-Space Theory with a Universal Auxiliary Rebit”
Institute of Mathematical Sciences, Chennai, India
“The Ubit Model in Real-Vector-Space Quantum Theory”
Perimeter Institute, Waterloo, Ontario, Canada

POSTGRADUATE PLANS OF PHYSICS MAJORS

Victoria F. Borish	Research Assistant in Anton Zeilinger’s Group, University of Vienna, Austria
Joel T. Clemmer	MGH Global Health (1yr, South Sudan Clinical/Organizational – Blood Bank
Thomas Crawford	Math PhD at Boston College
Maia D. Dickinson	Publishing in NYC or museum research in Anchorage
Richard D. Fusco	Alternative Energy company outside of NYC
Marni L. Jacobs	Teaching in Dorchester, Med at Tufts
Stephanie A. Jensen	Professional consulting for various firms
Murat Kologlu	Caltech PhD (Theoretical Particle Physics)
Peter S. Mertz	E4Sciences (Geophysics consulting firm in CT)
Benjamin M. Oliva	unknown
Margaret G. Robinson	Institute for Health metrics and Evaluation (2yr postbac Seattle)
Michael S. Ryan	Booz-Allen Hamilton (tech consulting for DoD in DC)
Takuto Sato	Intersystems (Boston, software, hospital databases)
Anders E. Schneider	Teaching 11 th Grade Physics in Houston (Teach for America)
Liyang Zhang	Mathematical Physics PhD at Yale

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 level lab courses, and others are in work-study or research assistant positions or as more formal independent studies. Also, in 2011-2012 students, nine students completed year-long senior honors thesis research under the direction of Psychology faculty, on topics such as “Chin Up! The Impact of Self-Esteem on Conformity,” “Self-Affirmation and Sports,” “Infant Contributions to Biobehavioral Still-Face Responding: The Regulatory Function of Infant Gaze Behavior,” and “‘Standing’ Against Prejudice: How We View those who Respond to Bias.” Their projects are listed in the Student Abstracts section of this report.

Department events this year included student/faculty/family picnics, evening programs on “Graduate Study in Psychology” and “Careers in Psychology,” and a wine and cheese reception to celebrate honors theses presentations in the Psychology Lounge. Our student club, P.S.Y.K. (“Psychology Students Yearning for Knowledge”) had biweekly meetings to discuss recent journal articles.

The faculty of the Psychology Department continued their varied and productive teaching and research programs. We congratulate Amie Hane on her promotion to Associate Professor, and Nate Kornell on his reappointment. We were happy to welcome back our colleague Ari Solomon as a visitor, teaching Advanced Topics in Personality. Arriving this year was Kate Stroud, a clinical psychologist, coming to us from her postdoctoral training at Northwestern University. We bid a fond farewell to Carin Perilloux from the University of Texas at Austin, who taught evolutionary psychology and social psychology courses this year

as a much-appreciated visitor. Next fall we will welcome two visitors for a year, Alicia Hofelich from the University of Michigan, and Jeremy Cone from Cornell University. They will enhance our curricular offerings in cognitive and social psychology. Lastly, special congratulations to clinical psychologists Laurie Heatherington and Marlene Sandstrom, who organized and hosted a Mellon Foundation sponsored national conference here in May, entitled “Clinical Psychology in the Liberal Arts College: Surviving and Thriving in the Twenty-First Century.”

Through all of these activities, 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 theses students, and they help keep our large department feeling friendly and accessible. It is deeply appreciated by faculty as well.

Professor **Phebe Cramer** continues her research on the development of personality from childhood to old age, and has published two new research papers, focusing on the development of Narcissism in children, and on change in the use of Defense Mechanisms in adults, based on two different longitudinal studies. She is also conducting a follow-up study of the Williams Class of 1997.

In January, 2012, she participated in a Research Symposium at the annual meeting of the American Psychoanalytic Association, held in New York City. Her presentation was titled: “Experimental Studies of Defense Mechanisms”, and reported on several of her research studies. Professor Cramer has continued to serve as Associate Editor of the *Journal of Research in Personality*, and as Consulting Editor for the *Journal of Personality Assessment* and the *European Journal of Personality*. In addition, she has been an invited ad hoc reviewer for multiple professional journals. To enhance her research skills, she attended a week long statistical workshop sponsored by the American Psychological Association, on the topic of Mining Archival Data. This was held at the University of California, Davis, in the summer of 2011.

Assistant Professor **Jennifer Randall Crosby** attended the bi-annual conference of the Society for the Psychological Study of Social Issues, where she presented a talk entitled, “Causes and Consequences

of Targeted Social Referencing.” Crosby also gave an invited colloquium at Bard College. Crosby advised the honors thesis of Jordan Mickens ’12, investigating how people evaluate individuals who respond to prejudice. She continued her research on how both majority and minority group members respond to situations where discrimination may be present. This research was assisted by Sivahn Barsade ’13, Michael DeJoseph ’12, Nick Marks ’13, Seamus McKinsey ’12, Chris Mezias ’12, and Effua Sosoo ’13. Crosby also acted as an invited reviewer for *Group Processes and Intergroup Relations*, *Journal of Experimental Social Psychology*, *Psychological Science*, *Social Psychological and Personality Science*, and the Social Science and Humanities Research Council of Canada.

During this past year Senior Lecturer **Susan Engel** published an article on curiosity in the *Harvard Educational Review*, and an opinion piece on children and happiness in *The Nation*. In January she traveled to Singapore and gave a series of six lectures on education at the Singapore International School. She continued her work with the Spencer Foundation, developing new ways to measure what children learn in school. The Spencer Group formed for this purpose met four times during the academic year.

Professor Engel helped Hannah Hausman ’12 write a math textbook for middle school students. Hannah also conducted an experiment to find out whether elementary school children learn new math concepts more easily if they are exposed, over time, to stories that use a lot of mathematical language (number, measurement, and shapes). Under Professor Engel’s guidance, Abi Stark ’12 conducted a study to learn more about what it means to “get lost in a book”. College students read a short story by John Updike called “The Swimmer.” While reading the book, subjects experienced an unusual event. Later they remembered far more about what was in the story than they did about what actually happened to them while reading the story. In early June Professor Engel attended, along with Steve Swoap, a conference at Bryn Mawr, which focused on getting more liberal arts students interested in teaching math and science. Starting in April, Professor Engel began a blog for Psychology Today about children and education.

The Program in Teaching hosted a lively teaching lunch series, including a talk by Kristen Baldiga ’10 about her experience as a graduate student at Harvard School of Education, and her first year of science teaching in a public high school outside of Boston. The program also hosted a talk by renowned develop-

mental psychologist Angela Duckworth, about the role of self control in education.

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 Felecia Ferrell ’14, Julia Bender-Stern ’13, Sarah Rosemann ’13, Kaitlin Dinert ’13, Chelsey Barrios ’12, and Amber Cardoos ’12. Professor Hane worked together with honors thesis student Chelsey Barrios ’12 on research examining neonatal sensitivity to discomfort during routine home-based caregiving tasks. Professor Hane also worked with honors thesis student Amber Cardoos ’12 on her project examining the regulatory function of infant gaze behavior during experimental exposure to a mild, social stressor.

Professor Hane 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 mother-infant interaction and infant self regulation. She is a co-investigator in an ongoing study at New York Presbyterian Hospital 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 *Infancy*, *BMC Pediatrics*, *Social Development*, *Journal of Abnormal Child Psychology*, and in a special edition on Parenting at Risk: New Perspectives, New Approaches, for the *Journal of Family Psychology*. She presented her research at the biennial meeting of the International Society in Infant Studies and gave an invited talk to the Department of Psychology at Columbia University. Professor Hane is an Associate Editor of the *International Journal of Behavioral Development* and served as an ad-hoc reviewer for several other journals this year.

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), 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 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.

She served as President of the North American chapter of the Society for Psychotherapy Research (NASPR), and was Co-Chair of the Planning Committee for the October 2011 NASPR Conference in Banff, Alberta, Canada. At the conference, she presented a poster, "Measuring the milieu: Outcomes of a unique residential treatment for major mental illness." For the June 2011 Society for Psychotherapy Research Conference, in Bern, Switzerland, with colleagues, she co-organized/co-authored a structured discussion group, "'Cultures' of group psychotherapies: Implications for alliance conceptualization and measurement," and a paper, "How do therapists ally with adolescents in the context of family therapy?" for the panel on Adolescents in Family Therapy: The Challenge of Building Therapeutic Alliances. She also attended the biannual meeting of the Penn State Conference on the Process of Change in Psychotherapy in March 2012. In August 2011, she was a participant the NIH/NIDCR Consultation Meeting, "Tailoring and Targeting Behavioral and Social Interventions: Weaving a Strategy for Effective Efficient Intervention Research, in Bethesda, MD.

She published a chapter in L. Castonguay and C. Hill (Eds.), *Transformation in Psychotherapy: Corrective Experiences Across Cognitive Behavioral, Humanistic, and Psychodynamic Approaches*, published in 2012 by the American Psychological Association, and a multi-authored chapter in the same book, *Corrective experiences in psychotherapy: Definitions, processes, consequences, and research directions*.

Professor Heatherington continued to serve on the editorial boards of *Psychotherapy Research*, *Journal of Family Psychology*, *Journal of Marital and Family Therapy*, *Psychotherapy: Theory, Research, Practice, and Applications*, and *Journal of Counseling Psychology*. She was newly appointed to the editorial board of *Journal of Clinical Psychology: In Session*, and did ad-hoc reviewing for several other journals and publishers. She served on the Directors and 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 thirteen-year program evaluation & outcomes

study there. She served as an external reviewer of the Bryn Mawr and Haverford Psychology departments. With Williams colleague Marlene Sandstrom, she organized a Mellon Foundation-funded conference at Williams May 18-21, "Clinical Psychology in the Liberal Arts College: Surviving and Thriving in the 21st Century." This brought together 21 clinical psychology faculty members from liberal arts colleges across the country to share ideas and resources on teaching, research, advising, and career development.

Professor **Saul Kassin** was on sabbatical while serving as a Distinguished Professor at the John Jay College of Criminal Justice in New York. Focused on policy reform and matters concerning wrongful convictions, Kassin worked this past year with the American Psychological Association in writing an amicus brief on false confessions and has continued working on his three-year National Science Foundation grant to study "The Videotaping of Interrogations: Testing Proposed Effects on Police, Suspects, and Jurors." This past year, Kassin received a Lifetime Achievement Award from the International Investigative Interviewing Research Group (iiiRG) after a keynote address in Dundee, Scotland. He also contributed chapters to three scholarly books; presented talks at various institutions; and worked with the news media on stories concerning false confessions. In October 2011, he appeared on CBS 48 Hours "Amanda Knox: The Untold Story;" in April 2012 he appeared in a Cannes Film Festival documentary by Ken Burns entitled "The Central Park Five" (in the fall of 2012, Kassin will appear on CBS 60 Minutes). He has also 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, reviewer for the National Science Foundation, and consultant and expert witness in a number of criminal and civil cases.

Professor **Kris Kirby** collaborated with Daniel Gerlanc '07, in developing the software package Bootstrap Effect Sizes ('bootES') for the R statistical computing environment. Professor Kirby joined the editorial board of Judgment and Decision Making, and continued to serve on the board of the Journal of Behavioral Decision Making. He also served as an ad hoc reviewer for the journals Behavioural Processes, Cognition, Learning & Behavior, Journal of Experimental Psychology: Learning, Memory, & Cognition, Psychological Science, and Psychonomic Bulletin &

Review. Professor Kris Kirby chaired the Cognitive Science Program.

Assistant Professor **Nate Kornell** continues to research the interaction between learning, memory, education, and self-monitoring. His research was featured in the *New York Times*, *the Atlantic*, and *New Scientist*. He continues to blog for *Psychology Today*.

Professor **Marlene Sandstrom**'s research focuses on children's social relationships. She is particularly interested in victimization, bullying, bystander behavior, peer rejection, popularity, and social influence. This year, Professor Sandstrom and her thesis student (Aaron Lim, '12) examined the extent to which an experimental boost in self-esteem buffers against pressure to conform to group opinion. This project examined developmental trends in conformity to peer opinion, and included research participants of multiple ages including 4th graders, 7th graders, and college students. In the fall, Professor Sandstrom presented a research talk at Bennington College, titled Popularity in the Peer World: What is the Price of the Prize. In the spring, Professor Sandstrom chaired a symposium at the Biennial Meeting of the Society for Research in Adolescence in Vancouver, titled Risky Business: Popularity and Social Influence Processes in Adolescence. At this same meeting, Professor Sandstrom presented her own work, titled Standing Out and Fitting In: Popularity, Conformity & Risk in High School. Over the past year, Professor Sandstrom has served as an ad hoc reviewer for several journals.

Associate Professor **Noah Sandstrom**, along with former thesis students Jennah Durham '10, Marijke DeVos '11, Katherine Jordan '09, and Erika Williams '08, published work on the neuroprotective effects of estradiol with photomicrographs from the paper being selected to appear on the cover of *Brain Research* (and also the cover of this publication!). Additional work in the lab has focused on the effects of exercise on mood with Logan Todhunter '12 as well as the role of hormonal changes associated with puberty in modifying brain and behavior with Greg Johnson '12 and Kate Shaper '12. Sandstrom is the Chair of the Behavioral Neuroscience Fellowship study section at the National Institutes of Health and currently serves as President-Elect of the Faculty for Undergraduate Neuroscience society.

Professor **Kenneth Savitsky** continued his research on everyday social judgment. He published two articles in the *Journal of Experimental Social Psychology*, one based on the honors thesis research of Robert Adel-

man '09 and one, coauthored with Professor Steven Fein, based on the honors thesis research of Anna Merritt '08. He also co-authored two presentations at the annual meeting of the Society of Personality and Social Psychology, in San Diego, CA, one with honors thesis student Robert Adelman '09, and one, with Assistant Professor Jennifer Randall Crosby, based on the honors thesis research of Maddie King '11.

Assistant Professor **Catherine Stroud** has begun a new project examining biological, psychological, interpersonal and environmental factors that affect adolescents' response to stressful life events and ultimately confer increased risk for the development of major depression during adolescence. In addition, Professor Stroud and Elizabeth Greiter '12 completed a study investigating emotion regulation strategies in adolescents. Stroud also presented her work on the influence of parents' marital relationship on parent-child relationships at the Annual Meeting of the Association of Behavioral and Cognitive Therapies in Toronto, Ontario. Professor Stroud and her colleagues published this work in the *Journal of Family Psychology*. In addition, she contributed to two manuscripts examining interpersonal relationships in adolescent girls and co-authored a chapter on the assessment of couple and family functioning.

Professor **Safa Zaki** continued her research in her laboratory on how humans perform various categorization and memory tasks. One paper on the idea that aimed at demonstrating that categorization and recognition can stem from a single brain system rather than distinct brain systems is in press in the *Journal of Experimental Psychology: Learning, Memory, and Cognition*. She also submitted two other papers for publication. Some of this research was presented at the Annual Meeting of the Psychonomic Society with co-author Dave Kleinschmidt '09. She also gave an invited address at One Day University in New York City as part of an effort to share current scientific findings with the general public.

In addition to reviewing grant proposals for the National Science Foundation, Professor Zaki reviewed articles for a number of different journals including *Cognitive Science*, *Journal of Experimental Psychology: Learning, Memory, and Cognition*; *Journal of Experimental Psychology: General*; *Memory and Cognition*; *Psychonomic Bulletin and Review*, *Psychological Bulletin*, *Psychological Science*, and *Visual Cognition*.

Betty Zimmerberg continued her service as chair of the Psychology Department this year. In November, she attended the annual meeting of the Society for Neuroscience, where Shivon Robinson '11 presented her senior honors thesis research, entitled "Communal nesting has an epigenetic effect on cognition in an animal model of affective behavior." Zimmerberg also gave a presentation on "Landscapes of the Mind:

Teaching Neuroscience in an Art Museum" at this meeting. Students in the lab this year, studying the effects of prenatal antidepressant exposure, were Sierra Germeyan '13, Manasi Iyer '14, Daniela Zarate '15 and Lillian Audette '15. 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.

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. The 2011-12 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 Chuzy family, parents of Sarah Chuzy '07, and given at graduation to a student who has demonstrated exceptional achievement in psychology. We were happy to award the prize to Amber Cardoos '12 for her outstanding thesis and contributions to departmental functions.

Class of 1960 Scholars in Psychology

Chelsey Barrios
Amber Cardoos
David Carlin
Sierra Germeyan
Elizabeth Greiter

Yiqin Jiang
Aaron Lim
Stephen Maier
JenniferAnne Morrison

Noah Schoenholtz
Alexandria Sherman
Abigail Stark
Emmanuel Whyte

PSYCHOLOGY DEPARTMENT COLLOQUIA

David Sherman, University of California, Santa Barbara

“Self-Affirmation and Threats to the Self: Implications for Stress, Defensiveness, and Academic Performance”

Rick Doblin, founder of the Multidisciplinary Association for Psychedelic Studies (MAPS)

“The Medical Benefits of Psychedelic Drugs”

Angela Duckworth, University of Pennsylvania

“Self Discipline in Childhood”

John Stobierski, Attorney, Greenfield, MA

“The Clergy Sex Abuse Crisis: How Psychology, Religion and the Law Collided to Expose Hypocrisy, Corruption and Child Sex Abuse

Leah Doane, Arizona State University

“Day-to-Day Dynamics of Loneliness and Stress in Adolescence and Young Adulthood: Physiological Pathways”

OFF-CAMPUS COLLOQUIA

Phebe Cramer

“Experimental Studies of Defense Mechanism”

American Psychoanalytic Association annual meeting, New York, NY

Jennifer Randall Crosby

“Who Says It’s Discrimination? Causes and Consequences of Targeted Social Referencing

Psychology Department Colloquium, Bard College

Amie A. Hane

“Sustained Influence of Infant Temperamental Inhibition on Dyadic and Maternal Behavior Across the First Five Years”

Paper presented in the symposium chaired by R. Brooker and E. Kiel entitled “Infant Influences on Parent Emotion Behaviors, and Symptoms: How Infants May Contribute to Their Own Early Risk for Anxiety” at the biennial meeting of the International Society on Infant Studies, Minneapolis, Minnesota with W. Marquis and N. A. Fox

“Beyond Licking And Grooming: Maternal Regulation Of Infant Stress In The Caregiving Context”

Invited presentation for the Department of Psychology, Columbia University

“Nurture Intervention in the NICU: Neurobehavioral Outcomes in Preterm Infants”

Paper presented as a poster at the annual meeting of the International Society of Developmental Psychobiology, Washington, DC with M. G. Welch, M. A. Hofer, S. A. Brunelli, J. Austin, R. J. Stark, R.A. Polin, J. M. Lorenz, E. S. Fiedor, and M. M. Myers

Laurie Heatherington

“Measuring the Milieu: Outcomes of a Unique Residential Treatment for Major Mental Illness”

Poster presented at North American Society for Psychotherapy Research Conference, Banff, Alberta, Canada

“‘Cultures’ of Group Psychotherapies: Implications for Alliance Conceptualization and Measurement”

Society for Psychotherapy Research Conference, Bern, Switzerland

“How Do Therapists Ally with Adolescents in the Context of Family Therapy?”

Paper presented for the panel on Adolescents in Family Therapy: The Challenge of Building Therapeutic Alliances

Society for Psychotherapy Research Conference, Bern, Switzerland

Saul M. Kassir

Colloquia and Guest Lectures

Rochester Institute of Technology – Conference on Wrongful Convictions

Saint Anselm College – The New Hampshire Institute of Politics

New York State Bar Association
Columbia University Law School
The Graduate Center - City University of New York
State University of New York at Albany - School of Criminal Justice

“Why Confessions Trump Innocence: The Case of Amanda Knox”

Keynote address at an International Conference titled, Global Perspectives on Justice, Security and Human Rights, New York City

“Accuracy and Potential for Bias in Judgments of Handwriting Evidence”

Poster presented at the Meeting of the Association for Psychological Science, Chicago with J. Kukucka

“Do Confessions Promote Confirmation Bias in Juror Evaluations of Handwriting Evidence?”

Poster presented at the Meeting of the Association for Psychological Science, Chicago with J. Kukucka

“Do Confessions Taint Juror Perceptions of Handwriting Evidence?”

Paper presented at the Meeting of the American Psychology-Law Society, Puerto Rico with J. Kukucka

“Confession Errors as “Structural Defects”

Poster presented at the Meeting of the American Psychology-Law Society, Puerto Rico with J. Kukucka

“Police Practices and Beliefs: Survey of European Investigators”

Paper presented at the Meeting of the American Psychology-Law Society, Puerto Rico with J. Schell

“Medium of Presentation and the Assessment of Juvenile False Confessions”

Poster presented at the Meeting of the American Psychology-Law Society, Puerto Rico with C. Honts and R. Craig

“Bluffing about Evidence: Do Laypersons Get It?”

Poster presented at the Meeting of the American Psychology-Law Society, Puerto Rico with J. Perillo

“Video Recording of Interrogations: Does It Alter Police Behavior Toward Suspects?”

Poster presented at the Meeting of American Psychology-Law Society, Puerto Rico with J. Kukucka, V. Lawson, and J. DeCarlo

“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

Marlene Sandstrom

“Standing Out and Fitting In: Popularity, Conformity and Risk in High School”

Paper presented at the Biennial Meeting of the Society for Research in Adolescence, Vancouver. Paper Symposium: Risky Business: Popularity & Social Influence in Adolescence with A.H.N. Cillessen

“Factors Affecting Susceptibility to Peer Influence on Risky Behavior: The Role of Puberty, Situational Context, and Parenting”

Discussant at the Biennial Meeting of the Society for Research in Adolescence, Vancouver

Kenneth Savitsky

“The Feature-Positive Effect in Allocations of Responsibility for Collaborative Tasks

Society of Personality and Social Psychology, San Diego, CA with R.M. Adelman and J. Kruger

“Race in the Spotlight: Minority Status, Conversation Topic, and Perceptions of Others’ Attention

Society of Personality and Social Psychology, San Diego, CA with J.R. Crosby and M.J. King

Catherine B. Stroud

“The Relationship between Stress and Depression in First Onsets versus Recurrences”

Bard College, Department of Psychology

“Spillover to Triadic and Dyadic Systems in Families with Young Children”

Poster presented at the Annual Meeting of the Association of Behavioral and Cognitive Therapies, Toronto, Ontario with C. E. Durbin, S. Wilson, & K. Mendelsohn

Safa Zaki

“Response Location Effects in Categorization: Evidence for Multiple Systems or Task Complexity? The Role of Gaze Direction”

50th Annual Meeting of the Psychonomics Society, Minneapolis, MN with D. Kleinschmidt

Betty Zimmerberg

“Landscapes of the Mind: Teaching Neuroscience in an Art Museum”

Society for Neuroscience annual meeting, Washington, DC

“Communal Nesting Has an Epigenetic Effect on Cognition in an Animal Model of Affective Behavior”

Society for Neuroscience annual meeting, Washington, DC with S. Robinson

POSTGRADUATE PLANS OF PSYCHOLOGY MAJORS

Katelyn S. Aldrin	Working at a talent agency in Los Angeles
Kristin M. Alotta	Unknown
Chelsey S. Barrios	Doing research in the Child Development Lab at University of Maryland with Nathan Fox, Ph. D. and plans to get a Ph.D. in clinical psychology after this 2 year research job
Daniel M. Canina	Unknown
Amber M. Cardoos	Working as a Research Coordinator at the Depression Clinical and Research Program at MGH in Boston
David A. Carlin	Risk analysis at PNC bank
Laurel A. Carter	Unknown
Susan T. Chapman	Unknown
Evan R. Cohen	Unknown
Benjamin L. Contini	Unknown
Colin D. Curzi	Unknown
Chase E. Davenport	Teaching at a bilingual elementary school for Teach for America in San Francisco
Jessica N. de la Cuesta	Unknown
Steven P. Denza	Unknown
Brett K. Eisenhart	Unknown
Kaitlin H. Ellis	Unknown
Brian D. Emerson	Unknown
Kathryn H. Evans	Unknown
Colleen W. Fitzpatrick	Working for women’s health services or an organization that helps to advocate for reproductive rights
Katrina E. Flanagan	Doing research with two professors at Harvard Business School next year, and then attending Harvard Law the year after that
Taylor D. Fleishhacker	Unknown
TiaMoya L. Ford	Unknown
Barry A. Frett	Unknown
Katharine F. Gallagher	Paralegal at Lankler, Siffert, & Wohl in New York City
Shelby D. Golan	Unknown
Jill E. Greenberg	Working at a management consulting firm called Parthenon in Boston
Elizabeth A. Greiter	Working as a research coordinator at the Bipolar Clinic and Research program at Mass General Hospital in Boston

Meeka S. Halperin	Unknown
Raven H. Hills	Planning on going to graduate school in Clinical Psychology
Imran K. Khoja	Working on his own Williamstown born startup called Designed Good (www.designedgood.com) and joining the Stanford Graduate School of Business Class of 2016 MBA program
Thomas M. Kuczmariski	Fulbright Scholarship winner teaching English as an English Assistant in Taiwan
Brianne S. Kumar	Applying to medical schools for 2013
Anna A. Lee	Unknown
Pinsi Lei	Doing marketing in New York City
Aaron C. Lim	Working at the Center for Addictions, Personality, and Emotion Research in College Park, MD
Stephen P. Maier II	Unknown
Ryan C. Marrano	Unknown
Mario J. Mastromarino	Unknown
Lia B. McNerney	Unknown
Meisha M. McIntosh	Unknown
Emily A. McTague	Unknown
Christopher M. Mezias	Unknown
Jordan L. Mickens	Working in Boston at a management consultant firm called OC&C Strategy Consultants
Nikola V. Mirkovic	Unknown
JenniferAnne L.M. Morrison	Unknown
Helena E. Nannes	Unknown

Cam V. Nguyen	Pursuing an MPhil in Development Studies at Cambridge in the UK
Benjamin M. Oliva	Unknown
Eric D. Outterson	Unknown
Xiomara E. Pinto	Attending Medical School at Albany Medical College
Margaret E. Richmond	Unknown
Taisha Rodriguez	College counselor and Spanish teacher at BART Charter School
Ana M. Rodriguez-Villa	Applying to medical school while working at The Gunderson Residence at McLean Hospital
Conor P. Ryan	Unknown
Nargis S. Sakhibova	Unknown
Noah E. Schoenholtz	Unknown
Kendra D. Sims	Unknown
Abigail M. Stark	Working at Mass General Hospital in the pediatrics unit of the OCD and Anxiety Clinic
Nicole J. Stenquist	Working at Children's Hospital Boston for two years assisting the Fellows on the Medical Surgical Intensive Care Unit (MSICU), and hopes to go to medical school
Pamela M. Summers	Unknown
Brian I. Thomas	Unknown
Logan P. Todhunter	Unknown
Sydney L. Tooze	Unknown
Kristen A. Tubbs	Working in Management Development for McMaster Carr in Cleveland, OH
Ashley E. Turner	Unknown
Philip E. Vestergaard	Managerial Consultant in the Department of Software Development for Booz Allen Hamilton in Washington, DC
James T. Wang	Unknown

ABSTRACTS FROM STUDENT THESIS

Astronomy

Integral-Field Spectroscopy of NGC 2392: The Eskimo Nebula

Matthew W. Hosek

I analyze observations of NGC 2392, a nearby planetary nebula known as the Eskimo Nebula. Planetary Nebulae are the remnants of low to intermediate mass stars (like our sun) that have run out of fuel and ejected their outer gas layers into the environment.

Monitoring H α Emission-Line Stars in Open Clusters

Allen Davis, Williams College '14, Yaron Teich, Vassar College

Advisor: Steven Souza, Williams College

presented at the Keck Northeast Astronomy Consortium Student Research Symposium, September 2011, Wellesley College

We are continuing a multi-year project to monitor hydrogen (H α) emission line variations in early-type stars, particularly Be stars. We use on-band (656 nm) and off-band (645 nm) filters to collect photometric data on hundreds of stars at a time, rather than looking spectroscopically at individual stars. We also refined our data reduction and processing methods. We have seen a significant rise in H α emission by the known Be star VES 606 over several months.

Biology

The role of DopR neuronal circuits in regulating endogenous arousal in *D. melanogaster*

Sameer Aryal

Endogenous arousal can be defined as the internally generated periodic changes in behavior that underlie the circadian cycle of sleep and wakefulness. A balanced level of endogenous arousal is fundamental to many behaviors. Unstimulated locomotor activity reflecting sleep-wake transitions can be measured to quantify endogenous arousal. The neurotransmitter Dopamine has been implicated in mediating endogenous arousal in *D. melanogaster*. It has been suggested that Dopamine regulates sleep and wakefulness by acting on DopR, the fly ortholog of the human Dopamine D1 receptor. We investigated the role of DopR-expressing neuronal circuits in regulating endogenous arousal by expressing the nonspecific cation channel Transient receptor potential channel (TrpA1) in different subsets of DopR-expressing neurons. The sleep-wake changes resulting from raising the temperature to 31°C allowed us to characterize the functions of different DopR circuits in regulating sleep and wakefulness. Our results confirm that there exist multiple DopR-expressing neuronal circuits regulating endogenous arousal in *Drosophila*. Our results also suggest that the mushroom body has a central role in regulating sleep and wakefulness.

Characterization of the Nitrogen Utilization Strategies and Carbon Fixation Mechanism of *Prochlorococcus*

Ellen Beauchamp

The marine cyanobacterium *Prochlorococcus* survives in a wide variety of open ocean environments. Dominating the subtropical and tropical oceans between the surface waters and depths of 200 meters, concentrations of this microorganism can reach 105 cells per milliliter. To date, the genomes of twelve different strains of *Prochlorococcus* have been completely sequenced. Strains differ in their physiology and cellular structure, genome size and content, and abundance in the water column. Such structural, physiological, and genomic differences are likely to impact strategies for acclimation to environmental conditions and to shape the distribution and population dynamics of *Prochlorococcus* within the oceans. In this study, I specifically examined the nitrogen utilization strategies and carbon fixation mechanism of *Prochlorococcus* strains. The dynamics of these processes are of particular interest due to the significant role *Prochlorococcus* plays in global primary production.

When cultures of the MED4 and MIT9313 strains of *Prochlorococcus* were grown under low environmental nitrogen conditions, the two strains responded differently. I observed differences in growth rate, chlorophyll concentration per cell, and the maximum quantum efficiency of Photosystem II between the strains under the two conditions. This is consistent with the physiological, structural, and genomic differences between MED4 and MIT9313, and it supports our hypothesis that strains have evolved different nitrogen utilization strategies to deal with low nitrogen conditions.

Prochlorococcus contains a Carbon Concentrating Mechanism (CCM), which includes a microcompartment called the carboxysome. This microcompartment is surrounded by a protein shell and increases the efficiency of carbon fixation by concentrating carbon dioxide in a small area near the enzyme RuBisCO. Using bioinformatic tools, I characterized the proteins that constitute the carboxysome shell. The chromosomal organization and amino acid sequences of these proteins are highly conserved. Furthermore, calculations of the ratio of nonsynonymous to synonymous nucleotide changes indicated that the gene encoding the CsoS3 protein is under negative selection. However, there are numerous amino acid changes in CsoS3 that differentiate *Prochlorococcus* from other cyanobacteria and which separate several clades of *Prochlorococcus* from each other.

Further information about nitrogen utilization and carbon fixation in *Prochlorococcus* is likely to be determined via gene expression analyses of genes under different environmental conditions in different strains. I began this work by optimizing an RNA isolation and qRT-PCR protocol which will be used in future experiments in our laboratory.

Host Plant Defenses and Their Modulation by the *Agrobacterium tumefaciens* T6SS are under Light and/or Circadian Control

Lauren Goldstein-Kral

Agrobacterium tumefaciens is a gram-negative soil bacterium that induces Crown Gall Disease in a broad range of primarily dicotyledonous hosts. Crown Gall Disease is caused by the transfer of T-DNA from a bacterial tumor-inducing (Ti) plasmid into the host plant through the Type IV Secretion System (T4SS). The T-DNA is stably incorporated into the host genome and results in tumor growth and the production of opines that serve as a food source for the bacterium. Gram-negative bacteria, such as *Agrobacterium tumefaciens*, can form other types of secretion systems in addition to the T4SS. One of these is the Type VI Secretion System (T6SS). A strain of *A. tumefaciens* (#20) was created in which the entire T6SS was deleted. In comparing *Arabidopsis thaliana* plants infected with wildtype (#58) or mutant (#20) *A. tumefaciens*, the mutant bacteria are less successful at promoting tumorigenesis. We hypothesized that *A. tumefaciens* secretes an effector through the Type VI Secretion System (T6SS) that suppresses host defense responses. The overarching goal of this thesis is to test this hypothesis.

Recent findings have suggested a circadian component to plant defenses, but there is limited research in this field. This thesis examines whether the effect of the bacterial T6SS on *Arabidopsis* plants is influenced by the plant circadian clock. Plant defense regulators, plant defense genes, and bacterial virulence genes were analyzed with respect to time of inoculation. Our results showed no time-of-day dependence for the induction of known regulators of plant defenses by wildtype or #20 mutant *A. tumefaciens*, but induction of *At2g17740*, a downstream plant defense gene, did show fluctuations based on the time of inoculation. Further, expression of *At2g17740* was different between plants infected with wildtype or #20 mutant bacteria and those differences were dependent on the time of day. Bacterial virulence genes showed fluctuations based on the time of day in a pattern similar to the pattern of plant defense gene induction. These bacterial genes did not show light-sensitivity, so their fluctuations can be attributed to an effect of the plant on the bacteria and not to an effect of light on the bacteria. The fluctuations in both plant defenses and bacterial genes were disrupted by exposure to constant light. This disruption supports the idea that plant defenses and associated bacterial virulence are under light and/or circadian control.

Photosynthetic Responses of *Prochlorococcus* to Environmental Stresses

Adena Hernandez

The marine cyanobacterium, *Prochlorococcus*, can be found thriving in a diverse range of environmental conditions in terms of nutrients, temperature and light levels. In this study, the effects of high light intensity were characterized in *Prochlorococcus* strains MED4 and MIT9313. We hypothesized that different strains of *Prochlorococcus* have evolved different molecular responses to light stress. By examining chlorophyll production and cell division after

48 hours of exposure to light stress we found that while MIT9313 was profoundly affected by the high irradiances, MED4 was not. A two-hour light stress experiment was also performed, and the effects of this short term light stress on chlorophyll production, cell division, and the quantum efficiency of Photosystem II were characterized. After a two hour light stress, both MIT9313 and MED4 exhibit a decrease in the quantum efficiency of Photosystem II, though the decrease was greater for MIT9313. From these results, it is apparent that MED4 and MIT9313 have evolved different mechanisms for acclimating to high light intensities. In particular, MED4 appears to have the ability to rapidly repair any damage resulting from exposure to high irradiance levels. Decreases in the quantum efficiency of Photosystem II in MED4 following exposure to short term light stress are not a result of irreversible damage to the photosynthetic apparatus, and MED4 cells are able to continue dividing and to retain their chlorophyll even following 48 hours of exposure to light stress. Examining the different responses of *Prochlorococcus* strains to environmental stresses is important for understanding the population dynamics and distribution of this genus in the world oceans.

Development of Twelve Polymorphic Loci in *Primula mistassinica*

Hannah Matheny

Molecular markers, like microsatellites, allow biologists to explore the genetic characteristics of a population. Microsatellites are highly variable DNA regions that enable fine-scale analyses of population genetics, such as calculations of genetic diversity and genetic distance. Using microsatellite markers, we hope to investigate the historical movements of *Primula mistassinica*, a distylous, self-incompatible diploid plant native to Alaska and the boreal forests of Canada. We designed twelve primer pairs that amplify polymorphic microsatellite loci in this species. These loci can be used to explore the relationships between a population of *P. mistassinica* on Isle Royale, MI, and more northern (Arctic) populations. Arctic plant populations shifted their range after the last ice age, but disjunct populations of some Arctic species exist far south of their typical range. They could be the relic of the northward migration of the plants or the result of a more recent colonization event. Studying historical plant movements can offer valuable insight as to the survival prospects of current plant populations, which face the pressures of global, anthropogenic climate change.

Arabidopsis thaliana* seedling pattern recognition defense activation by bacterial Type VI secretion during infection by *Agrobacterium tumefaciens

Greg McElroy

Arabidopsis thaliana, like all plants, lacks circulating immune cells and thus requires a range of defensive responses against pathogenic bacterial threats. Ultimately, for these defenses to function, the plant must first recognize the presence of an invading bacterium. *Agrobacterium tumefaciens* is a soil dwelling gram-negative plant pathogen that causes crown gall disease. It is primarily recognized by the EFR receptor in *Arabidopsis*, initiating plant defense. Data in this thesis suggest that the presence of a functional Type VI secretion system (T6SS) in *Agrobacterium* dampens plant defenses, but that in the absence of a functional EFR receptor, this T6SS may trigger alternate plant defenses. This finding may lead to the identification of a novel Pattern Recognition Receptor (PRR) in *Arabidopsis* that recognizes some aspect of the bacterial T6SS. Growth inhibition, anthocyanin production, and expression of defense gene transcription factors were used as metrics for plant defense activation in seedlings. The method of infection, degree of light-stress, and the timing of infection relative to circadian rhythms have different effects on the *Arabidopsis* defense response.

Small Heat Shock Proteins and Kupffer's Vesicle Cilia: An Early Role for hspb7 in *D. rerio* Left-Right asymmetry

Paloma Marin

Small heat shock proteins are low-molecular weight chaperones intended to protect cells from stresses such as heat or oxidative stress. hspb7 has been implicated in the establishment of left-right asymmetry in zebrafish. This thesis takes a closer look at the earliest asymmetric event in the zebrafish embryo: nodal flow at the level of Kupffer's vesicle. Kupffer's vesicle is the zebrafish equivalent of the mammalian ventral node, responsible for triggering

asymmetric gene expression via its monocilia. Strong knockdown of hspb7 leads to defects in morphology of KV as well as ciliary defects, pointing to a possible role of hspb7 early in the LR-asymmetry pathway.

Characterization of Microsatellite Markers in Arctic Disjunct Populations of *Sagina nodosa* (Caryophyllaceae), Isle Royale, Michigan

Tarjinder Singh

We investigated the population history and structure of *Sagina nodosa* populations in Isle Royale National Park by developing and characterizing eight novel microsatellite markers using next-generation sequencing technology. This is the first study to develop microsatellite markers of a plant in the *Sagina* genus. We characterized the 8 polymorphic markers on 29 individuals belonging to 7 island subpopulations in the northeastern tip of Isle Royale, and performed preliminary analyses to quantify the genetic variation, and population structure of *Sagina nodosa*. From our preliminary analysis of the genotyped population, we found that every locus significantly deviated from Hardy-Weinberg Equilibrium (HWE) with a p-value of less than 0.001 when treating the entire Isle Royale region as single population. If each island is treated as a unique subpopulation, no locus significantly deviated from HWE following Bonferroni correction. The pairwise F_{ST} values between islands range from 0.0486 to 0.3668, while 13 out of the 18 pairwise comparisons all had values that exceed an F_{ST} of 0.15. The multilocus estimate of F_{ST} was found to be 0.2073. Our preliminary population-level analysis of *S. nodosa* in Isle Royale suggests an underlying population substructure exists that limits gene flow across island populations. With these novel markers, we hope to genotype the remainder of the 103 samples from Isle Royale and additional individuals in the surrounding Lake Superior region and analyze the results using a landscape genetics framework. The optimized methods outlined in this thesis can serve as the basis for low cost, rapid development of microsatellite markers for small disjunct plant populations.

TRPM8 is necessary for cool sensation but is not required for torpor

Rachel Zipursky

The integration of ambient temperature sensation with internal thermoregulation is crucial to the livelihood of mammals. TRPM8, a thermo-TRP channel on peripheral neurons, is involved in sensing cool temperatures (18-26°C) and eliciting thermoregulatory responses. The current study hypothesized that TRPM8 (-/-) mice would engage in thermoregulation in response to environmental cool on a different time scale than control mice: experiencing a decrease in body temperature before engaging in a thermoregulatory response. In addition, because wild type mice enter torpor at ambient temperatures within the TRPM8 activity range, the hypothesis predicted that TRPM8 (-/-) animals would not enter torpor at temperatures within the TRPM8 activity range. TRPM8 (-/-) and (+/-) mice were exposed to warm and cool temperatures over 24 hour periods, during which metabolism was measured using indirect calorimetry, and body temperature and heart rate using EKG telemetry. TRPM8 (-/-) mice experienced a larger drop in body temperature (-1.8 ± 0.1 °C) than TRPM8 (+/-) mice (-1.0 ± 0.4 °C) ($p < 0.05$) during ambient cooling from 30°C to 20°C, and also experienced a larger increase in body temperature (2.3 ± 0.1 °C) than control animals (1.3 ± 0.1 °C) as ambient temperature changed from 20°C to 30°C. TRPM8 (+/-) and (-/-) animals and wild type animals were fasted at a series of ambient temperatures while their metabolism, heart rate, body temperature, and activity level were measured. All animals, regardless of genotype, entered torpor at ambient temperatures below 26-27°C. This demonstrated no difference in torpor behavior between control and TRPM8 (-/-) mice. Lastly, mice that were either fed ad libitum, 60% calorically restricted, or fasted, were given the choice between a 20°C ambient area and a 30°C ambient area over the course of the 12 hour dark phase. TRPM8 (-/-) mice spent more time (0.40 ± 0.03) in the cool area than TRPM8 (+/-) mice (0.26 ± 0.03) when fed, but when calorically restricted or fasted, there was no significant difference between the groups. These data show that when calorically restricted, a significant phenotype of TRPM8 (-/-) is abated. Together, these data suggest that while TRPM8 is necessary for normal cold sensation, it is not required for normal torpor bouts, and that during a fast, cool sensation is upregulated in both TRPM8 (+/-) and (-/-) mice.

CHEMISTRY

Dynamic Behavior in Artificial Genetic Networks: The Minimal 2-Gene Oscillator

Michael Alcala

We have designed and constructed the Minimal 2-Gene Oscillator, a two-gene transcriptional activator-repressor artificial genetic network based on the design of a previous artificial genetic network—the Repressilator (Elowitz, 2000)—that shows oscillatory behavior. We constructed a simpler model by using both a transcriptional repressor gene (tetR-lite) and a transcriptional activator gene (melR-lite), instead of three transcriptional repressor genes, and attempt to show that oscillatory behavior occurs when the half-lives of the gene products are of about the same magnitude as their mRNAs. Time-lapse fluorescence microscopy experiments monitoring the expression of a GFP variant over time suggests that the network displays oscillatory behavior under certain conditions.

Characterizing the Interactions of LexA and RecA in *B. subtilis* and *E. coli* Using Cross-Linking Experiments

Clarissa Andre

The bacterial SOS system is an inducible DNA repair system whose activation can lead to antibiotic resistance. Although many of the details of SOS regulation have been characterized, the interactions between the two regulatory proteins RecA and LexA remain unknown. Determining the binding site of RecA on LexA could shed light on the mechanism of these unique protein interactions. Previously, 14 surface amino acids on LexA that are critical for RecA binding have been identified and replaced by cysteine in preparation for crosslinking studies (Bergethon, 2009). The goal of this thesis is to investigate the binding site of RecA on LexA by using the heterobifunctional crosslinker 2-[N2-[N6-(4-Azido-2,3,5,6tetrafluorobenzoyl-6-aminocaproyl)-N6-(6-biotinamidocaproyl)-L-lysinylamido]] ethylmethane-thio-sulfonate (Mts-Atf-LC-Biotin) to covalently attach the *B. subtilis* LexA mutants to the *E. coli* RecA protein. We attached the Mts-Atf-LC-Biotin crosslinker to the purified LexA mutants, and added each Mts-Atf-LC-Biotin modified LexA mutant to RecA under UV light. Distinct bands corresponding to the combined molecular weights of LexA and RecA were observed by SDS-PAGE analysis, were excised from the gel, and are ready to be analyzed by mass spectrometry. Furthermore, we prepared cysteine mutants of *E. coli* LexA for future crosslinking experiments using proteins from the same organism.

Manipulation of the Electronic and Optical Properties of Phenylenevinylene-Based Oligomers Through Variation in Endcapping Groups

Grace Babula

As global energy consumption continues to grow, research in renewable energy sources becomes increasingly important. The Park Lab is interested in improving the efficiency of bulk heterojunction organic solar cells by inducing self-assembly within the active layer. We worked on developing a synthetic route to phenylenevinylene-based oligomers to serve as potential donor and acceptor materials and explored the effects of extending conjugation, altering the terminal groups, and introducing anthracene components on the electronic and optical properties of the oligomers. A dimeric and trimeric species, along with several other variations, were successfully synthesized and we determined that the identity of the terminal groups has significant effects on the properties of our oligomers.

Investigating LexA-RecA Binding Through Crosslinking Studies

Roop Dutta

The bacterial SOS response is activated by the RecA-mediated autocleavage of the LexA repressor and leads to the subsequent induction of a set of DNA repair and cellular survival genes. This response, characterized by increased DNA repair and mutagenesis, has been hypothesized to be a cause of antibiotic resistance in bacteria. If this is the case, drugs could be developed to inhibit the LexA-RecA interaction to combat antibiotic resistance. However, the specific amino acid interactions between RecA and LexA are not known. The research described here is aimed at identifying these interactions using crosslinking analysis. Previous studies in the Lovett lab have shown that there

are 14 surface amino acids conserved between *B. subtilis* LexA and *E. coli* LexA that may be critical to LexA-RecA interaction in their respective species. Bergethon (2009) produced 14 *B. subtilis* LexA mutants in which each of these surface amino acids was mutated to a cysteine. Bruton (2011) attached an Mts-Atf-LC-biotin crosslinker to these unique cysteines, but was unable to crosslink the LexA adduct to *E. coli* RecA presumably because LexA was cleaved before crosslinking could occur. We added a second mutation, S127A, to each of the 14 LexA mutants in order to inhibit LexA cleavage activity and we show that Mts-Atf-LC-biotin was successfully attached to 10 of these LexA double mutants. We also provide evidence that the Mts-Atf-biotin-LexA I101C/S127A adduct was crosslinked to *E. coli* RecA.

Partially Fluorinated Sidechains in Influencing Poly(p-phenylenevinylene) Behavior and Promoting Self-Assembly

Daniel Gross

Development of efficient and robust organic photovoltaic devices would confer several important advances in the way solar energy is harvested. With the ultimate goal of improving organic solar cell efficiency, we are attempting to influence morphology of the light-absorbing “active layer” of these devices. We wish to promote formation of nanoscale features conducive to enhanced photoconversion. Using polyphenylenevinylenes (PPVs) as a model system, and taking advantage of hydrocarbon-fluorocarbon interactions to promote phase segregation, we hope to develop a general strategy for controlling thin-film morphology that can be extended to other active layer materials.

We have prepared a library of PPVs incorporating partially-fluorinated sidechains, made to possess different linear architectures, and these materials have been characterized using range of techniques, for comparison to MDMO-PPV. In particular, we report here on the absorption behavior and the fluorescence quenching behavior of our polymers. Polymer degradation is also discussed.

Developing a High-Throughput Fluorometric Assay to Screen for SOS System Inhibitors

Andrew Kung

The bacterial SOS system is a DNA repair mechanism whose activation has been strongly linked to the development of antibiotic resistance, a growing problem in the medical field. Here, we develop a high-throughput assay to screen for inhibitors of the SOS system, exploiting the fluorescence properties of the LexA protein, whose autocleavage in vivo activates the DNA repair mechanism. The assay was successfully used to find two potential SOS system inhibitors from a library of bioactive compounds: N2-[3,5-di(trifluoromethyl)phenyl]-5-chlorothiophene-2-sulfonamide and ethyl 5-{2-[2-(4-chlorophenyl)-1-cyano-2-oxoethylidene] hydrazino}-3-methylisothiazole-4-carboxylate. Both compounds exhibit inhibition in fluorescence-based assay as well as SDS-PAGE gel electrophoresis. Further testing of these two compounds as well as screening more compounds with the assay may lead to better understanding of SOS system regulation, with tremendous potential in pharmaceutical applications.

An Examination of Undecylprodigiosin Production in *Streptomyces coelicolor* A3(2)

Erin A. McGonagle

The *Streptomyces* are a genus of gram positive, soil dwelling actinobacteria with a multicellular lifecycle that are prolific producers of secondary metabolites including antibiotics. *Streptomyces coelicolor* has been used as a model organism for understanding the molecular pathways that lead to both physiological and morphological development in the genus at large. *S. coelicolor* produces 5 antibiotics, one of which, undecylprodigiosin, is of particular interest as it has been shown to induce apoptosis in human breast carcinoma cells. The potential pharmaceutical implications of undecylprodigiosin give incentive to understanding and maximizing its biosynthesis in *S. coelicolor*. Previous studies found that a SCO6673 mutant, which bears a disruption in a phosphopantetheinyl transferase (PPTase)-encoding gene, exhibits a 5-fold increase in undecylprodigiosin production relative to the wild type concomitant with a complete elimination of calcium-dependent antibiotic (CDA) production.

The intent of this current study was to further maximize undecylprodigiosin production in the SCO6673 mutant

hyperproducer. The strategy was twofold: maximization via genomic manipulation and maximization via manipulation of the environment. With regard to genomic manipulation, the gene encoding an antibiotic down-regulator *wblA* was disrupted in both the SCO6673 mutant and wild type (M145) strain backgrounds. While the data quantifying undecylprodigiosin production in the *wblA* mutants remains preliminary, it suggested that there was no effect of a *wblA* disruption on antibiotic production in *S. coelicolor*. In terms of manipulating the environment, wild type and SCO6673 mutant strains were elicited with dead *Bacillus subtilis* cells. The introduction of *B. subtilis* to *S. coelicolor* liquid cultures was found to instigate a statistically significant 5 to 6-fold increase in undecylprodigiosin in both strain backgrounds, the largest increase in undecylprodigiosin production recorded in the SCO6673 mutant to date.

The second intent of this study was to elucidate the molecular mechanism behind the increase in undecylprodigiosin production in the SCO6673 mutant. One approach to this goal involved the comparison of undecylprodigiosin production in a CDA biosynthetic gene mutant and the SCO6673 mutant in order to determine the extent to which CDA elimination influences undecylprodigiosin production. The data indicated that the hyperproduction of undecylprodigiosin in the SCO6673 mutant is not solely due to an influx of metabolic precursors from the disrupted CDA pathway to the undecylprodigiosin pathway. It is therefore likely that the SCO6673 PPTase somehow indirectly affects the regulation of the undecylprodigiosin pathway.

Synthesis of Amphiphilic Glycopolymers for Micellization and Recognition

Michelle M. McRae

The development of self-assembling glycopolymers has the potential to profoundly affect modern medicine due to their ability to serve as inert drug carriers that safely shepherd drugs to malignant cells. This delivery can be targeted by taking advantage of the enhanced permeability and retention (EPR) effect and by functionalizing polymers with sugar moieties to target cell lines that over express particular receptors. With this in mind, amphiphilic diblock copolymers poly(2-(b-D-glucosyloxy)ethyl methacrylate)-co-poly(tert-butyl acrylate) and poly(2-(a-D-mannosyloxy)ethyl methacrylate)-co-poly(tert-butyl acrylate) were synthesized using reversible addition-fragmentation chain transfer (RAFT) polymerization.

The mannose containing glycopolymer, poly(2-(a-D-mannosyloxy)ethyl methacrylate)-co-poly(tert-butyl acrylate), demonstrated self-assembling properties, exhibiting a low critical micelle concentration ranging from 0.00928 mg/mL to 0.00743 mg/mL for pH 3.9 and pH 8.0, respectively. Dynamic light scattering (DLS) confirmed the presence of micelles with an average diameter of 32 nm. Both copolymers were shown to interact with concanavalin A (ConA), an indication that the sugar functionality of these glycopolymers could successfully bind to receptors. Due to this self-assembling nature and receptor recognition abilities, polymers such as these have a promising future in the field of drug delivery.

Potential Role of SCO6672 in Regulation of Antibiotic Production in *Streptomyces coelicolor*

Kenneth Tyler Murgo

Streptomyces coelicolor is the model organism for the genus *Streptomyces*, a group of gram positive, filamentous, soil-dwelling bacteria. *Streptomyces* are known for prolific production of bioactive secondary metabolites, including over two-thirds of the pharmaceutically important antibiotics. These antibiotics are often synthesized by non-ribosomal peptide synthetases (NRPS) and polyketide synthases (PKS). Phosphopantetheinyl transferases (PPTases) are essential to antibiotic production in *Streptomyces* because they post-translationally activate carrier protein domains by catalyzing the attachment of a 4'-phosphopantetheine group (Ppant). This modification occurs on the carrier proteins/domains of the biosynthetic enzymes, thus converting the apo-carrier protein to its activated holo-form. The SCO6673 PPTase is one of three in *Streptomyces coelicolor*, and it has been shown to be required for calcium-dependent antibiotic (CDA) biosynthesis.

Immediately upstream and overlapping the SCO6673 PPTase gene is SCO6672; the corresponding SCO6672 protein has a likely metallophosphoesterase domain and is homologous to calcineurin. It was predicted that SCO6672 is a phosphodiesterase that reverses the post-translational modification performed by SCO6673 on the CDA synthetase by hydrolyzing the bond between the Ppant cofactor and the peptidyl carrier protein (PCP) domains and thereby inactivating the CDA synthetase. To test this model, pure CDA holo-PCP2 was incubated with pure SCO6672.

As assessed by MALDI-TOF mass spectrometry, the holo-PCP2 was completely converted to the apo-form in the presence of SCO6672. This confirmed that in vitro SCO6672 catalyzes the inactivation of CDA synthetase (reversing the activation by the SCO6673 PPTase) by catalyzing the hydrolysis of the Ppant cofactor.

To test the in vivo effect of SCO6672 on the production of antibiotics including CDA, a number of SCO6672 knockout, complementation and overexpression strains were created. It was expected that overexpression of SCO6672 would result in the inhibition of CDA production because SCO6672 inactivates CDA synthetase, and this was observed. However, contrary to our expectations, the absence of SCO6672 did not increase CDA production. The production of the antibiotic undecylprodigiosin (RED), a potential anti-cancer drug, was also assayed. The absence of SCO6672 did not change the production of RED, but its overexpression resulted in a significant decrease in RED production. This indicates that SCO6672 has a physiological role that is more complex than just inactivating the CDA synthetase.

Efforts Toward the Total Synthesis of Enigmazole A: Model Studies of C3 Hydroxyl Deoxygenation

Rachel Patel

Enigmazole A is a complex phosphorylated 18-membered macrolide natural product derived from the marine sponge *Cinachyrella enigmatica*. The molecule has demonstrated potent tumor-suppressing qualities, although its biological mechanism of action remains unclear. Enigmazole A has become a target of synthetic exploration for its biological activity as well as its novel architecture. We envision installing asymmetry in the C1–C4 dipropionate unit using the powerful Evans β -ketoimide method. The elegance of this synthetic plan lies in its capability to rapidly and selectively install three of the eight stereogenic centers within the entire molecule. However, the β -ketoimide aldol reaction necessitates a superfluous carbonyl or hydroxyl group at the C3 position. Herein we present research efforts to construct a model system with a sterically crowded C3 hydroxyl that resembles the actual system, and subsequent tests of the radical Barton-McCombie deoxygenation and its variations as a method to reduce the C3 hydroxyl.

Methods for the Synthesis of a Family of Deuterofluorocarbons

Emma Pelegri-O'Day

Deuterofluorocarbons are volatile compounds that have utility in spectroscopic studies, both for their high boiling point and manageable computational size. However, many are not commercially available. Previous efforts developed [1] and improved upon [2] a method for synthesizing deuterofluorocarbons from their iodofluorocarbon precursors in high isotopic purity and yield and with relatively low cost. This work reports further optimization of the synthetic method using the previously synthesized deuterofluorocarbon 1,1,1,2,2,3,3,4,4-nonafluoro-4-deuterobutane (1D-nfb). The resulting synthetic conditions are then applied to the synthesis of additional deuterofluorocarbon products, namely 1,1,1,2,2,3,3,4,4-nonafluoro-5,5,6,6-tetrahydro-6-deuterohexane (1D-4H-nfh), 1,1,1,2,2,3,3,4,4,5,5-undecafluoro-5-deuteropentane (1D-pfp) and 1,2,3,4,5-pentafluoro-6-deuterobenzene (1D-pfb). The synthesis of the volatile 1,1,1,2,2,3,3-heptafluoro-3-deuteropropane (1D-hfp) is also attempted but remains incompletely optimized due to challenges associated with its low reactivity and high boiling point. Synthetic trials are analyzed by ^{19}F , ^{13}C and ^1H -NMR as well as GC/MS and FTIR spectroscopies to quantitatively assess isotopic purity and conversion. The optimized reaction conditions demonstrate selective conversion to the desired deuterofluorocarbon across a range of iodide substrates and can be applied to related substrates with similarly successful results.

Secreted Proteins and Development in *Streptomyces coelicolor*

Hetal Ray

Streptomyces are a genus of soil-dwelling, gram-positive bacteria important for their unique developmental complexity and secondary metabolism. Their intricate morphological development is believed to be influenced by extracellular proteins. Through the study of an *rsuA* mutant of *S. coelicolor* that fails to produce an aerial mycelium (NY415), several σU regulon members were implicated in multiple stages of the organism's development. Significantly, extracellular protease activity seems to be intimately tied to proper development. Disruption of *salO*, which encodes a putative protease, induced premature spore germination. Disruption of SCO0732, another putative protease-encoding gene, had a developmental effect on *S. coelicolor* by not only reducing sporulation but also affecting

the viability of its hyphae. Moreover, overexpression of SCO0732 also reduced sporulation; it is thus clear that an optimal expression level of SCO0732 is necessary for proper development of *S. coelicolor*. In addition to protease-encoding σ U regulon members, SCO0930, SCO2217, and SCO6650 were implicated in development in this study. Disruption of SCO0930 in the wild type background reduced sporulation while disruption of SCO2217 blocked aerial mycelium formation and led to weaker growth. Also, a SCO6650-rsuA double mutant showed weaker growth and a severely extended delay in actinorhodin secretion as compared to the rsuA single mutant. Lastly, application of concentrated wild type cell-free culture supernatant to rsuA mutant colonies restored their development. STI, an extracellular protease inhibitor, was purified from this concentrate but it did not cause complementation or have an inhibitory effect on the activity of NY415 proteases, including SCO0732 and SalO.

Copper(I) Complexes of Tridentate Pyridine-Imine Ligands and Their Derivatives and Their Use in Atom Transfer Radical Polymerizations

Zachary Remillard

Atom transfer radical polymerization (ATRP) allows control over the molecular weight, composition, and architectures of polymers. The precise functionalization of the polymers through ATRP allows for the creation of polymers that can perform specific functions in a variety of applications. This control is attained through a dynamic equilibrium which keeps the concentration of free radicals low, preventing termination events. Modifications to the catalyst design alter the position of this equilibrium and therefore the efficiency of ATRP. This study explores how modifications to tridentate heteroaromatic-imine and amine ligands complexed with the copper(I) bromide metal precursor affect the efficiency of the ATRP of styrene. We explore characterizations of our complexes including single crystal XRD, NMR, IR, ESI-MS, and cyclic voltammetry. The XRD data show that the copper(I) centers prefer pseudotetrahedral geometries in the solid state. The NMR and IR data show that changes in bonding of ligand occur upon ligation to the metal center. The polymerization data of styrene mediated by these catalysts is presented and discussed with respect to the structural and electrochemical data. We present several complexes which mediate styrene in an ATRP fashion and other complexes which seem to mediate the polymerization of styrene through other processes. Complex C10 bearing a pyridine-amine-amine ligand catalyzes the polymerization of styrene the most efficiently out of the complexes presented, with low PDI values (1.08 – 1.13) and molecular weight data close to the theoretical molecular weights and high polymerization rates. We also present preliminary polymerization data for a complex with a tetradentate pyridine-amine-pyridine-amine ligand C40 which shows promise as an ATRP catalyst and warrants further study.

The Role of *whiJ* Genes in the Sporulation Pathway of *Streptomyces coelicolor* A3(2)

Jennifer J. Rodriguez

Sporulation in *Streptomyces coelicolor* A3(2) involves synchronous septation of filamentous aerial hyphae to produce single-celled unigenomic spores. Studies of the *S. coelicolor* life cycle have revealed that sporulation requires *whi* genes whose encoded proteins are believed to interact in an orchestrated manner in a regulatory cascade involved in key checkpoint events, such as chromosome segregation, sporulation septation, and the characteristic grey polyketide spore pigment production. Of the known early *whi* genes, the *whiJ* genes are the least well characterized. This thesis focuses on determining the phenotypic effects of mutation of genes in the *whiJ* locus (*whiJB*, *whiJA*, SCO4544) to resolve two competing models for the relationship of genes within the *whiJ* cluster.

Chater proposed that the 5'-end of *whiJA* corresponding to the N-terminus of *WhiJA*, may be sufficient to encode a DNA-binding domain that represses sporulation genes. We found sporulation activity was not compromised in clean deletion mutants of *whiJA* and *whiJAB*, as indicated by visual inspection of the grey phenotype and confirmed by phase-contrast and scanning electron microscopy. However, complementation of the clean deletion mutants with the 5'-end of *whiJA* did not compromise sporulation as the Chater model would predict. Furthermore, whereas the Gehring group had proposed that SCO4544 represses sporulation, overexpression of SCO4544 in the clean deletion *whiJAB* mutant, as determined, by RT-PCR, suggested that SCO4544 overexpression is not enough to block the sporulation pathway. Thus, these results did not fully support either the Gehring or Chater models for the function of *whiJ*. Quantifying expression of other *whi* genes involved in sporulation could help shed light on the roles of the *whiJ* cluster genes in regulating sporulation activity.

Morphological Properties of Fluorinated PPV Copolymers for Photovoltaic Applications, Assessed by Atomic Force Microscopy and Carrier Mobility

Cameron Rogers

Although bulk heterojunction (BHJ) organic photovoltaics potentially enjoy several advantages in comparison to extant photovoltaic technology, their use is presently hampered by their low efficiency. These devices could be made more efficient if the materials that comprise their active layer could be brought to assume a certain well-ordered morphology; to this end, we have synthesized and characterized fluorinated derivatives of one common active layer material, poly(p-phenylenevinylene) (PPV), in hopes of influencing the polymer's thin-film morphological properties. The new polymer materials were studied by Atomic Force Microscopy (AFM), as well as by fabricating diodes from them and determining the mobility of charge carriers in those devices. These data, together with other observations, have led us to conclude that the polymer materials characterized this year had degraded prior to their study, meaning they will need to be resynthesized and studied again before conclusions about their morphological behavior can be drawn.

ESR Dating of Flint Tools in Dakhleh: Bracketing a New Cultural Unit

Nicole Wise

Obtaining accurate ages for prehistoric artifacts is crucial for expanding our knowledge of the development and spread of early human cultures. For groups which predate the use of writing or extensive building, there is little evidence beyond stone tool remnants. Dr. Kleindienst and Dr. Wiseman, in conjunction with the Dakhleh Oasis Project, have recovered a collection of tools which do not seem to fit into any currently accepted lithographic cultural units, and therefore little is known about their age, or when their makers inhabited the oasis. These tools cannot be directly dated. However, as there is evidence that they were deposited near the boundary of two main sedimentary layers in Dakhleh – red silt and green mud – we attempt to pinpoint their age by determining the age of this boundary. In order to do this, we selected one tooth sample collected from green mud (PT74) and one from red silt (PT66c) to be dated using electron spin resonance spectroscopy. We hoped that they would closely bracket the transition. Unfortunately, PT74 showed inconsistent age results, suggesting exposure to non-homogenous levels of radioactive sediment during burial, and was not a useful marker. PT66c gave an age of 116ka, which is consistent with other red silt dates, but did not extend our knowledge of the boundary age. In the future, more green mud samples need to be collected; increased care in obtaining collection site information could help minimize poor results such as PT74 in the future.

Synthesis and Aggregation of PNIPAM-PDMA Copolymers

Matthew N. Zhou

Macromolecules and nanoparticles have been shown to accumulate in tumor tissue via the enhanced permeation and retention (EPR) effect. Techniques for increasing the size of drugs and drug delivery systems are therefore promising given the need for selective chemotherapy agents. In this research, we explored the aggregation behavior of copolymers of poly(N-isopropylacrylamide) (PNIPAM) and poly(N,N-dimethyl acrylamide) (PDMA) synthesized via reversible addition-fragmentation chain transfer (RAFT) polymerization. PNIPAM exhibited lower critical solution temperature (LCST) behavior: when heated in an aqueous solution, it precipitated out of solution. Copolymerization with PDMA altered LCSTs, allowing us to tune transition temperatures between 27.5 °C with a PNIPAM homopolymer and 35.7 °C with a 74:26 PNIPAM:PDMA ratio. Dynamic light scattering (DLS) experiments revealed a dependence of aggregate sizes on heating rate, sample concentration, and copolymer composition. For instance, 3.5 µg/mL copolymer samples gave particle sizes in the 100-200 nm range using heating rates of 0.5, 1, and 2 °C/min, these sizes are within the optimal literature range for EPR targeting.

Enzyme-polymer conjugates could potentially serve as therapeutic agents, and previous work with peptide-PNIPAM conjugates suggested that conjugation improved aggregate stability upon undergoing LCST transitions. We used carboxylic acid chain transfer agents (CTAs) during polymerization, resulting in functionalized copolymers. Unfortunately, we were unable to successfully bioconjugate copolymers to a model enzyme, trypsin. Future work should therefore aim to synthesize conjugates for LCST analyses, enzyme activity, and cell toxicity studies.

The following thesis abstract was omitted from the Report of Science at Williams 2011. It was done in collaboration between Chemistry and the Center for Environmental Studies. Our apologies for the omission.

Residential Solar Thermal Energy in Williamstown, Massachusetts

JJ Augenbraun

This thesis explores a rapidly growing renewable energy technology in the United States: residential solar thermal heating systems that produce hot water for domestic use and for space heating. In particular, this thesis examines the energy production of the Thoman-Venolia solar thermal heating system in Williamstown, Massachusetts. This system is unique because it employs an innovative reflector positioned above the system's evacuated tube collectors. This reflector is tilted at 500 to the horizontal; collectors are tilted at the same angle but in the opposite direction. The 1000 angle between the reflector and the collectors causes the reflector to bounce extra light onto the collectors during the fall winter and spring when the sun's maximum elevation is generally below 500. Conversely, the reflector serves as a shade during the summer when the sun is generally higher in the sky. This system is monitored by 16 sensors that measure a variety of variables as often as every 30 seconds. Most relevant to this study are readings from the system's radiometer, thermocouples measuring the temperature of the heat transfer fluid, and a flow meter measuring the flow rate of the heat transfer fluid.

Based on measured data from four of these sensors for August 1, 2009 to July 31, 2010, the Thoman-Venolia system produced approximately 51.5×10^6 Btu from a 20.28 m² system or approximately 2.5 x 10⁶ Btu/m². The system offset more than 585 gallons of propane and 3520 kg of associated eCO₂ during this 12 month period. The system produced a significant amount of energy, even during the winter. Peak energy production occurred during the spring and fall months as a result of the three main design features of this system: collector tilt, the reflective house roof, and the reflector. The design features of the system minimize the discrepancy between the thermal energy supply and demand.

Computer Science

Dynamic Race Condition Detection via Synchronization Specification Automata

Antal B. Spector-Zabusky

Multithreaded programming, while powerful, opens up the possibility for new classes of bugs that cannot occur in single-threaded programs. One such class of bugs in particular are those termed race conditions: two concurrent accesses to the same variable, at least one of which is a write. Because race conditions are difficult to detect manually, there has been a great deal of work on automated tools for race condition detection. This thesis presents a source-level annotation language for ensuring race-freedom. The annotations detail how synchronization operations change which threads can read or write to each variable. We implemented an interpreter which incorporates this annotation language, and present a proof that a correctly-annotated program that executes successfully is guaranteed to be race-free.

CloudLight: A Distributed Global Illumination System for Real-Time Rendering

Michael T. Mara

Using the cloud, with its vastly superior computational capabilities when compared to local devices, should increase image quality, not decrease it. Current commercial uses of the cloud for remote rendering (e.g. OnLive, Gakai) increase convenience but decrease quality and responsiveness. This is because of the difficulty in leveraging local computation for simple streaming. Only brute force network bandwidth increases improve quality. However, by shifting from a video-streaming approach to a hybrid rendering model, where client and server both perform part of the rendering task, we can construct a system that leverage the computation of the cloud to increase image quality without effecting responsiveness. In this paper, we describe a 3-phase plan to bring a highly efficient remote rendering model to practical use and beyond, and docu-

ment the culmination of the first phase, a complete remote rendering system that we call CloudLight. CloudLight distributes computing between client and server in an intelligent way: direct illumination and an approximation of medium spatial frequency, temporally sensitive indirect illumination is computed on a low-power client in an efficient manner, while the computationally intensive task of low spatial frequency indirect illumination is computed on the powerful server. The cut of the rendering process between client and server was chosen to minimize the data flow between server and client, and to minimize the perceived error due to latency in sending the rendering information from server to client. The next two phases, in which we replace the individual components of our system to enable us to drop our unrealistic assumptions on network bandwidth while simultaneously speeding up parts of our system by several orders of magnitude, and eventually inject the network stack into the graphics pipeline itself, are laid out here as a motivation and plans for future work. One of the major components of our system is the client-side approximation of high-frequency, temporally sensitive indirect illumination. We present a new Screen-Space Ambient Occlusion (SSAO) algorithm variant called Architecture-Aware Alchemy Ambient Occlusion, which is an optimization of an algorithm presented in 2011 called Alchemy AO. The optimizations operate at three levels: reduce total bandwidth by carefully reconstructing positions and normals at high precision from a depth buffer; pre-filter the depth buffer to maximize memory hierarchy efficiency; and low-level inner- and inter-thread techniques appropriate for a parallel, floating-point architecture. This new algorithm produces a high-quality approximation in 0.81 ms for standard 720p resolution, 1.59 ms for standard 1080p resolution, and scales much better than previous algorithms. This includes an asymptotic cost reduction from $O(r)$ to $O(\log r)$ in the sampling radius r .

Geosciences

Magmatic Processes at the Hrafnfjörður Central Volcano, Northwest Iceland

Kathryn M. Kumamoto

The Hrafnfjörður central volcano is a 350 km² volcano located in the Northwest Fjords of Iceland. The volcano is part of the abandoned Snaefellsnes-Skagi rift complex (active 15-7 Ma) and with an age of 14 Myr is the oldest central volcano on Iceland. The flows from Hrafnfjörður are stratified, with basalts and basaltic andesites generally on the bottom close to the shore of the fjord and more silicic rocks forming cliffs above. Above the silicic cliffs is another package of extensive plateau basalts, but these basalts are believed to have originated elsewhere.

The petrographic and geochemical characteristics of the Hrafnfjörður flows were studied in order to determine the petrogenetic mechanisms that took place when the volcano was active. Evidence from bulk chemistry suggests that fractional crystallization was the dominant mechanism. Certain samples, though, do not lie on the fractional crystallization trend. Some of the off-trend samples contain signs of disequilibrium in the melt, including spongy cellular plagioclase and resorbed plagioclase and clinopyroxene phenocrysts. These were most likely formed through magma mixing. Off-trend dacites, on the other hand, are enriched in incompatible elements and were most likely formed through partial melting of the crust.

Placing this data in the context of other studies from the Snaefellsnes-Skagi Rift, fractional crystallization appears to be the most important mechanism for the formation of basalt, basaltic andesite, and andesite early in the rift's life. Partial melting, however, is necessary to form more silicic rocks. This is similar to the behavior of modern Iceland rift volcanoes, though intermediate-silica rocks are very uncommon in the Neovolcanic system. Magma mixing becomes more important as the rift ages.

Evidence for Methane Release from Laminated Bering Sea Sediments During the Penultimate Glacial Periods

Nari V. Miller

There are few high-resolution marine records of oceanographic conditions from Marine Isotope Stage 6, a time of millennial-scale variability in climate and atmosphere greenhouse gasses. The Bering Sea has an active role in climate, as well as being sensitive to climate changes. It experiences annual sea ice formation and high productivity today, and may have had a role in gas exchange and water mass formation. Sedimentation can be high on the

continental slopes, preserving millennial-scale features. Large amounts of organic material are buried in the Bering Sea, some of which is anaerobically digested to methane. Early Stage 6 sediments from IODP Site U1345 were characterized by carbon, oxygen, and nitrogen bulk stable isotope analysis; benthic and planktonic foraminifera stable isotopes and Scanning Electron Microscopy, and Electron Dispersive Spectroscopy. Our age model constrains the ages of the Marine Isotope Stage 7-6 interglacial-glacial and the Marine Isotope Stage 5-6 glacial-interglacial transitions by matching a coarse resolution benthic foraminifera record of U1345 to tie points on these transitions in the global stack of benthic foraminifera (Lisiecki and Raymo, 2004). This study focuses on a section of core corresponding to a 10-16 ky interval in early MIS 6, within the age span 154 ka to 188 ka. The sampling resolution is in the range of 0.13 ky/sample to 0.22 ky/sample. The sediments in this study surveys three millennial-scale intervals of laminated sediments.

Laminated intervals indicate suboxia in the water column, which causes denitrification, an isotopically fractionating process, throughout the water column. The bulk sediments show a gradually increasing trend in $\delta^{15}\text{N}$ upcore from 5.2‰ to 6.7‰, but do not have the expected $\delta^{15}\text{N}$ enrichment concurrent with the laminated intervals. The stable carbon and oxygen isotopes of benthic and planktonic foraminifera show excursions (N. pachyderma, maximum amplitude, $\delta^{13}\text{C}$: 7.61‰, $\delta^{18}\text{O}$: 1.06‰) in the laminated intervals.

Authigenic carbonates encrusted foraminifera from some sediment horizons in the core. A foraminifer encrusted with authigenic carbonates was compared to an unencrusted foraminifer (F2). The morphology of the shell is needle-like (width $\sim 1\mu\text{m}$) that are encrusted with smaller crystals ($<1\mu\text{m}$). F2 had distinctly different morphology, where the calcite crystals ($\sim 10\mu\text{m}$ width) have a smooth, ridged shape. The isotopic composition of the authigenic carbonate was plotted $\delta^{18}\text{O}$ vs. $\delta^{13}\text{C}$, and fell on a similar mixing line (between a foraminifer composition estimated as $\delta^{18}\text{O}_{\text{meas}} \sim 3.4\text{‰}$ and $\delta^{13}\text{C}_{\text{meas}} \sim -0.6\text{‰}$ and an authigenic carbonate composition $\delta^{18}\text{O}_{\text{meas}} \sim 6.5\text{‰}$ and $\delta^{13}\text{C}_{\text{meas}} \sim -22.4\text{‰}$) to that found by Cook et al. (2010) from MIS 3 sediments on the Umnak Plateau.

The $\delta^{18}\text{O}$ vs. $\delta^{13}\text{C}$ of bulk sediments were also plotted; foraminifer calcite and the authigenic carbonate endpoints clustered in the same region, and a third carbonate composition was appeared (estimated at $\delta^{18}\text{O}_{\text{meas}} \sim -8\text{‰}$ and $\delta^{13}\text{C}_{\text{meas}} \sim -1\text{‰}$). The percent of each carbonate end member was estimated by using the M44 peak of the bulk sediment mass spectrometry data as a measure of the total carbonate in each sample. The percent of each end member in a sample was determined using a linear mixing model based on the estimated carbonate end member values of $\delta^{18}\text{O}$ and $\delta^{13}\text{C}$. The background percentage of total carbonate is $<1\%$, but peaks up to 8.5% total carbonate occur with each laminated interval. This study presents evidence of active methane flux during Stage 6 coinciding with three laminated intervals, to region-wide responses to rapid global climate change.

Mathematics and Statistics

Dynamics, Information, and Energy of Morris-Lecar Neurons

Ji Won Ahn

We studied the Morris-Lecar model, which is a mathematical model of a motor neuron. In particular, we studied the mutual information, metabolic energy cost, and energy efficiency of unidirectionally connected Morris-Lecar neurons, and compared our result to the work of Moujahid et al., who studied the mutual information, metabolic energy cost, and energy efficiency of unidirectionally coupled Hodgkin-Huxley neurons.

We found that unidirectionally coupled Morris-Lecar models behave differently from unidirectionally coupled Hodgkin-Huxley neurons in both information transfer and energy efficiency. Unlike Moujahid et al., we found that among groups of one, five, ten, and twenty postsynaptic neurons, the single Morris-Lecar neuron synchronizes with the presynaptic neuron the best and is the most energy efficient.

On Multiply Recurrent and Manifold Mixing Properties on Infinite Measure Preserving Transformations

Praphruepong Athiwaratkun

We show an example of an infinite measure preserving transformation such that it is not 2-recurrent and not power weakly mixing. This example demonstrates the striking difference between measure preserving transformations in a finite and sigma-finite measure spaces.

Totally Knotted and Semi-Free Seifert Surfaces

Thomas N. Crawford

In 2005 Osamu Kakimizu determined the Kakimizu Complex, a simplicial complex whose vertices correspond to isotopy classes of Seifert surfaces of a given knot, for all knots with 10 crossings or fewer. We investigate a few properties the surfaces themselves. Specifically we show various combinations of semi-free and totally knotted surfaces, can be embedded in the same knot complement. We restrict ourselves to hyperbolic knots allowing us to also look at the maximal cusp diagrams of the resultant manifold.

Monkemeyer Map Analogues to Stern's Diatomic Sequence

Noah N. Goldberg

Stern's Diatomic Sequence is a well-studied sequence of integers which stems from continued fractions. The Monkemeyer Map is a type of multidimensional continued fraction. We will examine an analogue of Stern's Diatomic Sequence for the Monkemeyer Map.

Ergodic Properties of TRIP Maps: A Family of Multidimensional Continued Fractions

Stephanie Jensen

We study the ergodic properties of several of the most relevant TRIP maps, a family of multidimensional continued fractions that encompasses many well-known algorithms. As a first step, we show these maps converge almost everywhere. From there, we are able to prove ergodicity.

Spaces of Planar Polygons

Brian Li

We introduce the space of convex planar polygons with different side lengths. We then consider the side lengths that produce valid linkages as well as the relation of this space to the associahedra and $M_{0,n}$.

Choose to Play: A New Take on the Spatial Prisoner's Dilemma

Connor McKean Stern

The Prisoner's dilemma is one of the most important models we have to study the evolution of cooperation in a world of self-interested individuals. Defecting is the only evolutionarily stable strategy, but from previous studies we know that in repeated games and in games with spatial effects cooperating becomes not only possible, but also preferable under certain conditions. In this paper we explore a new repeated model of the spatial prisoner's dilemma game where a player can select which opponents to continue interacting with. By giving players this option we are rejecting the key condition of the repeated game that players cannot avoid interaction, yet we find that this new model shares the same underlying structure of the traditional spatial prisoner's dilemma.

Stochastic Calculus and Applications to Mathematical Finance

Gregory White

In this paper, we review fundamental probability theory, the theory of stochastic processes, and Ito calculus. We also study an application of Ito calculus in mathematical finance: the Black-Scholes option pricing model for the European call option. We study the development of the model and the assumptions necessary to arrive at the Black-Scholes no arbitrage rational price for a European call option.

We supplement the simple Black-Scholes model by relaxing the assumption that trading can be performed continuously in time, and studying the deviation the Black-Scholes replicating portfolio exhibits from the self-financing characteristic of the continuous-time portfolio. We term this deviation the cumulative correction of the portfolio and explain in detail its construction. We study the cumulative correction of Black-Scholes portfolios by performing a numerical analysis of the cumulative correction for outcomes of the stock price stochastic process. While finding a closed form probability distribution representing the cumulative correction proves difficult and we do not pursue that route in this paper, the numerical analysis indicates that the second central moment of the distribution of cumulative corrections decreases as the number of discrete time steps at which the portfolio is rebalanced increases. Additionally, we analyze the cumulative correction required to replicate the European call option for the historical stock price data series of certain actual stocks, finding examples of a stock that would have required a positive cumulative correction and a stock that would have required a negative cumulative correction.

Spectral Theory for Matrix Orthogonal Polynomials on the Unit Circle

Liyang Zhang

In this thesis, we first introduce the classical theory of orthogonal polynomials on the unit circle and its corresponding matrix representations - the GGT representation and the CMV representation. We briefly discuss the Sturm oscillation theory for the CMV representation. Motivated by Schulz-Baldes' development of Sturm oscillation theory for matrix orthogonal polynomials on the real line, we study matrix orthogonal polynomials on the unit circle. We prove a connection between spectral properties of GGT representation with matrix entries, CMV representation with matrix entries with intersection of Lagrangian planes. We use this connection and Bott's theory on intersection of Lagrangian planes to develop a Sturm oscillation theory for GGT representation with matrix entries and CMV representation with matrix entries.

Physics

The Ubit Real-Vector-Space Model: Deviations from Standard Quantum Theory

Victoria F. Borish

Quantum mechanics (the framework for much of modern physics) has always been described by the complex numbers; however there are reasons to consider describing it with purely real numbers instead. In my thesis, I investigate a specific model of real-vector quantum theory and try to explain some effects I see that deviate from standard quantum theory.

Information of RNA Folding

Joel T. Clemmer

We computationally studied the information already known about how a particular sequence will fold and with experimental methods in mind, quantified the information gained for particular measurements.

Efficiently Estimating Net Free Energy to Bind Oligomeric RNAs to mRNA

Julian M. Hess

In this thesis, we create a method to improve the accuracy of algorithms that predict RNA-RNA binding configurations.

An Effective $SU(2)'$ for Top Forward-Backward Asymmetry

Murat Kologlu

We propose a theoretically consistent extension of the Standard Model to explain the anomalous top quark forward-backward asymmetry observed at the Tevatron. Our model is shown to better explain the observed asymmetry while producing reasonable top production phenomenology and meeting dijet and other constraints.

Searching for a b-friendly Z' Boson at the LHC

Margaret G. Robinson

The search for new phenomena not predicted by the Standard Model (SM) of particle physics is a primary goal of the Large Hadron Collider (LHC). This thesis examines the phenomenology of a neutral gauge boson, a Z' , that couples predominantly to right-handed SM bottom quarks.

Measuring the Stark Shift in the $5P_{1/2} \rightarrow 6S_{1/2}$ 410 nm Transition in Indium

Anders E. Schneider

An investigation of the effect of a strong electric field on the energy level structure of indium with the goal of determining its atomic polarizability.

Measurement of the Hyperfine Splitting and Isotope Shift for the $7S_{1/2} \rightarrow 7P_{1/2}$ Transition in Thallium Using Two-Step Excitation Laser Spectroscopy

Taryn R. Siegel

We use two lasers to excite the valence electrons of thallium in order to measure subtle features of thallium's level structure very precisely.

PSYCHOLOGY

Infant Contributions to Biobehavioral Still-Face Responding: The Regulatory Function of Infant Gaze Behavior

Amber Cardoos

The regulatory function of three infant gaze behaviors (gaze to mother, scanning, and focused gaze) during the modified still-face paradigm (SFP) were examined. Individual differences in these gaze behaviors and their associations with biobehavioral responding (vocal distress, autonomic, and neuroendocrine responding) and maternal report of temperament were examined. Forty-seven mother/infant dyads participated in the SFP when their infants were six months old. Infant gaze to mother, scanning, focused gaze (on proximal objects or the self), and duration of vocal distress during the modified (double) SFP were coded and measures of heart rate and vagal tone were collected at baseline and throughout the SFP. Saliva was collected from the infants immediately (at baseline) before and 15- and 30-minutes after the SFP. Infant focused gaze behavior during the two still-face episodes of the SFP was associated with less vocal distress, less cardiac reactivity, and augmented vagal tone, as well as maternal reports of less proneness to distress and better self-regulation. Gaze toward the still-faced mother and scanning during the still-face portions of the SFP were characterized by more dysregulated biobehavioral profiles during the SFP. Gaze to mother was associated with more vocal distress, increased cardiac reactivity, and vagal suppression. Scanning was associated with less vocal distress, but vagal suppression, higher basal cortisol levels, and maternal reports of increased proneness to distress. The convergence of behavioral, autonomic, neuroendocrine, and maternal report data supports distinct regulatory functions for each form of infant gaze behavior. Consistent with research examining attention regulation in children, infants who were able to focus gaze on proximal objects or the self showed a robust biobehavioral profile of effective regulation, across multiple levels of measurement (behavioral, physiological, and maternal report). Results converge to show that the ability to focus attention, or self-distract, when confronted with a stressor supports self-regulation early in infancy and in the context of the SFP.

The Baby in the Bath Water: Associations Among Maternal Caregiving, Neonatal Somatic Discomfort and Stress Reactivity during Bathing and Dressing

Chelsey Barrios

Previous research has demonstrated that quality of maternal caregiving behavior in infancy influences development of the neuroendocrine stress response, but little research to-date has focused on infant contributions to the caregiving context. The current study sought to extend this literature by using a novel coding scheme adapted from NICU pain scales to examine levels of infant discomfort in relation to stress reactivity and quality of maternal caregiving behavior during the routine stressor of being undressed, bathed, and redressed. Mothers and infants were visited in the home and videotaped during their daily routines. The bathtime process was coded for behavioral indicators of infant pain, infant negative reactivity, and quality of maternal caregiving behavior (MCB). Infant salivary cortisol (CORT) was sampled at baseline and 15 minutes following removal from the tub. Results showed that there was a significant positive relationship between infant behavioral discomfort and increase in CORT response. There was a significant negative association between infant discomfort and quality of MCB, such that more uncomfortable infants received lower quality MCB. It was demonstrated that quality of MCB significantly and fully mediates the effects of behavioral discomfort on change in CORT, revealing a strong association between MCB and infant biobehavioral defensive responding to routine care. Future research examining this novel construct of infant sensitivity to discomfort separate from the caregiving context is suggested, and intervention programs that emphasize maternal protection of the neonate's comfort are discussed.

Contexts and Benefits of Women's Sexual Misperception

David A. Carlin

We studied female misperception in an evolutionary context using Error Management Theory (Haselton & Buss, 2000). In the first experiment, female participants perceived greater interest from male targets with high mate value than from lower mate value targets. These differences between conditions appeared for single women but

not for mated women. These findings suggest that single women's perceptions of male interest are influenced by the characteristics of the man in question. In the second experiment, men showed more interest in women who appeared to overperceive their initial interest. While female underperception may elicit greater male interest in the case of men who are already interested, in men who are not already interested in the target the use of short-term mating strategies raised questions about the hypothesized effects of female underperception.

To Convict or Not to Convict: Motivations behind Juror Bias in Decision-Making

Jessica N. de la Cuesta

Building upon the literature of race salience, self-affirmation, and moral self licensing, two studies were conducted to clarify the motivations behind juror decision-making in studies on race salience. In Study 1, we hypothesized that affirming jurors would result in a reversal of the reduction in anti-Black bias associated with race salient trials. The study failed to find anti-Black bias. However, race salience was found to significantly reduce the pro-Black bias jurors did display, suggesting that the concept of race salience may be more complex than previously thought. Given the surprising findings of Study 1 and that no interaction was found between juror verdicts and self-affirmation, a second study was conducted to re-test our original hypothesis. For exploratory reasons, moral self-licensing was also included in Study 2. Like self-affirmation, it was expected to moderate juror bias. Again, evidence for racial bias against Black defendants was not found. However, both self-affirmation and moral self-licensing were found to moderate juror leniency toward Black defendants. Implications of the findings and future directions are discussed.

What Should I Study?: The Effectiveness of Different Study Strategies in Both Short- and Long-Term Learning

Katrina E. Flanagan

The present research explored learners' restudy choices. We start by identifying a study strategy that has been established both as one that students actually employ and as one that is in fact optimal for learning: restudy unknown items. We then move to an evaluation of the effectiveness of this strategy as compared to that of an alternative strategy (restudy known items) for both short- and long-term learning. We present a series of experiments designed to test our hypothesis that the strategy of restudying unknown items is good for short-term retention but bad for long-term retention. Our results generally supported the hypothesis that restudying known items can be simultaneously a good learning strategy for short-term retention and not particularly beneficial for long-term retention. This challenges the assumption that if a study strategy is optimal for short-term learning, it will be optimal for long-term learning as well. Students and teachers should be aware of this and other errors in their beliefs about learning and memory, and they should use this awareness to improve the effectiveness of their studying and teaching.

Chin Up! The Impact of Self-Esteem on Conformity

Aaron C. Lim

This study was designed to explore the impact of a self-esteem boost on peer conformity in three age groups (4th graders, 7th graders, and college students). In addition, a number of personality characteristics were examined as potential moderators of resistance to conformity (e.g., social status, fear of negative evaluation, trait self-esteem, and importance of popularity). Participants completed self-report measures of individual characteristics and then were randomly assigned to an ego boost or neutral task. Finally, participants rated the humor value of three cartoons. Half of the participants were randomly assigned to rate the comics independently, while the other half rated the comics after viewing bogus peer ratings. Results revealed that participants of all age groups engaged in conformity. Participants rated a bland comic as significantly more funny when they believed that their peers thought it was funny than when they rated it independently. This conformity effect was not moderated by age, gender, or individual characteristics. An ego boost was somewhat successful in mitigating against conformity. Among 4th graders, participants assigned to the ego boost condition exhibited less conformity than those assigned to the neutral condition. The ego boost had a similar effect among participants who placed a high value on popularity. Future research should examine self-esteem's impact across multiple types of conformity, as such boosts may represent a short-term intervention strategy for helping young children resist antisocial norms.

Standing” Against Prejudice: How We View Those Who Respond to Bias

Jordan Mickens

In four studies, we examined how the group membership and apparent standing (see Miller, Effron, & Zak, 2009) of an individual who responds to discrimination affects how that individual is evaluated. Study 1 found that participants rated a responder more negatively and as more of a complainer than a non-responder, but participants also liked the responder more and found him more justified. Studies 2 and 3 found that participants viewed an individual who responded with no standing most negatively, and an individual with racial standing least negatively. In addition, participants high in prejudice liked the responder with racial standing more than the responder with no standing, while this pattern was reversed for participants low in prejudice. Study 4 found that Blacks liked responders more than non-responders and felt they were more justified, regardless of standing. Taken together, these studies provide evidence that psychological standing affects how majority group members view those who respond to prejudice, and that Black individuals are more concerned about someone responding to discrimination than about the standing of the responder.

The Science of Politics and the Politics of Science: An Examination of How Liberals and Conservatives Value and Are Influenced by Science-Based versus Non-Science-Based Evidence

Helena E. Nannes

Although scientific research has the potential to greatly inform public debate about issues such as energy and the environment, it is clear that politicians and the general public often ignore, subvert, or dismiss evidence from science when forming or promoting relevant policies. Samples of adults from across the United States participated in three studies that were designed to address three important questions. First, are people’s attitudes influenced more by arguments that are based on scientific evidence rather than non-scientific opinions? Second, do the effects of these arguments vary as a function of whether liberals or conservatives are said to endorse the issue? Third, do liberals and conservatives differ in the extent to which their attitudes are influenced by science rather than non-science and by the political framing of the issues? Results showed that (1) scientific evidence sometimes has no more effect on attitudes than non-scientific opinion; (2) liberals were more swayed by scientific evidence when the issue was framed in an apolitical context, whereas conservatives were more swayed when the science supported a conservative perspective; and (3) liberals reported more trust and placed more value in learning information from science than did conservatives.

Self-Affirmation and Sports

Noah E. Schoenholtz

For experienced athletes, the high pressure and stress of performance in competition can lead to sub-maximal performance. Empirical research in non-athletic fields has demonstrated that people can be buffered against self-threats in a specific domain if they affirm the core aspects of themselves that they value most (Steele, 1988). The present studies examined the hypothesis that self-affirmative exercises will protect experienced athletes from the detrimental effects that pressure and stress can have on their performance. Study 1 demonstrated that self-affirmation can increase the likelihood that experienced golfers will perform well under pressure. Experienced golfers who focused attention on a specific, successful facet of their lives in a domain unrelated to athletics putted more successfully under pressure than did golfers who completed a manipulation that did not affirm any core aspects of their self-concepts. Study 2 failed to extend the findings from Study 1 to a general population of participants with no golf experience. Study 3 found that self-affirmation can improve an experienced rower’s ability to produce power over the course of a 15-minute ergometer test compared with experienced rowers who completed a manipulation unrelated to affirmation. Self-affirmed rowers in Study 3 achieved a greater average speed and covered more meters over 15 minutes than non-affirmed rowers did. Studies 1 and 3 demonstrate the effectiveness of a highly realistic self-affirmation technique in improving the high-pressure performance of experienced athletes. In Studies 1 and 3, female athletes tended to show a greater negative effect of high pressure on performance, as well as a greater positive effect of self-affirmation on high-pressure performance, compared with male athletes. Possible explanations for this gender difference are discussed.

FACULTY PUBLICATIONS AND PRESENTATIONS

Astronomy

Structure and Dynamics of the 11 July 2010 Eclipse White-Light Corona

Jay M. Pasachoff, Vojtech Rušin, Hana Druckmüllerová, Metod Saniga, Muzhou Lu, Craig Malamut, Daniel B. Seaton, Leon Golub, Alex J. Engell, Steele W. Hill, and Robert Lucas

Astrophysical Journal, 734, 114-123 (2012) <http://stacks.iop.org/0004-637X/734/114>

The white-light corona (WLC) during the total solar eclipse on 2010 July 11 was observed by several teams in the Moon's shadow stretching across the Pacific Ocean and a number of isolated islands. We present a comparison of the WLC as observed by eclipse teams located on the Tatakoto Atoll in French Polynesia and on Easter Island, 83 minutes later, combined with near-simultaneous space observations. The eclipse was observed at the beginning of the solar cycle, not long after solar minimum. Nevertheless, the solar corona shows a plethora of different features (coronal holes, helmet streamers, polar rays, very faint loops and radial-oriented thin streamers, a coronal mass ejection, and a puzzling "curtain-like" object above the north pole). Comparing the observations from the two sites enables us to detect some dynamic phenomena. The eclipse observations are further compared with a hairy-ball model of the magnetic field and near-simultaneous images from the Atmospheric Imaging Assembly on NASA's Solar Dynamics Observatory, the Extreme Ultraviolet Imager on NASA's Solar Terrestrial Relations Observatory, the Sun Watcher, using Active Pixel System Detector and Image Processing on ESA's PROject for Onboard Autonomy, and the Naval Research Laboratory's Large Angle and Spectrometric Coronagraph on ESA's Solar and Heliospheric Observatory. The Ludendorff flattening coefficient is 0.156, matching the expected ellipticity of coronal isophotes at $2 R_{\odot}$, for this rising phase of the solar-activity cycle.

Sunlight Refraction in the Mesosphere of Venus During the Transit on June 8th, 2004

Tanga, P., T. Widemann, B. Sicardy, J. M. Pasachoff, J. Arnaud, L. Comolli, A. Rondi, S. Rondi, and P. Suetterlin

Icarus, 218, 207-219 (2012) <http://dx.doi.org/10.1016/j.icarus.2011.12.004>; <http://arxiv.org/abs/1112.3136>
<http://www.sciencedirect.com/science/article/pii/S0019103511004696>

Many observers in the past gave detailed descriptions of the telescopic aspect of Venus during its extremely rare transits across the Solar disk. In particular, at the ingress and egress, the portion of the planet's disk outside the Solar photosphere has been repeatedly perceived as outlined by a thin, bright arc ("aureole"). Those historical visual observations allowed inferring the existence of Venus' atmosphere, the bright arc being correctly ascribed to the refraction of light by the outer layers of a dense atmosphere. On June 8th, 2004, fast photometry based on electronic imaging devices allowed the first quantitative analysis of the phenomenon. Several observers used a variety of acquisition systems to image the event -- ranging from amateur-sized to professional telescopes and cameras -- thus collecting for the first time a large amount of quantitative information on this atmospheric phenomenon. In this paper, after reviewing some elements brought by the historical records, we give a detailed report of the ground based observations of the 2004 transit. Besides confirming the historical descriptions, we perform the first photometric analysis of the aureole using various acquisition systems. The spatially resolved data provide measurements of the aureole flux as a function of the planetocentric latitude along the limb. A new differential refraction model of solar disk through the upper atmosphere allows us to relate the variable photometry to the latitudinal dependency of scale-height with temperature in the South polar region, as well as the latitudinal variation of the cloud-top layer altitude. We compare our measurements to recent analysis of the Venus Express VIRTIS-M, VMC and SPICAV/SOIR thermal field and aerosol distribution. Our results can be used a starting point for new, more optimized experiments during the 2012 transit event.

Structure and Dynamics of the 2 July 2009 Eclipse White-Light Corona

Jay M., Vojtech Rušin, Metod Saniga, Hana Druckmüllerová, and Bryce A. Babcock

Astrophysical Journal, 742, 29-42 (2011)

The white-light corona (WLC) during the total solar eclipse of 2009 July 22 was observed by several teams in the Moon's shadow stretching from India and China across the Pacific Ocean with its many isolated islands. We present a comparison of the WLC as observed by eclipse teams located in China (Shanghai region) and on the Enewetak Atoll in the Marshall Islands, with observations taken 112 minutes apart, combined with near-simultaneous space observations. The eclipse was observed at the beginning of solar cycle 24, during a deep solar minimum (officially estimated as 2008 December according to the smoothed sunspot number, but very extended). The solar corona shows several different types of features (coronal holes, polar rays, helmet streamers, faint loops, voids, etc.), though it was extremely sparse in streamers as shown from Large-Angle Spectroscopic Coronagraph data. No large-scale dynamical phenomena were seen when comparing the observations from the two sites, confirming that the corona was quiescent. We measure a Ludendorff flattening coefficient of 0.238, typical of solar minimum.

Lomonosov, the Discovery of Venus's Atmosphere, and Eighteenth-century Transits of Venus

Jay M. Pasachoff and William Sheehan

Journal for the History and Heritage of Astronomy, 15, (1), RPO, 1-12 (2012) <http://adsabs.harvard.edu/abs>

The discovery of Venus's atmosphere has been widely attributed to the Russian academician M.V. Lomonosov from his observations of the 1761 transit of Venus from St. Petersburg. Other observers at the time also made observations that have been ascribed to the effects of the atmosphere of Venus. Though Venus does have an atmosphere one hundred times denser than the Earth's and refracts sunlight so as to produce an 'aureole' around the planet's disk when it is ingressing and egressing the solar limb, many eighteenth century observers also upheld the doctrine of cosmic pluralism: believing that the planets were inhabited, they had a preconceived bias for believing that the other planets must have atmospheres. A careful re-examination of several of the most important accounts of eighteenth century observers and comparisons with the observations of the nineteenth century and 2004 transits shows that Lomonosov inferred the existence of Venus's atmosphere from observations related to the 'black drop', which has nothing to do with the atmosphere of Venus. Several observers of the eighteenth-century transits, including Chappe d'Auteroche, Bergman, and Wargentin in 1761 and Wales, Dymond, and Rittenhouse in 1769, may have made bona fide observations of the aureole produced by the atmosphere of Venus. Therefore, it appears that several observers-but not Lomonosov-should receive credit for first detecting the aureole due to refraction of sunlight by the atmosphere of Venus during a transit. This crucial observation occurred almost three decades before Johann Schroeter independently demonstrated the existence of the atmosphere of Venus from his analysis of extensions of the semicircle of light of the planet near inferior conjunction, which are produced by back-scattering of light by aerosol-sized particles.

Spectroscopic Coronal Observations during the Total Solar Eclipse of 11 July 2010

Voulgaris, Aris, Paul Gaintatzis, John H. Seiradakis, Jay M. Pasachoff, and Thanasis E. Economou

Solar Physics, 278, (1), 187-202; DOI:10.1007/s11207-012-9929-4 (2012)

The flash spectrum of the solar chromosphere and corona was measured with a slitless spectrograph before, after, and during the totality of the solar eclipse, of 11 July 2010, at Easter Island, Chile. This eclipse took place at the beginning of the 24th solar cycle, after an extended minimum of the solar-activity. The spectra taken during the eclipse show a different intensity ratio of the red and green coronal lines compared with those taken during the total solar eclipse of 1 August 2008, which took place towards the end of the 23rd solar cycle. The characteristic coronal forbidden emission line of [Fe XIV] (5303 Å) was observed in the east and west solar limbs in four areas relatively symmetrically located with respect to the solar rotation axis. Subtraction of the continuum flash-spectrum background led to the identification of several extremely weak emission lines, including [Ca XV] (5694 Å), which is normally detected only in regions of very high excitation, e.g., during flares or above large sunspots. The height of the chromosphere was measured spectrophotometrically, using spectral lines from light elements and compared with the equivalent height of the lower chromosphere measured using spectral lines from heavy elements

Abundances of Planetary Nebulae in the Outer Disk of M31

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

Astrophysical Journal, 753, 12 (2012)

We present spectroscopic observations and chemical abundances of 16 planetary nebulae (PNe) in the outer disk of M31. The [O III] $\lambda 4363$ line is detected in all objects, allowing a direct measurement of the nebular temperature essential for accurate abundance determinations. Our results show that the abundances in these M31 PNe display the same correlations and general behaviors as Type II PNe in the Milky Way Galaxy. We also calculate photoionization models to derive estimates of central star properties. From these we infer that our sample PNe, all near the bright-end cutoff of the Planetary Nebula Luminosity Function, originated from stars near 2 solar masses. Finally, under the assumption that these PNe are located in M31's disk, we plot the oxygen abundance gradient, which appears shallower than the gradient in the Milky Way.

Using Spectra to Determine Planetary Nebula Properties

Karen B. Kwitter and Richard B.C. Henry

The Classroom Astronomer, 9 (2011)

Planetary nebulae are hot glowing gas clouds ejected by dying low- to intermediate-mass stars. The nebulae glow because they are heated by energetic ultraviolet photons from the exposed stellar core. The light produced by a planetary nebula is an emission spectrum, with spikes of emission at specific wavelengths corresponding to the elements in the gas. A spectrum can be displayed as a picture showing colored stripes, or a graph. We have developed three exercises, all available online, for determining various properties related to planetary nebulae or their environs. These exercises make use of the "Gallery of Planetary Nebula Spectra" database at tinyurl.com/63ed7tx. The database contains optical spectra, shown as graphs, of more than 160 planetary nebulae that we and our colleagues have observed in the Milky Way Galaxy, along with distance and other information about them, links to images, references in the literature, and more.

Galactic Disk Abundance Gradients and the 10 kpc R_g Region

J.B. Milingo, R.B.C Henry, K.B. Kwitter and B. Balick

Bulletin of the American Astronomical Society, **441.05** meeting in Austin, TX (January 2012)

We examine the radial abundance gradient in the Milky Way disk via homogeneously determined data for 124 Galactic planetary nebulae. With O, Ne, S, Cl, and Ar available and a range of galactocentric distance (R_g) from 0.9 to 21 kpc, we explore the gradient by statistically analyzing a series of short segments of increasing average R_g. Though the detailed nature of the radial gradient remains somewhat uncertain, we find the short segments support a discontinuity at R_g ~10 kpc, consistent with that shown via open clusters, hence providing a potential constraint on the dynamic history of the Galactic disk.

Reduce, Reuse, Recycle: Planetary Nebulae as Green Galactic Citizens

Karen B. Kwitter and Richard B. C. Henry

IAU Symposium #283, "Planetary Nebulae: An Eye to the Future", Manchado, Stanghellini & Schönberner eds. (Cambridge) in press.

We review gas-phase abundances in PNe and describe their dual utility as archives of original progenitor metallicity via the alpha elements, as well as sources of processed material from nucleosynthesis during the star's evolution, i.e., C, N, and s-process elements. We describe the analysis of PN spectra to derive abundances and discuss the discrepancies that arise from different choices at each step. Abundance results for the Milky Way and Magellanic Clouds from various groups of investigators are presented; the observational results are compared with theoretical predictions of AGB stellar yields. Finally, we suggest areas where more work is needed to improve our abilities to determine abundances in PNe.

Abundances of Disk Planetary Nebulae in M31 and the Radial Oxygen Gradient

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

IAU Symposium #283, "Planetary Nebulae: An Eye to the Future", Machado, Stanghellini & Schönberger eds. (Cambridge) in press.

We have obtained spectra of 16 planetary nebulae in the disk of M31 and determined the abundances of He, N, O, Ne, S and Ar. Here we present the median abundances and compare them with previous M31 PN disk measurements and with PNe in the Milky Way. We also derive the radial oxygen gradient in M31, which is shallower than that in the Milky Way, even accounting for M31's larger disk scale length.

Further Exploration of Galactic Disk Abundance Gradients

J.B. Milingo, R.B.C. Henry, K. B. Kwitter, and B. Balick

IAU Symposium #283, "Planetary Nebulae: An Eye to the Future", Machado, Stanghellini & Schönberger eds. (Cambridge) in press.

With a compiled set of homogeneously determined abundances for 124 Galactic planetary nebulae (PNe), we examine the abundance gradient in the Milky Way disk. We present recent results from a detailed regression analysis of the oxygen gradient. With O, Ne, S, Cl, and Ar available for both Peimbert Types I and II PNe, and a range of galactocentric distance from 0.9 to 21 kpc, we present additional exploration of the disk abundance gradient by statistically analyzing a series of short segments of increasing average galactocentric distance. Finally, we further analyze the scatter observed in PNe abundances within these segments.

Luminosity and Abundance Correlations in a Carefully-Studied Sample of PNe

J. McKeever, B. Balick, K.B. Kwitter, K. Braxton, T. Gomes, J. Green, and R.B.C Henry

IAU Symposium #283, "Planetary Nebulae: An Eye to the Future", Machado, Stanghellini & Schönberger eds. (Cambridge) in press.

We report the results of empirical correlation studies of a homogeneously observed and analyzed set of 120 Galactic PNe spanning a wide range of distances, abundances, excitation, densities, and both major Peimbert types. Our goal is to continue the analysis of these data begun in Milingo et al 2010 and Henry et al 2010 who primarily examined correlations of abundances and with galactocentric radius R_{gal} . We find that a subsample of PNe chosen for their large [OIII] luminosities, $L[OIII]$, generally show tighter abundance correlations as a function of $\log(O/H)$ than does the full sample. In addition to He/H and N/H, the abundances of Cl and Ar correlate with Peimbert types I and II. These results are not sensitive to the derived values of ionization correction factors, ICF. Finally, we show that $L[OIII]$ rises and then falls when plotted against the physical radius R_{neb} of PNe, the latter a likely proxy for nebular age. This result nicely complements the studies of Frew 2008 (PhD thesis) who found a tight correlation of $H\beta$ and [OIII] surface brightness with R_{neb} . $[NII]/H\alpha$ and $HeII\ 4686/H\beta$ ratios also correlate with R_{neb} , but the trends are scattered.

3D Ionization Structure & Kinematics of NGC 2392

R.J. Dufour, J.N. Sick, P.M. Hartigan, R.B.C. Henry, K.B. Kwitter, and J. Bohigas

IAU Symposium #283, "Planetary Nebulae: An Eye to the Future", Machado, Stanghellini & Schönberger eds. (Cambridge) in press.

We discuss the three dimensional morphology, ionization structure, and kinematics of NGC 2392, the "Eskimo," based on new and archival HST imagery and new long-slit echelle and integral field spectroscopy. High spatial resolution 2D ionization maps of the nebula were made from the HST WFPC2 imagery and compared with maps of the emission-line structure in weaker diagnostic lines from the VIRUS-P IFS observations obtained at McDonald Observatory. Then high velocity resolution long-slit spectroscopy with the KPNO 4m echelle spectroscopy was used to map the kinematics and evaluate the 3D ionization structure of the nebula in several important ions, including C^{++} for the first time.

Biology

Using comparative genomics for inquiry-based learning to dissect virulence of *Escherichia coli* O157:H7 and *Yersinia pestis*.

Baumler, D. J., L. M. Banta, K. F. Hung, J. A. Schwarz, E. L. Cabot, J. D. Glasner, and N. Perna

Cell Biology Education-Life Science Education 11:81-93.

Genomics and bioinformatics are topics of increasing interest in undergraduate biological science curricula. Many existing exercises focus on gene annotation and analysis of a single genome. In this paper, we present two educational modules designed to enable students to learn and apply fundamental concepts in comparative genomics using examples related to bacterial pathogenesis. Students first examine alignments of genomes of *Escherichia coli* O157:H7 strains isolated from three food-poisoning outbreaks using the multiple-genome alignment tool Mauve. Students investigate conservation of virulence factors using the Mauve viewer and by browsing annotations available at the A Systematic Annotation Package for Community Analysis of Genomes database. In the second module, students use an alignment of five *Yersinia pestis* genomes to analyze single-nucleotide polymorphisms of three genes to classify strains into biovar groups. Students are then given sequences of bacterial DNA amplified from the teeth of corpses from the first and second pandemics of the bubonic plague and asked to classify these new samples. Learning-assessment results reveal student improvement in self-efficacy and content knowledge, as well as students' ability to use BLAST to identify genomic islands and conduct analyses of virulence factors from *E. coli* O157:H7 or *Y. pestis*. Each of these educational modules offers educators new ready-to-implement resources for integrating comparative genomic topics into their curricula.

Integrating genomics research throughout the undergraduate curriculum: A collection of inquiry-based genomics lab modules.

L. M. Banta, E. J. Crespi, R. H. Nehm, J. A. Schwarz, S. Singer, C. A. Manduca, E. C. Bush, E. Collins, C. M. Constance, D. Dean, D. Esteban, S. Fox, J. McDaris, C. A. Paul, G. Quinan, K. M. Raley-Susman, M. L. Smith, C. S. Wallace, G. S. Withers and L. Caporale

Cell Biology Education-Life Science Education, in press.

Streamlined strategies to better visualize Southern blotting

D.M. Dean. (2012)

American Biology Teacher. 74(4): 270-271.

The “Frankenplasmid” Lab: an investigative exercise for teaching recombinant DNA methods

D.M. Dean and J. Wilder (2011).

Biochemistry and Molecular Biology Education. Sep-Oct;39(5):367-74. doi: 10.1002/bmb.20531.
Epub 2011 Jul 25.

Butterfly genome reveals promiscuous exchange of mimicry adaptations among species

HELICONIUS GENOMIC CONSORTIUM

L.S. Maroja

Nature doi:10.1038/nature11041.

The evolutionary importance of hybridization and introgression has long been debated¹. Hybrids are usually rare and unfit, but even infrequent hybridization can aid adaptation by transferring beneficial traits between species. Here we use genomic tools to investigate introgression in *Heliconius*, a rapidly radiating genus of neotropical butterflies widely used in studies of ecology, behaviour, mimicry and speciation^{2–5}. We sequenced the genome of *Heliconius melpomene* and compared it with other taxa to investigate chromosomal evolution in Lepidoptera and gene flow among multiple *eliconius* species and races. Among 12,669 predicted genes, biologically important expansions of families of chemosensory and Hox genes are particularly noteworthy. Chromosomal organization

has remained broadly conserved since the Cretaceous period, when butterflies split from the Bombyx (silkworm) lineage. Using genomic resequencing, we show hybrid exchange of genes between three co-mimics, *Heliconius melpomene*, *eliconius timareta* and *Heliconius elevatus*, especially at two genomic regions that control mimicry pattern. We infer that closely related *Heliconius* species exchange protective colour-pattern genes promiscuously, implying that hybridization has an important role in adaptive radiation.

Where Do I Come From? Using Student's Mitochondrial DNA to Teach About Phylogeny, Molecular Clocks, and Population

L.S. Maroja and J. Wilder

Genetics. Evolution: outreach and Education.

Phylogenetic reconstruction, divergence times, and population genetics are critical concepts for a complete understanding of evolution. Unfortunately, students generally lack “tree-thinking” skills and are often unmotivated to explore these concepts using typical classroom exercises that feature taxa unknown to students or simulated datasets. To generate greater student interest, we have developed an affordable practical lab (\$16 dollars per student) where students extract and sequence their own mtDNA and use it for exercises involving phylogenetic reconstruction (placement of own DNA into the world tree), divergence (speciation) time (comparing current student population with chimps, gorillas, and Neanderthal), and population genetics (demographic change calculation based on student's sample). In contrast to traditional labs, we found that students were highly motivated and enthusiastic throughout the four-week activity. Students had a 100% rate of success in obtaining DNA sequences and their evaluations report high satisfaction with the learning outcome. Here we provide all details and datasets needed to run the lab and discuss a series of assessments and possible exercises.

Convergent, modular expression of ebony and tan in the mimetic wing patterns of *Heliconius* butterflies.

L. Ferguson, L.S. Maroja, & C.D. Jiggins

Development, Genes and Evolution 221: 297-308

The evolution of pigmentation in vertebrates and flies has involved repeated divergence at a small number of genes related to melanin synthesis. Here, we study insect melanin synthesis genes in *Heliconius* butterflies, a group characterised by its diversity of wing patterns consisting of black (melanin), and yellow and red (ommochrome) pigmented scales. Consistent with their respective biochemical roles in *Drosophila melanogaster*, ebony is upregulated in non-melanic wing regions destined to be pigmented red whilst tan is upregulated in melanic regions. Wing regions destined to be pigmented yellow, however, are downregulated for both genes. This pattern is conserved across multiple divergent and convergent phenotypes within the Heliconii, suggesting a conserved mechanism for the development of black, red and yellow pattern elements across the genus. Linkage mapping of five melanin biosynthesis genes showed that, in contrast to other organisms, these genes do not control pattern polymorphism. Thus, the pigmentation genes themselves are not the locus of evolutionary change but lie downstream of a wing pattern regulatory factor. The results suggest a modular system in which particular combinations of genes are switched on whenever red, yellow or black pattern elements are favoured by natural selection for diverse and mimetic wing patterns.

Characterisation and expression of microRNAs in developing wings of the neotropical butterfly *Heliconius melpomene*.

A.K. Surridge, S. Lopez-Gomollon, S. Moxon, L.S. Maroja, T. Rathjen, N.J. Nadeau, T. Dalmay & C.D. Jiggins

BMC Genomics 12: 62doi:10.1186/1471-2164-12-62

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 2380bp 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 (~2.5Mb) 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.

Model selection analysis of temporal variation in benefit for an ant-tended treehopper.

M.A. Morales

Ecology. 92: 709-719.

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.

Reciprocally beneficial interactions between introduced plants and ants are induced by the presence of a third introduced species.

J.H. Ness, *M.A. Morales*, *E. Kenison*, *E. Leduc* ('06), *P. Leipzig-Scott*, *E. Rollinson*, and *B.J. Swimm* ('09)

Oikos, In press.

Interspecific interactions play an important role in the success of introduced species. For example, the 'enemy release' hypothesis posits that introduced species become invasive because they escape top-down regulation by natural enemies while the 'invasional meltdown' hypothesis posits that invasions may be facilitated by synergistic interactions between introduced species. Here, we explore how invasional meltdown and enemy release interact to moderate the potential effect of a large category of positive interactions – protection mutualisms. We use the interactions between an introduced plant (Japanese knotweed, *Fallopia japonica*), an introduced herbivore (Japanese beetle, *Popillia japonica*), an introduced ant (European red ant, *Myrmica rubra*), and native ants and herbivores in riparian zones of the northeastern United States as a model system. Japanese knotweed produces sugary extrafloral nectar that is attractive to ants, and we show that both sugar reward production and ant attendance increase when plants experience a level of leaf damage that is typical in the plants' native range. Using manipulative experiments at six sites, we demonstrate low-levels of ant patrolling, little effect of ants on herbivory rates,

and low herbivore pressure during midsummer. Herbivory rates and the capacity of ants to protect plants (as evidenced by effects of ant exclusion) increased significantly when plants were exposed to introduced Japanese beetles that attack plants in the late summer. Beetles were also associated with greater on-plant foraging by ants, and among-plant differences in ant-foraging were correlated with the magnitude of damage inflicted on plants by the beetles. Last, we found that sites occupied by introduced *M. rubra* ants almost invariably included Japanese knotweed. Thus, underlying variation in the spatiotemporal distribution of the introduced herbivore influences the provision of benefits to the introduced plant and to the introduced ant. More specifically, the presence of the introduced herbivore converts an otherwise weak interaction between two introduced species into a reciprocally beneficial mutualism. Because the prospects for invasional meltdown are linked to the prospects for enemy release, species introductions can have complex effects on existing species interactions, between both native and introduced species.

Chemistry

Identification of Intensity Ratio Break Points from Photon Arrival Trajectories in Ratiometric Single Molecule Spectroscopy

Dieter Bingemann and Rachel M. Allen '08

International Journal of Molecular Sciences, 13, 7445-7465 (2012)

We describe a statistical method to analyze dual-channel photon arrival trajectories from single molecule spectroscopy model-free to identify break points in the intensity ratio. Photons are binned with a short bin size to calculate the logarithm of the intensity ratio for each bin. Stochastic photon counting noise leads to a near-normal distribution of this logarithm and the standard student t-test is used to find statistically significant changes in this quantity. In stochastic simulations we determine the significance threshold for the t-test's p-value at a given level of confidence. We test the method's sensitivity and accuracy indicating that the analysis reliably locates break points with significant changes in the intensity ratio with little or no error in realistic trajectories with large numbers of small change points, while still identifying a large fraction of the frequent break points with small intensity changes. Based on these results we present an approach to estimate confidence intervals for the identified break point locations and recommend a bin size to choose for the analysis. The method proves powerful and reliable in the analysis of simulated and actual data of single molecule reorientation in a glassy matrix.

Di- μ -bromido-bis{[N,N-dimethyl-N'-(thiophen-2-ylmethylidene) ethane-1,2-diamine]copper(I)}

Christopher Goh, Zachary Remillard '12, Andre P. Martinez '09, Amanda C. Keeley, and Jerry P. Jasinski

Acta Crystallographica E., 68, m691-m692 (2012)

Copper complexes of ligands containing hetero-aromatic and amine donor moieties have multiple applications in metal-catalyzed processes. Examples include catalysts for polymerizations and organic transformations, and model complexes in the biomimetic study of copper proteins. Our group has been interested in the use of neutral tridentate hetero-aromatic-amine ligands in metal-mediated atom transfer radical polymerizations (ATRP). Here we report the synthesis and structure of a doubly bromide bridged dinuclear copper(I) complex with the ligand N,N-dimethyl-N'-(thiophen-2-ylmethylene)ethane-1,2-diamine, $[\text{Cu}_2\text{Br}_2(\text{C}_9\text{H}_{14}\text{N}_2\text{S})_2]$. In the crystal structure of this title compound the molecule resides about a crystallographic inversion center. The coordination sphere around each copper ion has a distorted tetrahedral geometry, with ligation by two bridging bromide ions, an amine N atom and an imine N atom. The thiophene ring is disordered over two sites, with occupancies of 0.719 (3) and 0.281 (3). Weak C–H \cdots p interactions feature in the crystal packing.

Hammett Correlations of Benzhydrylium Cations

Sarah L. Goh, William H. Parsons '07, Louisa Hong '08, and J. Hodge Markgraf (deceased)

Chemical Educator 17, 53-56 (2012)

This laboratory experiment investigates linear free energy relationships between Hammett σ^+ parameters and the ^1H -NMR chemical shifts of substituted benzhydrol reagents. The significance of resonance and field effects on proton shielding can be determined by relating chemical shift data to various forms of Hammett equations. Benzhydrylium cations can be studied as well by ^{13}C -NMR spectroscopy.

Complex Dynamics in a Modified Lotka-Volterra Model with Predator Pairing

Syed Kashif Akhtar '06, Alison B. Peet '03, and Enrique Peacock-López

Journal of Biological Systems, 20, 87-108 (2012)

In this work we propose an ecological model, which is a modified version of the Bazykin model. This model of predator–prey interaction emphasizes predator pairing that yields steady state, periodic and extinction stable solutions. Moreover, we find attractor coexistence between limit cycles, steady states, and the extinction solution, which is always a stable attractor. We also study this model as a spatially extended system in one and two dimensions and obtain Turing patterns such as stripes and spots as well as the so-called black-eye patterns, and, as in the homogeneous case, the spatial patterns coexist with the homogeneous extinction solution.

Switching Induced Complex Dynamics in an Extended Logistic Map

Erik A. Levinsohn '12, Steve A. Mendoza '13, and Enrique Peacock-López

Chaos, Solitons and Fractals, 45, 426-432 (2012)

Switching strategies have been related to the so-called Parrondian games, where the alternation of two losing games yields a winning game. We can consider two dynamics that, by themselves, yield different simple dynamical behaviors, but when alternated, yield complex trajectories. In the analysis of the alternate-extended logistic map, we observe a plethora of complex dynamic behaviors, which coexist with a super stable extinction solution.

Self-regulation in a Minimal Model of Chemical Self-replication

Sylvia J. Lou '09 and Enrique Peacock-López

Journal of Biological Physics, 38, 349-364 (2012)

In biological systems, regulation plays an important role in keeping metabolite concentrations within physiological ranges. To study the dynamical implications of self-regulation, we consider a functional form used in genetic networks and couple it to a mechanism associated with chemical self-replication. For the two-variable minimal model, we find that activation can yield chemical toggles similar to those reported for gene repression in *E. coli* as well as more complex dynamics.

Seasonality as a Parrondian Game

Enrique Peacock-López

Physics Letters A, 375, 3124-3129 (2011)

Switching strategies can be related to the so-called Parrondian games, where the alternation of two losing games yields a winning game. We consider two dynamics that by themselves yield undesirable behaviors, but when alternated, yield a desirable oscillatory behavior. In the analysis of the alternate-logistic map, we prove that alternating parameter values yielding extinction with parameter values associated with chaotic dynamics results in periodic trajectories. Ultimately, we consider a four season logistic model with either migration or immigration.

Stereochemically Versatile Synthesis of the C1—C2 Fragment of Tedanolide C

Thomas E. Smith '88, Sarah J. Fink '08, Zebulon G. Levine '11, Kerani A. McClelland '10, Adrian A. Zackheim '09, and Mary E. Daub '11

Organic Letters, 14, 1452-1455 (2012)

A flexible synthesis of the C1–C12 fragment of tedanolide C has been accomplished in eight steps from 2-methyl-2,4-pentadienal. Asymmetric hydroformylation of a 1,3-diene allows for the late-stage generation of either C10 epimer with complete catalyst control. Diastereoselective addition of an isobutyryl β -ketoester dianion to an α,β -disubstituted chiral aldehyde sets the C5 stereochemistry while installing the geminal dimethyl unit. Differential protection of a syn-1,3-diol is performed as a highly efficient single-pot operation.

Computer Science

Exploiting Home Automation Protocols for Load Monitoring in Smart Buildings

David Irwin, Anthony Wu, Sean Barker, Aditya Mishra, Prashant Shenoy, and Jeannie Albrecht

Proceedings of the Third ACM Workshop On Embedded Sensing Systems For Energy-Efficiency In Buildings (BuildSys), November 2011

Monitoring and controlling electrical loads is crucial for demand-side energy management in smart grids. Home automation (HA) protocols, such as X10 and Insteon, have provided programmatic load control for many years, and are being widely deployed in early smart grid field trials. While HA protocols include basic monitoring functions, extreme bandwidth limitations ($<180\text{bps}$) have prevented their use in load monitoring. In this paper, we highlight challenges in designing AutoMeter, a system for exploiting HA for accurate load monitoring at scale. We quantify Insteon's limitations to query device status — once every 10 seconds to achieve less than 5% loss rate — and then evaluate techniques to disaggregate coarse HA data from fine-grained building-wide power data. In particular, our techniques learn switched load power using on-off-dim events, and tag fine-grained building-wide power data using readings from plug meters every 5 minutes.

Distributed Application Configuration, Management, and Visualization with Plush

Jeannie Albrecht, Christopher Tuttle, Ryan Braud, Darren Dao, Nikolay Topilski, Alex C. Snoeren, and Amin Vahdat

ACM Transactions on Internet Technology (TOIT), December 2011

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.

SmartCap: Flattening Peak Electricity Demand in Smart Homes

Sean Barker, Aditya Mishra, David Irwin, Prashant Shenoy, and Jeannie Albrecht

Proceedings of the Tenth IEEE Conference On Pervasive Computing and Communications (PerCom), March 2012. Best Paper Session.

Flattening household electricity demand reduces generation costs, since costs are disproportionately affected by peak demands. While the vast majority of household electrical loads are interactive and have little scheduling flexibility (TVs, microwaves, etc.), a substantial fraction of home energy use derives from background loads with some, albeit limited, flexibility. Examples of such devices include A/Cs, refrigerators, and dehumidifiers. In this paper, we study the extent to which a home is able to transparently flatten its electricity demand by scheduling only background loads with such flexibility. We propose a Least Slack First (LSF) scheduling algorithm for household loads, inspired by the well-known Earliest Deadline First algorithm. We then integrate the algorithm into SmartCap, a system we have built for monitoring and controlling electric loads in homes. To evaluate LSF, we collected power data at outlets, panels, and switches from a real home for 82 days. We use this data to drive simulations, as well as experiment with a real testbed implementation that uses similar background loads as our home. Our results indicate that LSF is most useful during peak usage periods that exhibit “peaky” behavior, where power deviates

frequently and significantly from the average. For example, LSF decreases the average deviation from the mean power by over 20\% across all 4-hour periods where the deviation is at least 400 watts.

An Intermittent Energy Internet Architecture

Barath Raghavan, David Irwin, *Jeannie Albrecht*, Justin Ma, and Adam Streed

Proceedings of the Third International Conference on Future Energy Systems (e-Energy), May 2012

We examine how to re-design the Internet for an energy-constrained future powered by diffuse, intermittent, and expensive power sources. We consider the types of constraints this might place upon the Internet architecture and the manner in which important network components can function in this new environment. We then attempt to chart a path forward for future research.

A Porous Aperiodic Decagon Tile

Duane A. Bailey and Feng Zhu '02

The 10th Gathering for Gardner, March 2012

We consider the development of a single universal aperiodic prototile that tiles the plane without overlap. We outline, here, an approach to constructing a porous, positive measure, non-overlapping prototile from the universal aperiodic decagon tile that covers the plane. Many characteristics of the decagon cover are inherited by this tiling.

Feature Selection via Probabilistic Outputs

Andrea Danyluk and Nicholas Arnosti '11

ICML 2012: Proceedings of the Twenty-Ninth International Conference on Machine Learning (2012)

This paper investigates two feature-scoring criteria that make use of estimated class probabilities: one method proposed by Shen et al, and a complementary approach proposed here. We develop a theoretical framework to analyze each criterion and show that both estimate the spread (across all values of a given feature) of the probability that an example belongs to the positive class. Based on our analysis, we predict when each scoring technique will be advantageous over the other and give empirical results validating those predictions.

Types for Precise Thread Interference

Stephen Freund, Jaeheon Yi, Tim Disney, and Cormac Flanagan

Workshop on Foundations of Object-Oriented Languages, 12 pages, 2011

The potential for unexpected interference between threads makes multithreaded programming notoriously difficult. Programmers use a variety of synchronization idioms such as locks and barriers to restrict where interference may actually occur. Unfortunately, the resulting actual interference points are typically never documented and must be manually reconstructed as the first step in any subsequent programming task (code review, refactoring, etc).

This paper proposes explicitly documenting actual interference points in the program source code, and it presents a type and effect system for verifying the correctness of these interference specifications.

Experimental results on a variety of Java benchmarks show that this approach provides a significant improvement over prior systems based on method-level atomicity specifications. In particular, it reduces the number of interference points one must consider from several hundred points per thousand lines of code to roughly 13 per thousand lines of code. Explicit interference points also serve to highlight all known concurrency defects in these benchmarks.

Cooperative Concurrency for a Multicore World

Stephen Freund, Jaeheon Yi, Caitlin Sadowski, and Cormac Flanagan

Proceedings of the International Conference on Runtime Verification, 3 pages, 2011

Developing reliable multithreaded software is notoriously difficult, due to the potential for unexpected interference between concurrent threads. Much prior work has addressed this problem, mostly focused on verifying the correctness properties of race-freedom and atomicity. We propose an alternative approach whereby all thread interference must be specified with explicit yield annotations.

Rigid Components in Fixed-Lattice and Cone Frameworks

Matthew Berardi, Brent Heeringa, Justin Malestein, and Louis Theran

Proceedings of the 23rd Annual Canadian Conference on Computational Geometry (CCCG), 2011

We study the fundamental algorithmic rigidity problems for generic frameworks periodic with respect to a fixed lattice or a finite-order rotation in the plane. For fixed-lattice frameworks we give an $O(n^2)$ algorithm for deciding generic rigidity and an $O(n^3)$ algorithm for computing rigid components. If the order of rotation is part of the input, we give an $O(n^4)$ algorithm for deciding rigidity; in the case where the rotation's order is 3, a more specialized algorithm solves all the fundamental algorithmic rigidity problems in $O(n^2)$ time.

Batch Active Learning via Coordinated Matching

Javad Azimi, Alan Fern, Xiaoli Z. Fern, Glencora Borradaile, and Brent Heeringa

Proceedings of the 29th International Conference on Machine Learning (ICML), 2012

We propose a novel batch active learning method that leverages the availability of high-quality and efficient sequential active-learning policies by approximating their behavior when applied for k steps. Specifically, our algorithm uses Monte-Carlo simulation to estimate the distribution of unlabeled examples selected by a sequential policy over k steps. The algorithm then selects k examples that best matches this distribution, leading to a combinatorial optimization problem that we term “bounded coordinated matching.” While we show this problem is NP-hard, we give an efficient greedy solution, which inherits approximation bounds from supermodular minimization theory. Experiments on eight benchmark datasets show that the proposed approach is highly effective.

Scalable Ambient Obscure

Morgan McGuire, M. Mara '12, and D. Luebke

ACM SIGGRAPH/Eurographics High Performance Graphics, June 2012

This paper presents a set of architecture-aware performance and integration improvements for a recent screen-space ambient obscuration algorithm. These improvements collectively produce a 7x performance increase at 2560x1600, generalize the algorithm to both forward and deferred renderers, and eliminate the radius- and scene-dependence of the previous algorithm to provide a hard real-time guarantee of fixed execution time. The optimizations build on three strategies: pre-filter the depth buffer to maximize memory hierarchy efficiency; reduce total bandwidth by carefully reconstructing positions and normals at high precision from a depth buffer; and exploit low-level intra- and inter-thread techniques for parallel, floating-point architectures.

A Reconstruction Algorithm for Plausible Motion Blur

Morgan McGuire, P. Hennessy, M. Bukowski, and B. Osman

ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games (I3D), February 2012

This paper describes a novel filter for simulating motion blur phenomena in real time by applying ideas from offline stochastic reconstruction. The filter operates as a 2D post-process on a conventional framebuffer augmented with a screen-space velocity buffer. We demonstrate results on video game scenes rendered and reconstructed in real-time on NVIDIA GeForce 480 and Xbox 360 platforms, and show that the same filter can be applied to cinematic post-processing of offline-rendered images and real photographs. The technique is fast and robust enough that we deployed it in a production game engine used at Vicarious Visions.

The Alchemy Screen-Space Ambient Obscurance Algorithm

Morgan McGuire, B. Osman, M. Bukowski, and P. Hennessy

ACM SIGGRAPH/EuroGraphics High-Performance Graphics, 8, August 5, 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.

Efficient Triangle and Quadrilateral Clipping in Shaders

Morgan McGuire

The Journal of Graphics Tools, Taylor and Francis, **15**(4), 2011

Clipping a triangle or a convex quadrilateral to a plane is a common operation in computer graphics. This clipping is implemented by fixed-function units within the graphics pipeline under most rasterization APIs. It is increasingly interesting to perform clipping in programmable stages as well. For example, to clip bounding volumes generated in the Geometry unit to the near plane, or to clip an area light source to the tangent plane of a surface in a Pixel unit.

While clipping a convex polygon is algorithmically trivial, doing so efficiently on vector architectures like GPUs can be tricky. This article presents an efficient implementation of Sutherland-Hodgman clipping for vector processors. It has high branch coherence, uses only register storage (i.e., it does not require a move-relative memory operation), leverages both data and instruction parallelism, and has a peak register count of only two 4-vectors (7 scalars).

I found it to be about five times faster than direct Sutherland-Hodgman and yield a 45% increase in net throughput when applied in the algorithm from a previous publication on two different GPU architectures. The principles of optimization presented for this class of parallel algorithm extend to other algorithms and architectures.

Geosciences

Benthic foraminiferal stable oxygen isotope stratigraphies from IODP Sites U1339 and U1345

Mea Cook, Assistant Professor of Geosciences, A. C. Ravelo, and A. C. Mix

American Geophysical Union, (2012)

We present preliminary age models from two sites drilled during the Integrated Ocean Drilling Program Expedition 323 to the Bering Sea: U1339 at Umnak Plateau and U1345 on the continental slope in north-central Bering Sea. The age models are based on the $\delta^{18}\text{O}$ measured in benthic foraminifera, then correlated to the global stack of Lisiecki and Raymo (2005). Since no one species was present throughout the core, we measured stable isotopes on five species: *Uvigerina peregrina*, *U. senticosa*, *Elphidium cf. batialis*, *Nonionella labradorica*, and *Globobulimina affinis*. We corrected the oxygen isotope measurements for the offset between *U. peregrina* and the other species. Authigenic carbonates appear in sediments at both sites, and affect some of the stable isotope measurements. Bulk sediment stable isotopes measurements from U1339 reveal that there are at least four distinct compositions of authigenic carbonates in those sediments, including ones with anomalously low $\delta^{13}\text{C}$, anomalously low $\delta^{18}\text{O}$ or both, compared to foraminifera.

Intermediate-Depth Ventilation in the Bering Sea from the Last Glacial Maximum to the Holocene

Mea Cook, Assistant Professor of Geosciences, S. A. Schlung, A. C. Ravelo, and T. P. Guilderson

American Geophysical Union, (2011)

The Bering Sea is the northernmost marginal basin in the Pacific Ocean. Though no subsurface water mass forms there today, it has long been regarded as a location where intermediate or deep water may have formed in the past. During the last deglaciation, intermediate-depth sediments from around the North Pacific margin from Baja California to Japan are dysoxic or laminated, including in the Bering Sea. It is not clear what are the relative roles of several mechanisms that could have contributed to the oxygen depletion: the intensification of local export production, reduced intermediate water ventilation rate, lower preformed oxygen concentration, or change in the source of intermediate water. With sediment cores that range from 1.0 to 2.2 km water depth, we investigate the ventilation history of the Bering Sea using stable oxygen and carbon isotope and radiocarbon measurements on planktonic and benthic foraminifera. During the Bolling warm period, water at intermediate depths in the Bering Sea were enriched in ^{14}C and ^{13}C . This well-ventilated water mass co-existed with a more intense and expanded oxygen minimum zone, implying that the intense surface ocean productivity that occurred in the subarctic Pacific at this time was responsible for the oxygen depletion. Therefore, dysoxia observed around the rest of the North Pacific margin at this time is associated with better intermediate water ventilation, and a decoupling of oxygen concentrations and ventilation rates.

Paleo-Iron Supply to the Western Subarctic Pacific Since the Last Glaciation

P. J. Lam, L. F. Robinson, J. Blusztajn, J. F. McManus, Mea Cook, Assistant Professor of Geosciences, and L. D. Keigwin

American Geophysical Union, (2011)

A strong and pervasive productivity peak has been observed in cores around the North Pacific during the Bølling-Allerød warm period of the last deglaciation. Recently, it has been hypothesized that this peak may have been caused by an influx of iron from the continental shelves as they were flooded during the deglaciation. Here, we examine this hypothesis by reconstructing the flux and sources of detrital material to a sediment core from the Detroit seamount (Vinogradov 19/4 GGC-37, 50.4°N, 167.7°E, 3300m) in the Western Subarctic Pacific since the last glacial maximum (LGM), and compare to several proxies of paleo-the Western Subarctic Pacific since the last glacial maximum (LGM), and compare to several proxies of paleoproductivity. We use ^{230}Th -normalization to reconstruct the flux of biogenic and detrital material, and the neodymium and strontium isotopic compositions to distinguish between volcanic margin and continental loess sources of detrital material. We find that total detrital flux is highest during the last glacial maximum and early deglacial periods, a time of relatively low productivity, with approximately equal contributions from the volcanic margin and from continental loess. Total detrital flux starts to decline around 16 kya, but increases again to 80% of the glacial maximum flux around the time of the Bølling-

Allerød productivity peak. The local deglacial maximum in detrital flux coincides with a maximum in authigenic uranium, and immediately precedes maxima in opal flux, carbonate flux, benthic foraminifera abundance, and excess $^{231}\text{Pa}/^{230}\text{Th}$. While the local deglacial maximum in detrital flux is consistent with iron stimulation of productivity, we conclude that iron supply alone is not sufficient to explain the deglacial productivity peak, since glacial times exhibited low productivity despite high detrital flux. Further, the relative and absolute contributions of detrital material of volcanic origin is lower during the deglaciation than during the LGM, suggesting that loess may have contributed more iron during the deglacial productivity peak. To explain the low—high—low pattern of productivity during glacial, deglacial, and Holocene periods, respectively, we suggest that productivity was primarily major nutrient-limited but iron replete during glacial times, replete in both iron and major nutrients during the deglacial productivity peak, and primarily iron limited during the Holocene and modern times. Iron-replete production during the LGM and the deglacial productivity peak is consistent with a higher nutrient utilization suggested by high $\delta^{15}\text{N}$ during these times.

Enhanced Southern Ocean Ventilation Through the Last Deglaciation

A. C. Elmore, E. L. Sikes, *Mea Cook, Assistant Professor of Geosciences*, B. Schiraldi, and T. P. Guilderson
American Geophysical Union, (2011)

During the last deglaciation, abrupt changes in Southern Ocean ventilation are linked to corresponding abrupt changes in climate, where ventilation began with a flush of the shallow interior and progressively spread well-ventilated waters deeper as the deglaciation continued. Ventilation changes in the New Zealand region of the Southern Ocean were reconstructed using high-resolution, mono-specific (*P. wuellerstorfi*), benthic foraminiferal $\delta^{13}\text{C}$ from 6 cores on the New Zealand Margin, spanning 663 to 3836 m water depth. Age models for these cores were determined using tephrostratigraphy and benthic foraminiferal $\delta^{18}\text{O}$. At the Last Glacial Maximum (LGM), the $\delta^{13}\text{C}$ difference ($\Delta\delta^{13}\text{C}$) between 663 to 2541 m is $\sim 1.7\%$. In the Holocene, the deep water $\delta^{13}\text{C}$ value is higher, and $\Delta\delta^{13}\text{C}$ decreases to $\sim 1.0\%$, implying that glacial deep waters were less ventilated. In the early deglaciation, during Heinrich Event 1, $\delta^{13}\text{C}$ at the site of modern-day Antarctic Intermediate Water (1165 m) was significantly higher suggesting a pulse of newly ventilated water emanated from the Southern Ocean. During the Antarctic Cold Reversal, the $\Delta\delta^{13}\text{C}$ profile is similar to the LGM, indicating that ventilation slowed, with a return to glacial-like conditions. Enrichment of the water column in $\delta^{13}\text{C}$ from 1165 to 3836 m during the Younger Dryas suggests increasing ventilation of deeper water masses, whereas at 663 m, $\delta^{13}\text{C}$ decreases, implying reduced formation of Subantarctic Mode Water.

Depleted Radiocarbon in Deep Water in the Southwest Pacific and Southern Ocean at the Last Glacial Maximum

E. L. Sikes, *Mea Cook, Assistant Professor of Geosciences*, A. C. Elmore, and T. P. Guilderson
American Geophysical Union, (2011)

The relative ^{14}C ages of surface and deep marine waters reflect the balance between air-sea exchange of $^{14}\text{CO}_2$ in deep-water formation areas, the radioactive decay of ^{14}C during subsurface circulation, and the mixing between adjacent water masses. The $\Delta^{14}\text{C}$ of the interior ocean is known to vary due to the major reorganization of circulation and CO_2 sequestration associated with glacial to interglacial climate changes. Using benthic and planktonic ^{14}C ages from deep-sea sediment cores from the southwest Pacific, east of New Zealand, we have constructed a composite depth profile of ^{14}C ages from the late glaciation through the early deglaciation. By using regionally widespread tephra layers as independent stratigraphic markers we can estimate atmosphere-ocean $\Delta^{14}\text{C}$ differences. Relative to the atmosphere, our estimates of the $\Delta^{14}\text{C}$ at intermediate depths (above 1600 m) are broadly consistent with ventilation similar to today. In contrast, the $\Delta^{14}\text{C}$ of upper and mid-depth deep water (~ 2000 -3800 m) at several points between the late glacial and early deglaciation (24-15 ka) indicate a deep water mass with significantly lower $\Delta^{14}\text{C}$ than we would expect for a deep circulation similar to today's. The $\Delta^{14}\text{C}$ depletions are range from 50-500‰, with the gradient between deep and intermediate waters both shallower and steeper than today. Below 3800 m, deep water $\Delta^{14}\text{C}$ appear less depleted. Benthic-planktonic $\Delta^{14}\text{C}$ differences at all depths show greater relative differences than modern, with the largest differences in upper deep waters. The data from these deep Pacific cores may be susceptible to biases from dissolution and/or bioturbation. However, our consistently low $\Delta^{14}\text{C}$ estimates of deep water during the late glacial support the hypothesis that there was a

¹⁴C-depleted CO₂ rich water mass in the deep Pacific Ocean during the Last Glacial Maximum that was released to the atmosphere through exchange in the Southern Ocean during the deglaciation.

Boulder Ridges on the Aran Islands (Ireland): Recent Movements Caused by Storm Waves, not Tsunami

Rónadh Cox, Professor of Geosciences, D. B. Zentner '09, B. J. Kirchner '13 and M. S. Cook

Journal of Geology, 120 (3), 249-272 (2012)

Ireland's Aran Islands are an excellent place to test whether coastal boulder deposits—including individual rocks weighing several tens of tonnes near sea level, and clasts weighing several tonnes transported at tens of m above sea level—require tsunamis for emplacement, or whether storm waves can do this work. Elongate deposits of cobbles, boulders, and megagravel are strung along the Atlantic coasts of the Aran Islands. No tsunamis have affected this region in recent centuries, so if these deposits are forming or migrating at the present time, they must be storm-activated. We find a diverse range of evidence for recent ridge activity. First, shells of *Hiattella arctica* (subtidal rock-boring bivalves preserved in life position within ridge boulders) yield radiocarbon ages from ~200 AD to modern (post-1950 AD). Second, recent motion is attested to by eye-witness accounts that pin movement of several individual 40-80 tonne blocks to a specific 1991 storm, and by repeat photography over the last few field seasons (2006-2011) that captures movement of boulders (masses up to ~10.5 tonnes) even in years without exceptionally large storms. Finally, GIS comparison of 19th C Ordnance Survey maps with 21st C orthophotos shows that in several areas the boulder ridges have advanced tens of metres inland since the mid-19th C, overrunning old field walls. These advancing ridges contain boulders with masses up to 78 tonnes at 11 m above high-water mark, so wave energies sufficient to transport those blocks must have occurred since the 1839 survey. Thus there is abundant evidence for ridge activity since the 1839 mapping; and as there have been no tsunamis in the northeastern Atlantic in that time period, we conclude that the Aran Islands boulder ridges are built and moved by storm waves.

Hydrodynamic Fractionation of Zircon Age Populations

R. L. Lawrence '07, Rónadh Cox, Professor of Geosciences, 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 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.

Host sand size is correlated with average size of co-transported zircons, implying hydrodynamic fractionation. Zircon size is positively correlated with percent medium sand, and inversely correlated with percent very fine sand ($p < 0.0001$ in both cases). In samples with >50% medium sand, average zircon size is $100 \mu\text{m}$, compared with $80 \mu\text{m}$ in samples with >50% very fine sand. We infer from these data that zircon deposition is not size-blind, and that zircons track with hydraulically comparable sand grains. As different aged grains tend to have different characteristic sizes, this indicates the possibility of hydrodynamic fractionation of age populations.

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.

Crust-Breaching Impacts at Europa: Hydrocode Models and Geomorphologic Constraints on Ice Thickness

Rónadh Cox, Professor of Geosciences and A. W. Bauer '11

Geological Society of America Abstracts with Programs, 43, 75 (2011)

Estimates of Europa's surface ice thickness range from 1 to 40 km (median estimate is 6 km). For crust thicknesses in this range, some proportion of impactors is likely to fully penetrate through the ice to water beneath. But because inner solar system bodies behave as fully solid targets (having rocky mantles beneath their crusts), our understanding of the dynamics of penetrative impacts is limited. So we have made numerical simulations—using the iSALE hydrocode—of impacts into ice over water, varying impact energy and ice thickness, to examine impact behaviour under European conditions.

We find the entire range of proposed European crust thickness liable to full impact penetration. For crusts <5 km thick, icy bolides 500 m diameter (impacting at 26.5 km.s^{-1}) will penetrate. In 10 km crust, 500 m objects will form craters but anything larger will penetrate to water (by melting through at smaller diameters or by impact breaching as diameter increases). In 20 km crust, a 1.5 km object will crater, but larger ones will go through. For 30 km crust, a 2 km bolide will crater, but a 3 km one will penetrate. At 40 km, a 3 km bolide will crater, but a 5 km one will punch straight through to liquid beneath.

We may be able to constrain ice thickness at Europa by comparing depth/diameter (d/D) ratios of modeled craters with those measured from Galileo imagery, because shapes of the modeled craters vary as a function of impactor energy and ice thickness. Our data suggest thicknesses <10 km, because large craters produced in thicker crusts have profiles that do not match those of features measured on Europa. For example, the crater produced by a 1.5 km impactor in 20 km crust is 38.5 km in diameter and 1.3 km deep after 50 hours; but actual impact features in the ≈ 40 km size range on Europa are much shallower (only 50-100 m). We find d/D ratios consistent with European observations only for crusts <10 km thick.

Storm Waves Move Large Boulder Ridges on the Aran Islands, Ireland

Rónadh Cox, Professor of Geosciences, D. B. Zentner '09, and M.S. Cook

Geological Society of America Abstracts with Programs, 43, 596 (2011)

Boulder ridges on the Atlantic coasts of the Aran Islands are linear or arcuate deposits of cobbles, boulders, and megagravel. The ridge deposits occur at elevations 1-40 m above Higher High Water (HHW), and at horizontal distances that range from a few m to 250 m inland from HHW. Some are perched on top of sheer cliffs, and others are at the back of wide, gently sloping platforms. The boulders come from seaward, eroded from the cliff top or platform surface and transported landward. Clast size is variable: average boulder size decreases at higher elevation, but lower elevation ridges (≈ 12 m above HHW) incorporate boulders weighing up to 78 tonnes. We present evidence that the ridges are formed and moved by storm waves. First, shells of *Hiatella arctica* (subtidal rock-boring bivalves preserved in life position within ridge boulders) yield radiocarbon ages from ≈ 200 AD to modern (post-1950 AD). Second, GIS comparison of 19th C Ordnance Survey maps with 21st C orthophotos shows that in several areas the boulder ridges have advanced 10s of metres inland since the mid-19th C, overrunning old field walls in the process. The advancing ridges include the segment with boulders up to 78 tonnes at 12 m above sea level, so wave energies sufficient to transport those blocks must have occurred since the 1839 survey. Finally, recent motion is attested to by eye-witness accounts that pin movement of several individual 40-80 tonne blocks to a specific 1991 storm, and by repeat photography over the last few field seasons (2006-2011) that captures movement of boulders (masses up to 12 tonnes) even in years without exceptionally large storms. Thus there is abundant evidence for ridge activity since the 1839 mapping. As there have been no tsunamis in the northeastern Atlantic in that time period, we conclude that the Aran Islands boulder ridges are built and moved by storm waves.

**Geologic map of the Cochiti Dam quadrangle, Sandoval County, New Mexico: U.S. Geological Survey
Scientific Investigations Map 3194**

David Dethier, Professor of Geosciences, R. A. Thompson, M. R. Hudson, S. A. Minor, and D. A. Sawyer

United States Geological Survey (2011)

The Cochiti Dam quadrangle is located in the southern part of the Española Basin and contains sedimentary and volcanic deposits that record alluvial, colluvial, eolian, tectonic and volcanic processes over the past seventeen million years. The geology was mapped from 1997 to 1999 and modified in 2004 to 2008. The primary mapping responsibilities were as follows: Dethier mapped the surficial deposits, basin-fill sedimentary deposits, Miocene to Quaternary volcanic deposits of the Jemez volcanic field, and a preliminary version of fault distribution. Thompson and Hudson mapped the Pliocene and Quaternary volcanic deposits of the Cerros del Rio volcanic field. Thompson, Minor, and Hudson mapped surface exposures of faults and Hudson conducted paleomagnetic studies for stratigraphic correlations. Thompson prepared the digital compilation of the geologic map.

The mapped distribution of units is based primarily on interpretation of 1:16,000-scale, color aerial photographs taken in 1992, and 1:40,000-scale, black-and-white, aerial photographs taken in 1996. Most of the contacts on the map were transferred from the aerial photographs using a photogrammetric stereo-plotter and subsequently field checked for accuracy and revised based on field determination of allostratigraphic and lithostratigraphic units. Determination of lithostratigraphic units in volcanic deposits was aided by geochemical data, $^{40}\text{Ar}/^{39}\text{Ar}$ geochronology, aeromagnetic and paleomagnetic data. Supplemental revision of mapped contacts was based on interpretation of USGS 1-meter orthoimagery.

**Characteristics of a Paleosol and its Implication for the Critical Zone Development, Rocky Mountain
Front Range of Colorado, USA**

Matthias Leopold, Jörg Völkel, David Dethier, Professor of Geosciences, Juliane Huber, and Markus Steffens

Applied Geochemistry, 26, S72-S75 (2011)

Activity and stability phases as well as geomorphic processes within the Critical Zone are well known. Erosion and deposition of sediments represent activity; soils represent geomorphic stability phases. Data are presented from a 4 m deep sediment section that was dated by luminescence techniques. Upslope erosion and resulting sedimentation started in the late Pleistocene around 18 ka until 12 ka. Conditions at the study site then changed, which led to the formation of a well-developed soil. Radiocarbon dating of the organic matter yielded ages between 8552 and 8995 cal. BP. From roughly 6.2 to 5.4 ka another activity phase accompanied by according sediment deposition buried the soil and a new soil, a Cambisol, was formed at the surface. The buried soil is a strongly developed Luvisol. The black colors in the upper part of the buried soil are not the result of pedogenic accumulation of normal organic matter within an A-horizon. Nuclear magnetic resonance spectroscopy clearly documents the high amount of aromatic components (charcoal), which is responsible for the dark color. This indicates severe burning events at the site and the smaller charcoal dust (black carbon) was transported to deeper parts of the profile during the process of clay translocation.

Revisiting Long-Term Dustfall Rates and Chemistry, Colorado Front Range

David Dethier, Professor of Geosciences, James McCarthy '11, and William Ouimet

Geological Society of America Abstracts with Programs, 43 (5), 336 (2011)

For many decades, geomorphologists and soil scientists have noted the influence of dustfall (clay + silt) on the morphology, texture and chemistry of late Pleistocene and Holocene soils in the Front Range and other upland areas of the S. Rocky Mountains. Contemporary measurements demonstrate the influence of dustfall P and other elements on ecosystem function, but deposition rates over longer time periods are also significant. In addition, recent advances in applying meteoric ^{10}Be to analyze soil age and evolution argue that dust may be an important component of ^{10}Be delivery. Measurements from sites in the Boulder Creek catchment and published values from nearby areas suggest that the long-term, net clay accumulation rate is about $0.04 \text{ gm cm}^{-2} \text{ kyr}^{-1}$ in soils on stable, dated surfaces such as Neoglacial, Pinedale and Bull Lake moraines. Clay concentration in parent material is the principal source of measurement uncertainty. Clay+ silt accumulation rates are $\sim 0.1 \text{ gm cm}^{-2} \text{ kyr}^{-1}$. Because

measured accumulation rates integrate fines generated by weathering and dustfall, they provide an upper limit for dustfall rates. If our values are correct, dustfall should not significantly influence the total amount of ^{10}Be delivered to soil surfaces in the upland Front Range. The chemistry of soil fine fractions does not permit clear separation of pedogenic vs. dustfall origin nor provide simple clues about dust provenance. Trace components such as Zr, Nb and P show strong size fractionation in crushed fresh-rock samples of Boulder Creek granodiorite and other local rock types, complicating elemental-ratio approaches for assessing the origin of fine material. Contemporary dustfall measurements in the upland Front Range suggest that modern rates are much greater than long-term values, perhaps reflecting changes in land use or climate.

Oceanic Crustal Velocities from Laboratory and Logging Measurements of Integrated Ocean Drilling Program Hole 1256D

Lisa Gilbert, Assistant Professor of Geosciences and Marine Sciences and M. H. Salisbury

Geochem. Geophys. Geostyt., 12, 09001 (2011)

Drilling and logging of Integrated Ocean Drilling Program (IODP) Hole 1256D have provided a unique opportunity for systematically studying a fundamental problem in marine geophysics: What influences the seismic structure of oceanic crust, porosity or composition? Compressional wave velocities (V_p) logged in open hole or from regional refraction measurements integrate both the host rock and cracks in the crust. To determine the influence of cracks on V_p at several scales, we first need an accurate ground truth in the form of laboratory V_p on crack-free, or nearly crack-free samples. We measured V_p on 46 water-saturated samples at in situ pressures to determine the baseline velocities of the host rock. These new results match or exceed V_p logs throughout most of the hole, especially in the lower dikes and gabbros, where porosities are low. In contrast, samples measured at sea under ambient laboratory conditions, had consistently lower V_p than the V_p logs, even after correction to in situ pressures. Crack-free V_p calculated from simple models of logging and laboratory porosity data for different lithologies and facies suggest that crustal velocities in the lavas and upper dikes are controlled by porosity. In particular, the models demonstrate significant large-scale porosity in the lavas, especially in the sections identified as fractured flows and breccias. However, crustal velocities in the lower dikes and gabbros are increasingly controlled by petrology as the layer 2-3 boundary is approached.

Geological and Geophysical Observations of Normal Oceanic Crust

Lisa Gilbert, Assistant Professor of Geosciences and Marine Sciences and M. H. Salisbury

Geological Society of America Abstracts with Programs, 43 (5), 278 (2011)

Observations of exposed oceanic crust in tectonic windows and analogies to ophiolites have helped advance our understanding of the geologic nature of oceanic crust. In recent years, the Integrated Ocean Drilling Program (IODP) has succeeded in reaching through lavas and dikes to gabbros for the first time in a section of normal oceanic crust. IODP Hole 1256D provides a unique opportunity to integrate geologic and geophysical data at several scales. Samples and geophysical data logged in the open hole allow us to ground-truth the geophysical layers identified by regional seismic experiments. To determine the influence of cracks on seismic velocity at several scales, we first need an accurate ground-truth, in the form of laboratory velocity of crack-free, or nearly crack-free samples. Hand samples include few cracks since drilling recovery generally excludes cracks except those that have been filled or are small enough to be preserved within the 6 cm diameter core. The influence of cracks on seismic velocity is then determined as the difference between seismic velocities of hand samples and seismic velocities logged in the open hole or from regional experiments. Crack-free velocities calculated from simple models of logging and laboratory porosity data for different lithologies and facies suggest that crustal velocities in the lavas and upper dikes are strongly influenced by porosity. In particular, our models demonstrate significant large-scale porosity in the lavas, especially in the units previously identified as fractured flows and breccias. In the lower dikes and gabbros porosity drops to less than 1% and crustal velocities are controlled by other factors. At this location, seismic velocity and porosity both change noticeably at the transition between lavas and dikes and the seismic layer 2/3 boundary is estimated to be within about 100 m of the bottom of the hole and likely near or coincident with the transition between dikes and gabbros.

The Lavas-Dikes Boundary in Superfast Spreading Crust: Inferences from Structure and Geophysical Logs at IODP Hole 1256D (Equatorial Pacific)

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Geotitalia, the 8th Italian Forum of Earth Sciences (2011)

The boundary between seismic layer 2B (basalt extrusives) and layer 2C (sheeted dike complex) in the oceanic crust created at fast and superfast-spreading ridges is commonly characterized by intense rock fracturing and occurrence of breccias hosting metal sulfides. In ODP-IODP Hole 1256D (East Pacific Rise, Cocos Plate) the layer 2B/2C boundary corresponds to the Transition Zone (TZ) located between the overlying Sheet and Massive Flows and the underlying Sheeted Dike Complex. The TZ is about 60m thick and consists of basaltic sheet and massive flows, a cataclastic unit, and hyaloclastitic breccias cemented by sulfides, quartz, anhydrite, calcite, and minor amphibole. It separates two contrasting metamorphic zones, the shallowest basalts being altered at low temperature conditions, and the deeper basalts being affected by greenschists-facies alteration. The upper and lower boundaries of the TZ have been defined at 1004mbsf and 1061mbsf, respectively. However, due to low recovery rates in Hole 1256D, especially from brecciated intervals and fracture fillings, these two boundary depths do not perfectly fit with those suggested by wireline geophysical logs and by structural data on cores. Namely, steep fractures and cataclasites, likely related to the stress field induced by intrusion of dikes at depth, are concentrated up to ca. 800 mbsf, in accord with FMS and UBI images. The seismic structure of the crust is affected by fracture shape, namely, low aspect ratio (thin fractures) have much more effect on compressional wave velocity than wide open pores, with varying porosity. By integrating structural/microstructural data with physical properties investigations and geophysical logs, the actual thickness of the TZ can be revised and defined more precisely. We used structural data from cores, thin section observation, and X-ray tomography on fractured samples for characterizing the crack porosity and shape, in order to calibrate the geophysical signals along the TZ. The thickness and position of the TZ are crucial for controlling the pattern of crustal permeability and hydrothermal fluid circulation.

Vegetation and Geomorphic Changes in a New England Salt Marsh in the Last 1,000 Years

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Geological Society of America Abstracts with Programs, 44 (2), 95 (2012)

Headquarters marsh is one of several marshes in the Barn Island Wildlife Management Area in Stonington, CT near the Connecticut-Rhode Island border. Modern coastal marshes in Connecticut generally began forming after the period of rapid post-glacial sea level rise, which ended 3,000 y ago. Headquarters marsh peat records approximately the last 1,000 y of relative sea level rise and subsequent coastal change. We compare peat accumulation rates from Cs-137 derived 1954 horizons, excess Pb-210 dating, and C-14 dating with nearby tide gauge records to trace the growth and landward encroachment of Headquarters marsh. With sea level rise, succession of marsh grasses is preserved in peat as roots or rhizomes. In recent decades, there is a particularly striking reduction in the mid to high marsh species *Juncus gerardi* and *Distichlis spicata*. There is also a gradual increase in *Spartina spp.* on the upper slope of the high marsh. Marsh flora follow a general pattern from low marsh to high marsh to upland, but microtopography, drainage, and other factors such as human modifications influence the mosaic of vegetation visible today. Using data from thirty new cores (up to 7 m in length), we present geomorphic and vegetation changes to the area since the marsh first formed, with some dramatic changes since early studies of this location in the 1940s.

Diverse Macroids and Rhodoliths from the Upper Pleistocene of Baja California Sur, Mexico

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Journal of Coastal Research, 28 (1), 296-305 (2012)

Small multi-taxonomical nodules characterized as rhodoliths, balanuliths, coralloliths, bryoliths and nodules composed of vermetids “vermetuliths”, are described from one horizon in carbonate sand from the Upper

Pleistocene Mulegé Formation at Playa La Palmita, Baja California Sur, Mexico. Such a diversity of fossil, free-rolling biota is seldom described in the literature. This is the first time vermetuliths are reported in the fossil record, also the coral *Astrangia* has not been reported to constitute coralloliths before. These nodules and their associated firm-ground were generated in a shallow bay near rocky shores. Break up of a firm-ground during a sedimentary hiatus provided fragments of loosely consolidated carbonate sandstone for organic nucleation. Fast growers, like balanids, vermetids and bryozoans settled on these sandstone fragments or on bioclasts. Initial rapid growth of pioneer organisms was succeeded by a period of bioerosion, and finally encrustation with a thin, crustose to lumpy cover of coralline red algae in the climax stage of succession. These were insipient rhodoliths, where the thin cover of coralline red algae reflects a short residence time. Also evident is a rich crypto- and endofauna that lived within and epifauna upon the nodules.

Distribution, Sediment Source, and Coastal Erosion of Fan-Delta Systems on Isla Cerralvo (Lower Gulf of California, Mexico)

D. H. Backus, Markes E. Johnson, Professor of Geosciences, and R. Riosmena-Rodriguez

Journal of Coastal Research, 28 (1), 210-224 (2012)

Located near the tip of the Baja California peninsula, Isla Cerralvo is the sixth largest island in the Gulf of California. Although surrounded by some of the most productive waters in the world, field surveys show that Isla Cerralvo's shelf is largely devoid of biogenic carbonates, especially rhodolith beds, which are found in abundance elsewhere within the region. In counterpoint, a series of prominent fan deltas extend from the mouths of arroyos on Isla Cerralvo, despite the fact that the island has a granitic core, suggesting that the island's bedrock is severely weakened. Field observations suggest that the fracture patten (submeter), hydrothermal alteration, as well as the orientations of metamorphic foliation, fracture sets, and fault planes all play a role in the accelerated rate of erosion on the island. The role of hydrothermal alteration is illustrated by a principal components analysis of Advance Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Short Wave Infrared (SWIR) bands, which links heavily eroded areas at the south end of the island to areas with high concentrations of clays. A synthetic drainage system created using a 30-m resolution digital elevation model (DEM) generated from an ASTER image was used to model the Isla Cerralvo drainage basins and stream channel networks. Analyses of basin and stream network information, including basin slope values and channel slope values, were used to identify island-wide differences in basin morphology and erosion characteristics. Stream channel profiles and slope-area data supported by limited uplift data indicate that Isla Cerralvo has not been uplifted as a single block, but it is broken into at least two major structural blocks with different uplift histories. Due to the arid climate and low annual precipitation, we find that sediment removal from the interior of Isla Cerralvo can only be accomplished by episodic, but very short (hours to days), catastrophic rainfall events caused by hurricanes or chubascos (winter storms). Subsequently, the sediment is eroded from fan deltas and transported southward by longshore currents and wind-generated waves, choking carbonate production along Isla Cerralvo's shores and shelf.

Pliocene Stratigraphy at Paredones Blancos: Significance of a Massive Crushed-Rhodolith Deposit on Isla Cerralvo, Baja California Sur (Mexico)

K.F. Emhoff '10, Markes E. Johnson, Professor of Geosciences, D. H. Backus, and J. Ledesma-Vázquez

Journal of Coastal Research, 28 (1), 234-243 (2012)

A white blaze across coastal cliffs is the hallmark of Paredones Blancos on Isla Cerralvo. Cliff-forming strata include three roughly 10-m thick units with a lateral coherence of only 0.75 km. The middle unit is a massive deposit of crushed rhodoliths. The other two units consist of matrix-supported conglomerate with cobbles and boulders of granodiorite, basaltic andesite, and hornblende diorite. By volume, the matrix accounts for >80% of those units, mostly grus from weathered granite. Thin sections were studied from samples collected at five levels through the middle rhodolith unit to determine carbonate purity as a ratio between organic CaCO₃ and inorganic minerals. The bottom and top margins of the deposit show higher levels of mixed clastics with 37% inorganic mineral content, as compared with 11% toward the middle. Original depositional environments are interpreted as a rhodolith bank adjacent to a large fan delta built seaward from a wide canyon mouth. The stratigraphic sequence records a rise in sea level that brought rhodolith debris to the flooded canyon mouth above the basal conglomerate, and a drop that emplaced another conglomerate above the rhodolith deposit. A Middle Pliocene age is based on co-occurrence of *Clypeaster bowersi* and *Argopecten revellei* within the carbonates.

Development of Intertidal Biotas through Phanerozoic Time

Markes E. Johnson, Professor of Geosciences and B. G. Baarli

In: Talent, J.A. (ed), Earth and Life: Global Biodiversity, Extinction Intervals and Biogeographic Perturbations Through Time, Springer Sciences and Media 1,1107 p. (2012)

Changes in the biodiversity and organization of intertidal biotas from rocky, sandy, and muddy shores are summarized on the basis of information in the fossil record for 1,622 extinct and extant species through Phanerozoic strata from the Cambrian to the Pleistocene at 361 localities around the world. To enter the database, each fossil species qualified as intertidal in origin based on sedimentological, geological, and other spatial criteria. Among the study sites documented in the scientific literature, 45% are considered former rocky shorelines. Another 31% represent former muddy shores and 24% are indicative of former sandy shores. Rocky-shore biotas demonstrate the greatest change in biodiversity, with species per Cenozoic study site nearly 2.5 times more than found on average at Paleozoic study sites. Key elements of the modern rocky shore biota were in place by Oligocene time and reflect much the same kind of ecological crowding found in that setting today. Coastal mudflat biotas show only a minor increase in biodiversity based on body fossils, although evidence from trace fossils implies an increase in ecological crowding through time. Sandy-shore biotas are the most conservative and least diverse in their development. The influence on intertidal habitat space by global tectonics, sea-level change, and relationship to other ecosystems is considered.

Rhodoliths, Uniformitarianism, and Darwin: Pleistocene and Recent Carbonate Deposits in the Cape Verde and Canary Archipelagos

Markes E. Johnson, Professor of Geosciences and others

Palaeogeography, Palaeoclimatology, Palaeoecology, 329-330, 83-100 (2012)

Visiting “St. Jago” (Santiago) in the Cape Verde Islands in 1832 and again in 1836 aboard HMS Beagle, Charles Darwin was the first to trace and describe the tri-part sequence of white limestone and sandstone beds stratigraphically located between two levels of basalt exposed almost uninterrupted for 10 km along coastal cliffs. The Pleistocene carbonate sediments dominated by rhodoliths and rhodolith debris accumulated on a basalt shelf and subsequently became buried by subaerial and submarine basalt on the southeast coastline of Santiago. The main goal of this contribution is to re-examine Darwin’s stratigraphic sequence. The secondary goal is to provide a general taphonomical model based on the observation of Recent rhodolith deposits for evaluation of fossil rhodolith assemblages. Environmental uniformitarianism is employed to understand the depositional history of the southern Santiago rhodolith-bearing strata. The mixed clastic-carbonate sequence includes a basalt-derived basal conglomerate with an intertidal to shallow subtidal fossil assemblage mainly denoted by limpets and oysters. Upper layers typically demonstrate swaley and hummocky cross stratification incorporating rhodolith debris further modified by bioturbation. Pillow basalts from 10 – 18 m in thickness succeeded by subaerial flows imply swift burial of the carbonate succession under equivalent water depths. The calcareous nannofossil assemblage was investigated to more precisely date the deposits. Darwin’s paleoshore is reinterpreted to represent two different transgressions occurring between approximately 1.1 and 0.7 Ma. Taphonomic grades from whole rhodoliths to finely crushed rhodolith debris observed under present-day conditions on Maio (Cape Verde Islands) and Fuerteventura (Canary Islands) were used to model rhodolith preservation and to constrain the depositional settings to which rhodoliths may be transported from the offshore banks where they naturally thrive. Coastward transport of rhodoliths commonly ends with deposition in subtidal storm beds, tidal pools, and platform over-wash deposits, as well as beach, berm, hurricane, tsunami, and coastal dune deposits.

Lagoon Microbialites on Isla Angel de la Guarda and Associated Peninsular Shores, Gulf of California, Mexico

Markes E. Johnson, Professor of Geosciences, J. Ledesma-Vásquez, D. H. Backs, and M. R. González

Sedimentary Geology, 263-264, 76084 (2012)

Examples of two closed lagoons with extensive growth of Recent microbialites showing variable surface morphology and internal structure are found on Isla Angel de la Guarda in the Gulf of California. Comparable

lagoonal microbialites also occur ashore from Ensenada El Quemado on the adjacent peninsular mainland of Baja California. The perimeters of all three lagoons feature crusted structures indicative of thrombolites with a knobby surface morphology 2 cm to 3 cm in relief and internal clotting without any sign of laminations. Outward from this zone, thrombolitic construction thins to merge with a white calcified crust below which a soft substratum of dark organic material 4 cm to 6 cm in thickness is concealed. The substratum is laminated and heavily mucilaginous, as observed along the edges of extensive shrinkage cracks in the overlying crust. The thrombolitic crust is anchored to the shore, while the thinner crust and associated stromatolitic mats float on the surface of the lagoons. Laboratory cultures of the dark organic material yielded the solitary cyanobacterium *Chroococcidiopsis* as the predominant taxon interspersed with filamentous forms. In decreasing order of abundance, other morphotypes present include *Phormidium*, *Oscillatoria*, *Geitlerinema*, *Chroococcus*, and probably *Spirulina*. The larger of the two island lagoons follows an east-west azimuth and covers 0.225 km² while the smaller lagoon has a roughly north-south axis and covers only 0.023 km². The salinity of water in the smaller lagoon was measured as 148 ppt. Pliocene strata along the edge of the smaller modern lagoon include siltstone bearing calcified platelets suggestive of a microbial origin. Dry lagoons abandoned during the later Quaternary occur inland at higher elevations on the island, but retain no fossils except for sporadic white crusts cemented on cobbles around distinct margins. Raised Quaternary lagoons parallel to the big lagoon on Isla Angel de la Guarda are partly obscured by flood damage, but still easily mapped from aerial photos. These features suggest that Isla Angel de la Guarda experienced Quaternary uplift similar in scale to many other gulf islands on which marine terraces are preserved. Closed lagoons around the Gulf of California represent a stable oligotrophic ecosystem affected by extreme aridity and hypersalinity, punctuated episodically by the injection of floodwater from tropical storms. The taxonomic and geographic ranges of microbial communities throughout the larger region remain to be explored.

Rhodolith Stranding Event on a Pliocene Rocky Shore from Isla Cerralvo in the Lower Gulf of California (Mexico)

Markes E. Johnson, Professor of Geosciences, D. M. Perez '10, and B. G. Baarli

Journal of Coastal Research, **28 (1)**, 225-233

Controls on present-day sedimentation around Isla Cerralvo in the southern Gulf of California provide a model for restricted Pliocene limestone distribution. The 10.46-km² island is elongate and roughly parallel to the direction of prevailing north winds. Debris washed from deeply dissected valleys build fan deltas of sand to boulder-size igneous clasts. These are transported south by long-shore currents, but the fans also create leeward zones with less agitated water. Remnants of a large Pliocene fan are exposed during low tide at Los Carillos on the SE side of the island. Adjacent is an unconformity between granite and granite-derived conglomerate with *Nerita scabricosta*. This extant gastropod is typical of the high intertidal rocky shore. The conglomerate is capped by a sandstone ramp with *Argopecten abietus* as an offshore facies. Basalt dikes exhumed from the granite formed natural groins that captured sediments and shells in the sand ramp. Whole rhodoliths, mostly 3.5 cm in diameter and 15 cm deep, covered 150 m² within the ramp, now partly exposed among boulders in the basal conglomerate. Many rhodoliths encrust pea-sized rock cores. Accretion occurred in shallow water protected from extreme agitation by the nearby fan delta. Stranding of rhodoliths on the rocky shore was a storm-induced event.

An Extreme Habitat Adaptation by Boring Bivalves on Volcanically Active Paleoshores from North Atlantic Macaronesia

A. G. Santos, E. Mayoral, *Markes E. Johnson, Professor of Geosciences*, B. G. Baarli, C. M. da Silva, M. Cachão, and J. Ledesma-Vázquez

Facies, **58**, 325-338 (2012)

Extensive bivalve borings are described in detail for the first time from basalt rockgrounds in the North Atlantic volcanic islands of Macaronesia. They occur on a Middle Miocene rocky shore of a small islet of Porto Santo (Madeira Archipelago of Portugal), as well as on Plio-Pleistocene rocky shores on Santiago Island (Cape Verde). A basalt substrate is widely penetrated by clavate-shaped borings belong to the ichnogenus *Gastrochaenolites* interpreted as dwelling structures of suspension-feeding bivalves. Some of these borings still retain evidence of the alleged trace-makers preserved as body fossils, while others are filled with their casts. The ichnofossil assemblage

present on these bioeroded surfaces belongs to the *Entobia* ichnofacies. Recognition of *Gastrochaenolites* borings in volcanic rocks provides useful paleoenvironmental information regarding an expanded strategy for hard-substrate colonization. Preliminary results from fieldwork in the Cape Verde Archipelago indicate that such borings are more widespread through Macaronesia than previously thought.

Basalt Mounds and Adjacent Depressions Attract Contrasting Biofacies on a Volcanically Active Middle Miocene Shoreline (Porto Santo, Madeira Archipelago, Portugal)

A. G. Santos, E. Mayoral, *Markes E. Johnson, Professor of Geosciences*, B. G. Baarli, C. M. da Silva, M. Cachão, and J. Ledesma-Vázquez

Facies, 58, (2012)

Small basalt mounds with encrusting corals and inter-mound carbonate sandy zones with abundant rhodoliths corresponding to an ancient intertidal to shallow-water sea floor are exhumed from overlying volcanoclastic deposits and basalt lava flows at Pedra de Água on Ilhéu de Cima off Porto Santo, one of the islands of the Northeastern Atlantic Madeira Archipelago (Portugal). The mounds rise above the surrounding surface to attain a height of about a half meter. The mounds exhibit an assemblage of *in situ* hermatypic corals, dominated by *Tarbellastraea* and *Solenastrea*. They formed as massive (4.2×1.9 m average length), isolated patches in a protected bay close to shore eroded from an uneven basalt substrate dated to the Middle Miocene (14 to 15 Ma). The slightly deeper zones between basalt mounds, which alternate with them over a distance of more than 20 m, are covered mainly by coarse carbonate sand on which rhodoliths up to 14.8 cm in diameter are preserved *in situ*. Many rhodoliths have grown around a basalt core, which indicates a local, nearshore source for development. Complete burial of the elevated coral settlements and intervening low zones populated by rhodoliths occurred when volcanic lapilli and other tephra catastrophically buried this part of the rocky shore. The rhodoliths and coral assemblages exposed in an area of 12 m² were canvassed systematically using census quadrants to quantify community relationships.

The Role of Crustose Coralline Algae in Late Pleistocene Reef Development on Isla Cerralvo, Baja California Sur (Mexico)

P. W. Tierney '11 and Markes E. Johnson, Professor of Geosciences

Journal of Coastal Research, 28 (1), 244-254 (2012)

Crustose coralline algae played a fundamental role in reef establishment during the Late Pleistocene ($122,143 \pm 175$ years before present) on Isla Cerralvo in the southern Gulf of California. Transported cobbles with a generally elongated clast shape (mean sphericity: 0.6) were encrusted by coralline red algae before locking in a north-south alignment (mean: N2°W) and providing a fixed substrate for colonization by *Porites* and *Pocillopora* corals. A fringing reef grew on this pavement of clast-encrusting rhodoliths and was succeeded by additional cobble-coral cycles. Out of five stratigraphically repetitive cycles, only the second and third offer sufficient exposure to be quantified with any confidence. Census data, cobble orientations, and measurements of algal rinds were collected to characterize the transition from rhodoliths to corals. Clasts in the second cycle (mean dimensions: 7.4 x 4.6 cm) have rinds that average 5.4 mm (Standard Deviation: 4.2 mm) at their thickest and 0.9 mm (SD: 0.8mm) at their thinnest; overlying corals that average 16.2 cm in height. Clasts within the third cycle (mean dimensions: 7.2 x 4.6 cm) have rinds that average 3.1 mm (SD: 2.5 mm) at their thickest and 0.9 mm (SD: 0.8 mm) at their thinnest; overlying corals that average 15.4 cm in height. Coralline algae helped cement both the underlying cobble pavement and reef corals.

Creating Interactive 3-D Models from Geologic Maps and Cross Sections Using Google SketchUp

Paul Karabinos, Professor of Geosciences

Geological Society of America, Abstracts with Programs, 43, 302 (2011)

The power of geologic maps and cross sections to portray the structure of a region is dramatically enhanced by software that can create interactive 3-D models, which can be rotated, panned, and zoomed by the user. I developed a methodology for creating virtual block diagrams from digital maps and cross-sections primarily using Google SketchUp. It is also essential to have an image-processing program, such as Photoshop, for cropping maps

and cross-sections, and GIS software, such as Global Mapper, for preparing digital elevation models (DEM) for SketchUp.

The most effective 3-D models show how the maps and cross-sections connect at the topographic surface. The map can be segmented to give users the ability to ‘turn off’ individual portions of the surface to reveal cross-sections below. Such models help students and non-specialists visualize geologic structures, and provide experienced geologists with a valuable tool for assessing the validity of geologic interpretations.

Once a geologic map is draped on the DEM, SketchUp can aid in the creation of new geologic cross sections using traditional down-plunge and structure contour approaches adapted for a 3-D environment. This approach makes it possible to leverage the geologic information contained in geologic maps from regions with significant topographic relief. It also helps students effectively visualize the process of cross-section construction.

Evidence for Kilometer-Scale Fluid-Controlled Redistribution of Graphite in the Taconic Thrust Belt on Mount Greylock, Massachusetts: Implications for Strain Localization and Fault Growth

Paul Karabinos, Professor of Geosciences, R. F. Aronoff '09, and E. S. Nemser '98

Geological Society of America, Abstracts with Programs, 43, 324 (2011)

During the Ordovician Taconic orogeny, deep-water deposits from the Laurentian slope and rise were thrust westward over shelf rocks. On Mount Greylock graphite(C)-rich schist is interpreted as a flysch deposit, whereas C-poor schist is assigned to the Taconic thrust sheet by Ratcliffe et al. (1993). According to this interpretation, the major thrust is within the schistose rocks and separates C-rich Ordovician(?) Walloomsac Fm from structurally overlying, C-poor Late Proterozoic Greylock Schist. This interpretation assumes that the present distribution of C preserves primary variations in organic material.

The contact between C-rich and C-poor schist on Mount Greylock is diffuse and not marked by well-defined strain gradients. In contrast the contact between the C-rich schist and the structurally lower marble, is a *mélange* characterized by intense deformation. Our detailed field mapping indicates that the distinction between C-rich and C-poor rocks is not a reliable stratigraphic tool. Typically C-rich and C-poor rocks are interlayered on scales ranging from 10- to 100-m. Examination of 200 thin sections from 173 locations reveals that 55% of Walloomsac Formation samples are C-rich, but 45% are C-poor. Samples of Greylock Schist are more complex; although only 10% are C-rich; another 55% contain plagioclase porphyroblasts with abundant C inclusions surrounded by a C-poor matrix. This common texture suggests that C was once present in the matrix but was dissolved by aqueous fluids and transported out of the rock.

Thin section evidence suggests that C was formerly widely distributed in the schist on Mount Greylock, but that large-scale redistribution of C occurred during metamorphism and thrusting. We suggest that aqueous fluids dissolved C in large volumes of rock that are now C-poor, as shown by plagioclase porphyroblasts containing abundant C inclusions. Fluids later precipitated C in narrow zones to form C-rich schist. We suggest that a high density of fractures focused fluid flow parallel to thrust faults, and that C precipitated in these zones. C may have weakened the rocks and promoted faulting, thus creating a positive feedback between thrusting, fluid flow, and C precipitation.

Tectonic Thinning in the Mantling Sequence Around the Chester Dome, Vermont: Implications for the Mechanical Decoupling Between Basement and Cover Rocks

Paul Karabinos, Professor of Geosciences

in West, D.P., ed., Guidebook for field trips in Vermont, and adjacent New York, New England Intercollegiate Geological Conference, Middlebury, Vermont, C1-C27 (2011)

The New England Appalachians contain two north-south trending sets of gneiss domes. The western belt contains thirteen domes, including the Chester dome, that expose either 1 Ga Laurentian basement rocks or approximately 475 Ma rocks of the Shelburne Falls arc. The eastern belt contains twenty-one gneiss domes cored by either 600 Ma crust of possible Gondwanan affinity or approximately 450 Ma rocks of the Bronson Hill arc. Domes in both belts are surrounded by Silurian and Early Devonian metasedimentary rocks, which were deposited in two north-south

trending basins before the Acadian orogeny.

The Chester dome in southeastern Vermont is a classic example of a mantled gneiss dome. Doll et al. (1961) portrayed the contact between the Mesoproterozoic Mount Holly Complex, in the core of the dome, and Neoproterozoic metasedimentary rocks as an unconformity. They also mapped the contact between Ordovician rocks and Silurian and Devonian metasediments as an unconformity. They recognized that Lower Paleozoic units around the Chester dome are dramatically thinner than they are elsewhere in southern Vermont, but nonetheless interpreted the sequence of rocks as stratigraphic. In contrast, Ratcliffe (2000a, 2000b) explained the stratigraphic omissions around the Chester dome as the result of thrusting. A third explanation for the attenuation and omission of units in the Lower Paleozoic sequence was proposed by Karabinos et al. (2010), who argued that the mantling sequence around the Chester dome preserves a normal-sense shear zone. There is a strong spatial correlation between the highly attenuated mantling units and highly strained, mylonitic rocks. Further, garnet-bearing rocks in the core of the dome record metamorphism during decompression of 2 to 3 kbar, whereas rocks above the high-strain zone were metamorphosed during nearly isobaric conditions. Strain markers and kinematic indicators suggest that extension occurred during northward extrusion of lower to middle crustal wedges of Proterozoic and Ordovician quartz-feldspar-rich gneisses below and up into a thick tectonic cover of Silurian mica-rich metasediments that had been transported westward in large-scale nappes. Electron microprobe dating of monazite and other estimates of the age of peak Acadian metamorphism suggest that extrusion occurred at approximately 380 Ma.

Mathematics and Statistics

The Complimentary Regions of Knot and Link Projections

Colin Adams, R. Shinjo and K. Tanaka

Annals of Combinatorics, Vol. 15, No. 4, 549-563 (2011)

An increasing sequence of integers is said to be universal for knots and links if every knot and link has a reduced projection on the sphere such that the number of edges of each complementary face of the projection comes from the given sequence. In this paper, it is proved that the following infinite sequences are each universal for knots and links:

$(3, 5, 7, \dots)$, $(2, n, n+1, n+2, \dots)$ for each $n \geq 3$, $(3, n, n+1, n+2, \dots)$ for each $n \geq 4$. Moreover, the finite sequences $(2, 4, 5)$ and $(3, 4, n)$ for each $n \geq 5$ are universal for all knots and links.

It is also shown that every knot has a projection with exactly two odd-sided faces, which can be taken to be triangles, and every link of n components has a projection with at most n odd-sided faces if n is even and $n+1$ odd-sided faces if n is odd.

Planar and Spherical Stick Indices of Knots

Colin Adams, D. Collins, K. Hawkins '10, C. Sia, R. Silversmith '11, B. Tshishiku

Journal of Knot Theory and Its Ramifications, Vol. 20, No. 5, 721-739 (2011)

The stick index of a knot is the least number of line segments required to build the knot in space. We define two analogous 2-dimensional invariants, the planar stick index, which is the least number of line segments in the plane to build a projection, and the spherical stick index, which is the least number of great circle arcs to build a projection on the sphere. We find bounds on these quantities in terms of other knot invariants, and give planar stick and spherical stick constructions for torus knots and for compositions of trefoils. In particular, unlike most knot invariants, we show that the spherical stick index distinguishes between the granny and square knots, and that composing a nontrivial knot with a second nontrivial knot need not increase its spherical stick index.

Stick Index of Knots and Links in the Cubic Lattice

Colin Adams, M. Chu, T. Crawford '12, S. Jensen '12, K. Siegel, L. Zhang '12

Journal of knot Theory and Its Ramifications, Vol. 21, No. 5 (2012)

The cubic lattice stick index of a knot type is the least number of sticks necessary to construct the knot type in the 3-dimensional cubic lattice. We present the cubic lattice stick index of various knots and links, including all $(p, p+1)$ -torus knots, and show how composing and taking satellites can be used to obtain the cubic lattice stick index for a relatively large infinite class of knots. Additionally, we present several bounds relating cubic lattice stick index to other known invariants.

Duality Properties of Indicatrices of Knots

Colin Adams, D. Collins, K. Hawkins '10, C. Sia, R. Silversmith '11, B. Tshishiku

Geometriae Dedicata (on-line publication), (September 1, 2011)

The bridge index and superbridge index of a knot are important invariants in knot theory. We define the bridge map of a knot conformation, which is closely related to these two invariants, and interpret it in terms of the tangent indicatrix of the knot conformation. Using the concepts of dual and derivative curves of spherical curves as introduced by Arnold, we show that the graph of the bridge map is the union of the binormal indicatrix, its antipodal curve, and some number of great circles. Similarly, we define the inflection map of a knot conformation, interpret it in terms of the binormal indicatrix, and express its graph in terms of the tangent indicatrix. This duality relationship is also studied for another dual pair of curves, the normal and Darboux indicatrices of a knot conformation. The analogous concepts are defined and results are derived for stick knots.

CSI: MSRI

Colin Adams

Mathematical Intelligencer, Vol. 33, No. 2, 18-21 (2011)

What happens when there is a crime committed at the Mathematical Sciences Research Institute?

The Book

Colin Adams

Mathematical Intelligencer, Vol. 33, No. 3, 107-109 (2011)

Paul Erdos hypothesized a book in God's possession that contained all of the beautiful proofs ever discovered. What happens if you have access to that book.

Leonhard Euler and Seven Bridges of Konigsberg

Colin Adams

Mathematical Intelligencer, Vol. 33, No. 4, 18-20 (2011)

Many people attribute the birth of topology to Euler's solution of the Konigsberg Bridge Problem. But what is the true story of what really happened?

The Dog Who Knew Calculus

Colin Adams

Mathematical Intelligencer, Vol. 34, No. 1, 16-17 (2012)

In a 2003 article, the author explained how his dog Elvis seemed to understand calculus, as he was so good at minimizing the time it took to get a ball thrown in the water. So let's give him a job teaching.

Derivative vs. Integral: The Final Smackdown

Colin Adams, Thomas Garrity and Adam Falk

Mathematical Association of America (January 2012)

Which is better, the derivative or the integral? Recorded at Williams Family Days, Fall 2011.

A Generalization of a Theorem of Lekkerkerker to Ostrowski's Decomposition of Natural Numbers

Edward B. Burger, David C. Clyde, Cory H. Colbert, Gea Hyun Shin '11, and Zhaoning Wang '11

Acta Arithmetica, 153, 217-249 (2012)

Let a be a fixed, irrational real number and p_k/q_k its associated k th convergent. In 1921, Ostrowski proved that each natural number n can be expressed uniquely as a linear combination of the continuants of a , namely the q_k 's, in which the integer coefficients satisfy certain natural diophantine conditions. Here we analyze the asymptotic behavior of the average number of summands required in such decompositions relative to the size of the corresponding natural numbers in the case for which a is a quadratic irrational. Our results generalize the work of Lekkerkerker, who in 1951 explicitly computed this asymptotic ratio for the particular case $a = (1+\sqrt{5})/2$ and found it to equal $(5-\sqrt{5})/10 = 0.2763\dots$

The Shape of Associativity

Satyan Devadoss

Canadian Mathematical Society Notes, 44, 12-14 (2012)

Associativity is ubiquitous in mathematics. Unlike commutativity, its more popular cousin, associativity has for the most part taken a backseat in importance. But over the past few decades, this concept has blossomed and matured. We show how to visualize the concept of associativity.

What Makes a Tree a Straight Skeleton?

Satyan Devadoss

Proceedings of the European Conference on Computational Geometry (2012)

Given any polygon, one can construct a geometric tree associated to it called its straight skeleton. This appears in the construction of roof and origami folding designs. We ask the inverse question: For what tree does there exist polygons with the tree as its skeleton?

Triple Infinity

Satyan Devadoss, Associate Professor of Mathematics

Esopus Magazine (2011)

A conversation between a mathematician, a cosmologist, and an artist about the meaning and nature of infinity in these three fields.

A Robust Boosting Algorithm for Chemical Modeling

Richard DeVaux and Ville Satopa '11

Current Analytical Chemistry, Vol. 8, No. 2, 254-265 (2012)

Bagging and boosting have become increasingly important ensemble methods for combining models in the data mining and machine learning literature. We review the basic ideas of these methods, propose a new robust boosting algorithm based on a non-convex loss function and compare the performance of these methods to both simulated and real data sets both with and without contamination.

Using Mathematical Maturity to Shape our Teaching, our Careers and our Departments

Thomas Garrity

Notices of the American Mathematical Society, 1592 – 1593 (2011)

Derivative vs. Integral: The Final Smackdown

Thomas Garrity, Colin C. Adams and Adam Falk

Mathematical Association of America (January 2012)

Which is better, the derivative or the integral? Recorded at Williams Family Days, Fall 2011.

Semi-Local Formal Fibers of Minimal Prime Ideals of Excellent Reduced Local Rings

Susan Loepp, Nicholas Arnosti '11, Rachel Karpman, Caitlin Levenson, and Jake Levinson '11

Journal of Commutative Algebra, No. 1, 29-56 (2012)

Given a complete local ring T containing the rationals, and a positive integer m , the authors find necessary and sufficient conditions for there to exist an excellent reduced local ring A , whose completion is T , such that A has exactly m minimal prime ideals. In addition, the authors show that the formal fibers over the minimal prime ideals can be controlled.

Distribution of Eigenvalues for Highly Palindromic Real Symmetric Toeplitz Matrices

Steven J. Miller, Steven Jackson '10 and Thuy Pham '11

Journal of Theoretical Probability, 25, 464-495 (2012)

Consider the ensemble of real symmetric Toeplitz matrices whose entries are i.i.d random variables chosen from a fixed probability distribution p of mean 0, variance 1 and finite higher moments. Previous work showed that the limiting spectral measures (the density of normalized eigenvalues) converge in probability and almost surely to a universal distribution almost that of the Gaussian, independent of p . The deficit from the Gaussian distribution is due to obstructions to solutions of Diophantine equations and can be removed by making the first row palindromic.

In this paper, we study the case where there is more than one palindrome in the first row of a real symmetric Toeplitz matrix. Using the method of moments and an analysis of the resulting Diophantine equations, we show that the moments of this ensemble converge to a universal distribution with a fatter tail than any previously seen limiting spectral measure.

Rational Irrationality Proofs

Steven J. Miller and David Montague

Mathematics Magazine, 85, No. 2, 110-114 (2012)

Proving the irrationality of the square-root of 2 is a rite of passage for mathematicians. The purpose of this note is to spread the word of a remarkable geometric proof, and to generalize it. The proof was discovered by Stanley Tennenbaum in the 1950's, and first appeared in print in John H. Conway's article in *Power*. In the interest of space, we often leave out the algebra justifications for the lengths of the sides in our figures. The reader is encouraged to prove these expressions for themselves, or see the arxiv post for complete details.

Moments of the Rank of Elliptic Curves

Steven J. Miller and Siman Wong

Canadian Journal of Mathematics, 64, No. 1, 151-182 (2012)

Fix an elliptic curve E/\mathbb{Q} , and assume the Riemann Hypothesis for the L-function $L(E_D, s)$ for every quadratic twist E_D of E by D in \mathbb{Z} . We combine Weil's explicit formula with techniques of Heath-Brown to derive an asymptotic upper bound for the weighted moments of the analytic rank of E_D . We derive from this an upper bound for the density of low-lying zeros of $L(E_D, s)$ which is compatible with the random matrix models of Katz and Sarnak. We also show that for any unbounded increasing function f on \mathbb{R} , the analytic rank and (assuming in addition the Birch and Swinnerton-Dyer conjecture) the number of integral points of E_D are less than $f(D)$ for almost all D .

Generalized More Sums Than Differences Sets

Steven J. Miller, Geoffrey Iyer, Oleg Lazarev, Liyang Zhang '12

Journal of Number Theory, 132, No. 5, 1054-1073 (27 pp) (2012)

A More Sums Than Differences (MSTD, or sum-dominant) set is a finite set A of \mathbb{Z} such that $|A+A| < |A-A|$. Though it was believed that the percentage of subsets of $\{0, \dots, n\}$ that are sum-dominant tends to zero, in 2006 Martin and O'Bryant proved that a positive percentage are sum-dominant. We generalize their result to the many different ways of taking sums and differences of a set. We prove that $|\epsilon_1 A + \dots + \epsilon_k A| > |\delta_1 A + \dots + \delta_k A|$ a positive percent of the time for all nontrivial choices of $\epsilon_j, \delta_j \in \{-1, 1\}$. Previous approaches proved the existence of infinitely many such sets given the existence of one; however, no method existed to construct such a set. We develop a new, explicit construction for one such set, and then extend to a positive percentage of sets.

We extend these results further, finding sets that exhibit different behavior as more sums/differences are taken. For example, we prove that for any m , $|\epsilon_1 A + \dots + \epsilon_k A| - |\delta_1 A + \dots + \delta_k A| = m$ a positive percentage of the time. We find the limiting behavior of $kA = A + \dots + A$ for an arbitrary set A as k goes to infinity and an upper bound of k for such behavior to settle down. Finally, we say A is k -generational sum-dominant if $A, A+A, \dots, kA$ are all sum-dominant. Numerical searches were unable to find even a 2-generational set (heuristics indicate that the probability is at most 10^{-9}), and quite likely significantly less). We prove that for any k a positive percentage of sets are k -generational, and no set can be k -generational for all k .

Explicit Constructions of Large Families of Generalized More Sums Than Differences Sets

Steven J. Miller, Sidney Luc Robinson '12 and Sean Pegado '11

Integers, 12, No. A30 (2012)

A More Sums Than Differences (MSTD) set is a set of integers A of $\{0, \dots, n-1\}$ whose sumset $A+A$ is larger than its difference set $A-A$. While it is known that as n tends to infinity a positive percentage of subsets of $\{0, \dots, n-1\}$ are MSTD sets, the methods to prove this are probabilistic and do not yield nice, explicit constructions. Recently

Miller, Orosz and Scheinerman gave explicit constructions of a large family of MSTD sets; though their density is less than a positive percentage, their family's density among subsets of $\{0, \dots, n-1\}$ is at least C/n^4 for some $C > 0$, significantly larger than the previous constructions, which were on the order of $1/2 \{n/2\}$. We generalize their method and explicitly construct a large family of sets A with $|A+A+A+A| > |(A+A)-(A+A)|$. The additional sums and differences allow us greater freedom than in MOS, and we find that for any $\varepsilon > 0$ the density of such sets is at least $C/n\varepsilon$. In the course of constructing such sets we find that for any integer k there is an A such that $|A+A+A+A| - |A+A-A-A| = k$, and show that the minimum span of such a set is 30.

Models for Zeros at the Central Point in Families of Elliptic Curves

Steven J. Miller, Eduardo Duenez, Duc Khiem Huynh, Jon Keating and Nina Snaith

J. Phys. A: Math. Theor., 45, 115207 (2012)

We propose a random matrix model for families of elliptic curve L-functions of finite conductor. A repulsion of the critical zeros of these L-functions away from the center of the critical strip was observed numerically by S. J. Miller in 2006; such behaviour deviates qualitatively from the conjectural limiting distribution of the zeros (for large conductors this distribution is expected to approach the one-level density of eigenvalues of orthogonal matrices after appropriate rescaling). Our purpose here is to provide a random matrix model for Miller's surprising discovery. We consider the family of even quadratic twists of a given elliptic curve. The main ingredient in our model is a calculation of the eigenvalue distribution of random orthogonal matrices whose characteristic polynomials are larger than some given value at the symmetry point in the spectra. We call this sub-ensemble of $SO(2N)$ the excised orthogonal ensemble. The sieving-off of matrices with small values of the characteristic polynomial is akin to the discretization of the central values of L-functions implied by the formula of Waldspurger and Kohnen-Zagier. The cut-off scale appropriate to modeling elliptic curve L-functions is exponentially small relative to the matrix size on the order of N . The one-level density of the excised ensemble can be expressed in terms of that of the well-known Jacobi ensemble, enabling the former to be explicitly calculated. It exhibits an exponentially small (on the scale of the mean spacing) hard gap determined by the cut-off value, followed by soft repulsion on a much larger scale. Neither of these features is present in the one-level density of $SO(2N)$. When N goes to infinity we recover the limiting orthogonal behaviour. Our results agree qualitatively with Miller's discrepancy. Choosing the cut-off appropriately gives a model in good quantitative agreement with the number-theoretical data.

On the Number of Summands in Zeckendorf Decompositions

Steven J. Miller, Murat Kologlu '12, Gene S. Kopp, and Yinghui Wang

Fibonacci Quarterly, 49, No. 2, 116-130 (2011)

Zeckendorf proved that every positive integer has a unique representation as a sum of non-consecutive Fibonacci numbers. Once this has been shown, it's natural to ask how many summands are needed. Using a continued fraction approach, Lekkerkerker proved that the average number of such summands needed for integers in $[Fn, F\{n+1\})$ is $n / (j^2 + 1) + O(1)$, where $j = (1+\sqrt{5})/2$ is the golden mean. Surprisingly, no one appears to have investigated the distribution of the number of summands; our main result is that this converges to a Gaussian as n tends to infinity. Moreover, such a result holds not just for the Fibonacci numbers but many other problems, such as linear recurrence relation with non-negative integer coefficients (which is a generalization of base B expansions of numbers) and far-difference representations.

In general the proofs involve adopting a combinatorial viewpoint and analyzing the resulting generating functions through partial fraction expansions and differentiating identities. The resulting arguments become quite technical; the purpose of this paper is to concentrate on the special and most interesting case of the Fibonacci numbers, where the obstructions vanish and the proofs follow from some combinatorics and Stirling's formula.

From Fibonacci Numbers to Central Limit Type Theorems

Steven J. Miller and Yinghui Wang

Journal of Combinatorial Theory, Series A, 119, No. 7, 1398-1413 (2012)

A beautiful theorem of Zeckendorf states that every integer can be written uniquely as a sum of non-consecutive Fibonacci numbers $\{F_n\}_{n=1}^\infty$. Lekkerkerker [Lek] proved the average number of summands for integers in $[F_n, F_{n+1})$ is $n/(j+1)$, with j the golden mean. This has been generalized: given nonnegative integers c_1, c_2, \dots, c_L with $c_1, c_L > 0$ and recursive sequence $\{H_n\}_{n=1}^\infty$ with $H_1 = 1$, $H_{n+1} = c_1 H_n + c_2 H_{n-1} + \dots + c_n H_{n-1} + 1$ ($1 \leq n < L$) and $H_{n+1} = c_1 H_n + c_2 H_{n-1} + \dots + c_L H_{n+1-L}$ ($n \geq L$), every positive integer can be written uniquely as a sum of $a_i H_i$ under natural constraints on the a_i 's, the mean and variance of the numbers of summands for integers in $[H_n, H_{n+1})$ are of size n , and as n tends to infinity the distribution of the number of summands converges to a Gaussian. Previous approaches used number theory or ergodic theory. We convert the problem to a combinatorial one. In addition to re-deriving these results, our method generalizes to other problems (in the sequel paper we show how this perspective allows us to determine the distribution of gaps between summands). For example, it is known that every integer can be written uniquely as a sum of the $\pm F_n$'s, such that every two terms of the same (opposite) sign differ in index by at least 4 [3]. The presence of negative summands introduces complications and features not seen in previous problems. We prove that the distribution of the numbers of positive and negative summands converges to a bivariate normal with computable, negative correlation, namely $-(21-2j)/(29+2j)$, which is approximately -0.551058 .

Steiner and Schwarz Symmetrization in Warped Products and Fiber Bundles With Density

Frank Morgan, Sean Howe and Nate Harman

Revista Mat. Iberoamericana, 27, 909-918 (2011)

We provide very general symmetrization theorems in arbitrary dimension and codimension, in products, warped products, and certain fiber bundles such as lens spaces, including Steiner, Schwarz, and spherical symmetrization and admitting density.

Isoperimetric Pentagonal Tilings

Frank Morgan, Ping Ngai Chung, Miguel Fernandez, Yifei Li, Michael Mara '12, Isamar Rosa Plata, Niralee Shah '12, Luis Sordo Vieira, and Elena Wikner '11

Notices Amer. Math. Soc., 59, 632-640 (2012)

We generalize the isoperimetric problem from geometry to numbers.

Alan Alda's Flame Challenge and Kids' Five Most Popular Science Questions

Frank Morgan

Huffington Post Blog, (March 16, 2012)

Can Math Survive Without the Bees?

Frank Morgan

Huffington Post Blog, (March 6, 2012)

Recent and new results on perimeter-minimizing tilings.

Soap Bubbles in Scotland

Frank Morgan

Huffington Post Blog, (March 23, 2012)

The latest progress on the century-old search for the least-perimeter way to partition space into unit volumes.

Math Finds the Best Doughnut

Frank Morgan

Huffington Post Blog, (April 2, 2012)

A report on the proof of the Willmore Conjecture.

Geometry Festival

Frank Morgan

Huffington Post Blog, (April 30, 2012)

A mathematics progress report from this annual meeting of geometers.

Function Fields With Class Number Indivisible by A Prime ℓ

Allison Pacelli, Michael Daub '08, J. Lang, M. Merling and Natee Pitiwan '09

Acta. Arith., 150, 339-359 (2011)

In this paper, we prove that there are infinitely many function fields of any degree over the rational function field with class number indivisible by an arbitrary prime number.

On μ -Compatible Metrics and Measurable Sensitivity

Cesar E. Silva, Ilya Grigoriev, Nate Ince, Marius Catalin '09, and Amos Lubin

Colloquium Math. 126, 53-72 (2012)

We introduce the notion of W -measurable sensitivity, which extends and strictly implies canonical measurable sensitivity, a measure-theoretic version of sensitive dependence on initial conditions. This notion also implies pairwise sensitivity with respect to a large class of metrics. We show that nonsingular ergodic and conservative dynamical systems on standard spaces must be either W -measurably sensitive, or isomorphic mod 0 to a minimal uniformly rigid isometry. In the finite measure-preserving case they are W -measurably sensitive or measurably isomorphic to an ergodic isometry on a compact metric space.

Physics

Loop Entropy Assists Tertiary Order: Loopy Stabilization of Stacking Motifs

Daniel P. Aalberts

Entropy, **13**, 1958-1966 (2011)

The free energy of an RNA fold is a combination of favorable base pairing and stacking interactions competing with entropic costs of forming loops. Here we show how loop entropy, surprisingly, can promote tertiary order. A general formula for the free energy of forming multibranch and other RNA loops is derived with a polymer-physics based theory. We also derive a formula for the free energy of coaxial stacking in the context of a loop. Simulations support the analytic formulas. The effects of stacking of unpaired bases are also studied with simulations.

Multi-spatial-mode Single-Beam Quadrature Squeezed States of Light From Four-Wave Mixing in Hot Rubidium Vapor

Kevin M. Jones, McElfresh, and others

Optics Express, **19**, 21358 (2011)

We present experimental results on the generation of multispatial-mode, single-beam, quadrature squeezed light using four-wave mixing in hot Rb vapor. Squeezing and phase-sensitive deamplification are observed over a range of powers and detunings near the 85Rb D1 atomic transition. We observe -3 dB of vacuum quadrature squeezing, comparable to the best single-spatial mode results previously reported using atomic vapors, however, produced here in multiple spatial modes. We confirm that the squeezing is present in more than one transverse mode by studying the spatial distribution of the noise properties of the field.

Two-Photon 3D FIONA of Aqueous Individual Quantum Dots

Ruobing Zhang, Eli Rothenberg, Gilbert Fruhwirth, Paul Simonson, Fangfu Ye, Ido Golding, Tony Ng, Ward Lopes, Paul Selvin

Nano Letters, **11**, 4074 (2011)

We report the first two-photon (2P) microscopy of individual quantum dots (QDs) in an aqueous environment with both widefield and point-scan excitations at nanometer accuracy. Thiol-containing reductants suppress QD blinking and enable measurement of the 36 nm step size of individual Myosin V motors in vitro. We localize QDs with an accuracy of 2–3 nm in all three dimensions by using a 9×9 matrix excitation hologram and an array detector, which also increases the 3D scan imaging rate by 80-fold. With this 3D microscopy we validate the LamB receptor distribution on *E. coli* and the endocytosis of EGF-receptors in breast cancer cells.

Chemical Surface Nanopatterning Using Block Copolymer Templates

N.A. Yufa, S.L. Frank, S.J. Rosenthal, Seth B. Darling, W.A. Lopes, and S. J. Sibener

Materials Chemistry and Physics, **125**, 382 (2011)

Thin-film poly(styrene-block-methyl methacrylate) diblock copolymer (PS-b-PMMA) is used to create chemically patterned surfaces via metal deposition combined with self-assembled monolayers (SAMs) and UV exposure. We use this method to produce surfaces that are chemically striped on the scale of a few tens of nanometers. Atomic force and transmission electron microscopies are used to verify the spatially localized organization of materials, and contact angle measurements confirm the chemical tunability of these scaffolds. These surfaces may be used for arraying nanoscale objects, such as nanoparticles or biological species, or for electronic, magnetic memory or photovoltaic applications.

Ultraefficient Cooling of Resonators: Beating Sideband Cooling with Quantum Control

X. Wang, S. Vinjanampathy, *F.W. Strauch*, and K. Jacobs

Phys.Rev. Letters, **107**, 177204 (2011)

The present state of the art in cooling mechanical resonators is a version of sideband cooling. Here we present a method that uses the same configuration as sideband cooling—coupling the resonator to be cooled to a second microwave (or optical) auxiliary resonator—but will cool significantly colder. This is achieved by varying the strength of the coupling between the two resonators over a time on the order of the period of the mechanical resonator. As part of our analysis, we also obtain a method for fast, high-fidelity quantum information transfer between resonators.

Quantum Logic Gates for Superconducting Resonator Qudits

F.W. Strauch

Phys.Rev.A, **84**, 052313 (2011)

We study quantum information processing using superpositions of Fock states in superconducting resonators as quantum d-level systems (qudits). A universal set of single and coupled logic gates is theoretically proposed for resonators coupled by superconducting circuits of Josephson junctions. These gates use experimentally demonstrated interactions and provide an attractive route to quantum information processing using harmonic oscillator modes.

Entangled-State Synthesis for Superconducting Resonators

F.W. Strauch, D. Onyango, K. Jacobs, and R.W. Simmonds

Physical Rev.A, **85**, 022335 (2012)

We present a theoretical analysis of methods to synthesize entangled states of two superconducting resonators. These methods use experimentally demonstrated interactions of resonators with artificial atoms and offer efficient routes to generate nonclassical states. We analyze physical implementations, energy level structure, and the effects of decoherence through detailed dynamical simulations.

Singlet-Doublet Dark Matter

Timothy Cohen, Jonh Kearney, Aaron Pierce and *David Tucker-Smith*

Phys.Rev.D, **85**, 075003 (2012)

In light of recent data from direct detection experiments and the Large Hadron Collider, we explore models of dark matter in which an $SU(2)$ doublet is mixed with a Standard Model singlet. We impose a thermal history. If the new particles are fermions, this model is already constrained due to null results from XENON100. We comment on remaining regions of parameter space and assess prospects for future discovery. We do the same for the model where the new particles are scalars, which at present is less constrained. Much of the remaining parameter space for both models will be probed by the next generation of direct detection experiments. For the fermion model, DeepCore may also play an important role.

Higgs Friends and Counterfeits at Hadron Colliders

Patrick J. Fox, *David Tucker-Smith* and Neal Weiner

JHEP, **127**, 1106 (2011)

We consider the possibility of “Higgs counterfeits” - scalars that can be produced with cross sections comparable to the SM Higgs, and which decay with identical relative observable branching ratios, but which are nonetheless not responsible for electroweak symmetry breaking. We also consider a related scenario involving “Higgs friends,” fields similarly produced through gg fusion processes, which would be discovered through diboson channels WW , ZZ , $\gamma\gamma$, or even γZ , potentially with larger cross sections times branching ratios than for the Higgs. The discovery of either a Higgs friend or a Higgs counterfeit, rather than directly pointing towards the origin of the weak scale, would indicate the presence of new colored fields necessary for the sizable production cross sec-

tion (and possibly new colorless but electroweakly charged states as well, in the case of the diboson decays of a Higgs friend). These particles could easily be confused for an ordinary Higgs, perhaps with an additional generation to explain the different cross section, and we emphasize the importance of vector boson fusion as a channel to distinguish a Higgs counterfeit from a true Higgs. Such fields would naturally be expected in scenarios with “effective Z ’s,” where heavy states charged under the SM produce effective charges for SM fields under a new gauge force. We discuss the prospects for discovery of Higgs counterfeits, Higgs friends, and associated charged fields at the LHC.

An Effective Z ’

Patrick J. Fox, Jia Liu, *David Tucker-Smith* and Neal Winter

Phys.Rev.D, **84**, 115006 (2011)

We describe a method to couple Z ’ gauge bosons to the standard model (SM), without charging the SM fields under the $U(1)$ ’, but instead through effective higher dimension operators. This method allows complete control over the tree-level couplings of the Z ’ and does not require altering the structure of any of the SM couplings, nor does it contain anomalies or require introduction of fields in non-standard SM representations. Moreover, such interactions arise from simple renormalizable extensions of the SM - the addition of vector-like matter that mixes with SM fermions when the $U(1)$ ’ is broken. We apply effective Z ’ models as explanations of various recent anomalies: the D0 same-sign dimuon asymmetry, the CDF W +dijet excess and the CDF top forward-backward asymmetry. In the case of the W +dijet excess we also discuss several complementary analyses that may shed light on the nature of the discrepancy. We consider the possibility of non-Abelian groups, and discuss implications for the phenomenology of dark matter as well.

Limited Holism and Real-Vector-Space Quantum Theory

Lucien Hardy and *William K. Wootters*,

Found.Phys., **42**, 454-473 (2012)

Quantum theory has the property of “local tomography”: the state of any composite system can be reconstructed from the statistics of measurements on the individual components. In this respect the holism of quantum theory is limited. We consider in this paper a class of theories more holistic than quantum theory in that they are constrained only by “bilocal tomography”: the state of any composite system is determined by the statistics of measurements on pairs of components. Under a few auxiliary assumptions, we derive certain general features of such theories. In particular, we show how the number of state parameters can depend on the number of perfectly distinguishable states. We also show that real-vector-space quantum theory, while not locally tomographic, is bilocally tomographic.

Psychology

Narcissism through the Ages: What Happens When Narcissists Grow Older?

Phebe Cramer

Journal of Research in Personality, **45**, 479-492 (2011)

Three types of adult narcissism were studied over a period of 25 years, with participants from the Intergenerational Studies of the Institute of Human Development, UC Berkeley. Narcissism was assessed on three occasions, from age 34 to age 59. Hypersensitive narcissism was found to decrease, Autonomous narcissism increased, and Willfulness narcissism did not change with age. At age 34, both Willfulness and Autonomous narcissism were related to agentic personality characteristics, but only Autonomous narcissism was related to the communal personality characteristic of empathy. Change in narcissism between age 34 and age 59 was shown to predict change in personality at age 71. The agentic personality characteristics that had been associated with Willfulness narcissism at age 34 were no longer characteristic of those individuals at age 71. In addition, in contrast to Autonomous narcissism, at age 34 Willfulness and Hypersensitivity were associated with emotional maladjustment, and predicted continuing maladjustment and less favorable life outcomes in later life.

Psychological Maturity and Change in Adult Defense Mechanisms

Phebe Cramer

Journal of Research in Personality, **46**, 306 -316 (2012)

Change in the use of defense mechanisms between late adolescence and adulthood was assessed in two different longitudinal studies from the Institute of Human Development. The results were virtually identical: the use of Identification decreased, the use of Denial increased, and there was little change in the use of Projection. Both the use of Identification at adolescence, and its subsequent decrease in adulthood were found to be predicted by ego strength and committed identity – that is, by evidence of developmental maturity at late adolescence. The decrease in Identification is consistent with predictions from the theory of defense mechanism development: defenses are related to developmental period; once that period is concluded, the use of the related defense declines.

Children's Need to Know: Curiosity in Schools

Susan Engel

Harvard Educational Review, **81**, 625-645 (2011)

In this essay, Susan Engel argues that curiosity is both intrinsic to children's development and unfolds through social interactions. Thus, it should be cultivated in schools, even though it is often almost completely absent from classrooms. Calling on well-established research and more recent studies, Engel argues that interactions between teachers and students can foster or inhibit children's curiosity. She offers an explanation for why curiosity is not a priority in our educational system and calls for greater attention to children's interests and explorations, which, she argues, are the mechanisms that underlie authentic learning.

Maternal Caregiving Moderates the Relation Between Temperamental Fear and Social Behavior with Peers

E. C. Penela, H.A. Henderson, *Amie A. Hane*, M. M. Ghera, & N. A. Fox

Infancy, Advanced online publication. doi 10.1111/j.1532-7078.2012.00114.x. (2012)

Temperament works in combination with a child's environment to influence early socioemotional development. We examined whether maternal caregiving behavior at infant age 9 months moderated the relation between infant temperamental fear (9 months) and observations of children's social behavior with an unfamiliar peer at age 2 in a typically developing sample of 155 children. When infants received lower quality maternal caregiving, temperamental fear was inversely related to observed social engagement and aggression. These relations were nonsignificant when infants received higher quality maternal caregiving. Findings indicate that variations in temperamental fear may predict individual differences in future peer interactions, but sensitive, nonintrusive caregiving behaviors can attenuate these associations.

Reactive Temperament and Sensitivity to Context in Child Care

D. Phillips, N.A. Crowell, A.L. Sussman, M. Gunnar, N. Fox, *Amie Ashley Hane*, & J. Bisgaier

Social Development. Advanced online publication. doi: 10.1111/j.1467-9507.2011.00649.x (2012)

Consistent with Biological Sensitivity to Context and Differential Susceptibility hypotheses, this study found that children who, as infants, were more temperamentally reactive were more sensitive to the quality of childcare they experienced as toddlers, but not to the amount of childcare with peers they had experienced since birth. Children with both highly positively and negatively reactive temperaments were more socially integrated when care quality was higher and less integrated when care quality was lower compared with moderately reactive children. Reactive temperament was not found to moderate relations between care quality or care duration and internalizing or externalizing behavior problems. These findings support the need to consider individual differences among children in evaluating the impacts of childcare.

Family Nurture Intervention (FNI): Methods and Treatment Protocol of a Randomized Controlled Trial in the NICU

M. G. Welch, M.A Hofer, S.A. Brunelli, R.I. Stark, H.F. Andrews, J. Austin, M.M. Myers and Family Nurture Intervention (FNI) Trial Group

BMC Pediatrics **12**:14 (2012)

The stress that results from preterm birth, requisite acute care and prolonged physical separation in the Neonatal Intensive Care Unit (NICU) can have adverse physiological/psychological effects on both the infant and the mother. In particular, the experience compromises the establishment and maintenance of optimal mother-infant relationship, the subsequent development of the infant, and the mother's emotional well-being. These findings highlight the importance of investigating early interventions that are designed to overcome or reduce the effects of these environmental insults and challenges.

The Relations Between Infant Negative Reactivity, Non-Maternal Childcare, and Children's Interactions with Familiar and Unfamiliar Peers

A.N. Almas, K.A. Degnan, N.A. Fox, D.A. Phillips, H.A. Henderson, O.L. Moas, & *Amie Ashley Hane*

Social Development, **20**, 718-740 (2011)

The present study examined the influence of children's experiences during non-maternal childcare on their behavior toward unfamiliar peers. Participants included children classified as negatively reactive at four months of age ($N = 52$) and children not negatively reactive ($N = 61$), who were further divided into those who experienced non-maternal care and those who did not. Children were observed during childcare at 24 months of age and in the laboratory with an unfamiliar peer at 24 and 36 months of age, where their wariness, dysregulation, and social engagement were assessed. Within the negatively reactive childcare group, children's positive interactions with peers during childcare at 24 months predicted lower levels of wariness toward an unfamiliar peer at 36 months. This relation was not significant for children not classified as negatively reactive. The findings suggest that the influence of non-maternal childcare is dependent on a child's temperament and on the nature of peer interactions during care.

Mother and Child Interpretations of Threat in Ambiguous Situations: Relations with Child Anxiety and Autonomic Responding

Amie Ashley Hane & Emily Barrios '10

Journal of Family Psychology, **25**, 644-652. Special Issue: *Parenting at risk: New perspectives, new approaches* (2011)

This study examined maternal and child interpretive bias to threat (IBT) during dyadic conversation, child physiological reactivity and regulation during dyadic conversation, and maternal report of child anxiety in a community sample of 35 mothers and their 8- to 10-year-old children. Mothers and children discussed one neutral and six ambiguous scenarios, which were subsequently coded for frequency of maternal and child initiation, minimization, and expansion of threat-related themes. Child electrocardiogram data were collected during these conversations

and maternal reports of child anxiety and internalizing problems were obtained. Across the sample, children initiated threat-related discussion more often than mothers. Maternal threat expansions were significantly positively correlated with child anxiety and internalizing behaviors. Maternal minimizations of threat were significantly associated with augmented child vagal tone throughout the IBT paradigm. Implications for prevention of child anxiety and directions for extending IBT research within the context of the mother–child dyad are discussed.

Attention Biases to Threat Link Behavioral Inhibition to Social Withdrawal Over Time in Very Young Children

K. Pérez-Edgar, B.C. Reeb-Sutherland, J. M. McDermott, L.K. White, H.A. Henderson, K.A. Degnan, *Amie A. Hane*, D.S. Pine & N.A. Fox

Journal of Abnormal Child Psychology, **39**, 885-895 (2011)

Behaviorally inhibited children display a temperamental profile characterized by social withdrawal and anxious behaviors. Previous research, focused largely on adolescents, suggests that attention biases to threat may sustain high levels of behavioral inhibition (BI) over time, helping link early temperament to social outcomes. However, no prior studies examine the association between attention bias and BI before adolescence. The current study examined the interrelations among BI, attention biases to threat, and social withdrawal already manifest in early childhood. Children (N=187, 83 Male, M age =61.96 months) were characterized for BI in toddlerhood (24 & 36 months). At 5 years, they completed an attention bias task and concurrent social withdrawal was measured. As expected, BI in toddlerhood predicted high levels of social withdrawal in early childhood. However, this relation was moderated by attention bias. The BI-withdrawal association was only evident for children who displayed an attention bias toward threat. The data provide further support for models associating attention with socioemotional development and the later emergence of clinical anxiety.

Corrective Experiences from Clients' Perspectives

Laurie Heatherington

In L. Castonguay and C. Hill (Eds.), *Transformation in Psychotherapy: Corrective Experiences Across Cognitive Behavioral, Humanistic, and Psychodynamic Approaches*. Washington, DC: American Psychological Association (2012)

The chapter describes the results of multisite empirical study of clients' perceptions of corrective experiences in psychotherapy across diverse theoretical approaches to therapy and diverse therapy settings.

False Confessions

L. E. Hasel & *Saul Kassin*

In B. Cutler (Ed.), *Conviction of the Innocent: Lessons from Psychological Research*. Washington, DC: American Psychological Association (2012)

Forensic Personality and Social Psychology

Saul M. Kassin, & M. B. Kovera

In K. Deaux & M. Snyder (Eds.), *The Oxford Handbook of Personality and Social Psychology*. New York: Oxford University Press. (2012)

The “Messenger Effect” in Persuasion

Saul M. Kassin

In R. Arkin (Ed.), *Most Underappreciated: 50 Prominent Social Psychologists Talk About Hidden Gems*. New York: Oxford University Press (2011)

Why Confessions Trump Innocence

Saul M. Kassin

American Psychologist, posted online at doi 10.1037/a0028212 (2012)

As illustrated by the story of Amanda Knox and many others wrongfully convicted, false confessions often trump factual innocence. Focusing on consequences, recent research suggests that confessions are powerfully persuasive as a matter of logic and common sense; that many false confessions contain richly detailed narratives and accurate crime facts that appear to betray guilty knowledge; and that confessions in general can corrupt other evidence from lay witnesses and forensic experts—producing an illusion of false support. This latter phenomenon, termed “corroboration inflation,” suggests that pretrial corroboration requirements as well as the concept of “harmless error” on appeal are based on an erroneous presumption of independence among items of evidence. In addition to previously suggested reforms to police practices that are designed to curb the risk of false confessions, measures should be taken as well to minimize the rippling consequences of those confessions.

Paradigm Shift in the Study of Human Lie-detection: Bridging the Gap between Science and Practice

Saul M. Kassin

Journal of Applied Research in Memory and Cognition, <http://dx.doi.org/10.1016/j.jarmac.2012.04.009>, (2012)

Confessions that Corrupt: Evidence from the DNA Exoneration Case File

Saul M. Kassin, D. Bogart & J. Kerner

Psychological Science, **23**, 41-45 (2012)

Basic psychology research suggests the possibility that confessions--a potent form of incrimination--may taint other evidence, thereby creating an appearance of corroboration. To determine if this laboratory-based phenomenon is supported in the high stakes world of actual cases, we conducted an archival analysis of DNA exoneration cases from the Innocence Project case files. Consistent with the corruption hypothesis, multiple evidence errors were significantly more likely to exist in false confession cases than in non-confession cases; false confessions were most often accompanied, in order of frequency, by invalid or improper forensic science, followed by eyewitness identifications, and informants; and in cases containing multiple errors, confessions were more likely to have been obtained early in the investigation. We believe that these findings underestimate the problem and have important implications for the law concerning pretrial corroboration requirements and the principle of “harmless error” on appeal.

Harmless Error Analysis: How do Judges Respond to Confession Errors?

D. B. Wallace & Saul M. Kassin

Law and Human Behavior, **36**, 151-157 (2012)

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

Jennifer T. Perillo, & Saul M. Kassin

Law and Human Behavior, **35**, 327-337 (2011)

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 experi-

ments 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.

Police-Induced Confessions: An Empirical Analysis of their Content and Impact

Sara C. Appleby, Lisa E. Hasel & Saul M. Kassin

Psychology, Crime & Law, (posted online at doi:10.1080/1068316X.2011.613389 (2011))

Confessions have a greater impact on juries than other types of evidence, sometimes in the face of contradictory evidence. Twenty false confessions were content-analyzed to determine the substance of false confessions and perhaps help to explain why judges, juries, and others are prone to believe these statements. Our analysis indicated that most false confessions contained references to specific visual and auditory details concerning the crime and victim(s) as well as references to the confessor's thoughts, feelings, and motives during and after committing the crime. In a second study, mock jurors read confessions that were varied in terms of the presence of crime details, motive statements, and apologies, to determine the impact of these common aspects of confessions on a mock jury. Although a simple admission of guilt was often sufficient for conviction, more elaborate narrative confessions in which the defendant recounted how and why he committed the crime further increased confidence in these guilty verdicts.

A Stability Bias in Human Memory

Nate Kornell

In N. Seel (Ed.), *Encyclopedia of the Sciences of Learning* (pp. 4-7). New York: Springer (2012)

Human memory is anything but stable: We constantly add knowledge to our memories as we learn and lose access to knowledge as we forget. Yet people often make judgments and predictions about their memories that do not reflect this instability. The term stability bias refers to the human tendency to act as though one's memory will remain stable in the future. For example, people fail to predict that they will learn from future study opportunities; they also fail to predict that they will forget in the future with the passage of time. The stability bias appears to be rooted in a failure to appreciate external influences on memory, coupled with a lack of sensitivity to how the conditions present during learning will differ from the conditions present during a test.

Metacognition and the Social Animal

Lisa K. Son, Nate Kornell, Bridgid Finn, & Jessica F. Cantlon

In P. Briñol, & K. G. DeMarree (Eds.). *Social Metacognition* (pp. 159-175), New York: Psychology Press (2012)

Metacognition, at its most basic level, is cognition about cognition. For instance, metamemory involves judgments and beliefs about memory. In an ideal world, metacognitive processes would provide a perfect reflection of the mind's contents, the way a mirror does. But research has shown repeatedly that metacognition is, at best, a distorted mirror: Predictions of future knowledge and judgments of current knowledge are subject to bias and are frequently inaccurate. The current chapter seeks to answer why, with all of its inaccuracies, metamemory survives as one of the most critical mental processes for any individual in a social world.

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

Jannah L. Durham '10, Katherine A. Jordan '09, Marijke J. DeVos '11,
Erika K. Williams '08, & Noah J. Sandstrom

Brain Research, **144**, 64-74 (2012)

Estradiol protects against hippocampal damage and some learning impairments resulting from transient global ischemia in rats. Here, we seek to validate a mouse model of transient global ischemia and evaluate the effects of estradiol on ischemia-induced hippocampal damage and behavioral impairments. Female C57Bl6/J mice were ovariectomized and implanted with estradiol- or oil-secreting capsules. One week later, mice experienced 15-min of 2-vessel occlusion (2-VO) or sham surgical procedures. Five days later, mice were exposed to a fear conditioning protocol in which a specific context and novel tone were paired with mild footshock. Twenty-four hours following conditioning, contextual fear was assessed by measuring freezing behavior in the conditioned context (in the absence of the tone). This was followed by assessment of cue fear by measuring freezing behavior to the conditioned tone presented in a new context. When tested in the conditioned context, oil-treated mice that experienced 2-VO exhibited a significant reduction in freezing behavior whereas estradiol-treated mice that experienced 2-VO showed no disruption in freezing behavior. Freezing behavior when presented with the conditioned tone was unaffected by either surgery or hormone treatment. These findings suggest that global ischemia causes impairments in performance on the hippocampally-dependent contextual fear task but not conditioned cue-based fear. Furthermore, estradiol prevented the ischemia-induced impairment in contextual fear conditioning. Fluoro-Jade (FJ) staining revealed neuronal degeneration throughout the dorsal hippocampus of mice that experienced 2-VO. Estradiol treatment reduced the number of FJ+ cells in CA1 and CA2, but not in CA3 or in the dentate gyrus. Together, these findings suggest that 15 min of global ischemia causes extensive hippocampal neurodegeneration and disrupts contextual fear conditioning processes in mice and that estradiol protects against these adverse effects.

The Strategic Pursuit of Moral Credentials

Anna C. Merritt '08, Daniel A. Effron, Steven Fein, Kenneth K. Savitsky, Daniel M. Tuller, & Benoît Monin

Journal of Experimental Social Psychology, **48**, 774-777 (2012)

Moral credentials establish one's virtue and license one to act in morally disreputable ways with impunity (Monin & Miller, 2001). We propose that when people anticipate doing something morally dubious, they strategically attempt to earn moral credentials. Participants who expected to do something that could appear racist (decline to hire a Black job candidate in Studies 1 and 2, or take a test that might reveal implicit racial bias in Study 3) subsequently sought to establish non-racist credentials (by expressing greater racial sensitivity in Studies 1 and 2, or by exaggerating how favorably they perceived a Black job candidate in Study 3). Consistent with prior research, a follow-up study revealed that the opportunity to establish such credentials subsequently licensed participants to express more favorable attitudes towards a White versus a Black individual. We argue that strategically pursuing moral credentials allows individuals to manage attributions about their morally dubious behavior.

The Feature-Positive Effect in Allocations of Responsibility for Collaborative Tasks

Kenneth Savitsky, Robert M. Adelman '09, & Justin Kruger

Journal of Experimental Social Psychology, **48**, 791-793 (2012)

People commonly believe they have contributed more to collaborative tasks than others give them credit for. We distinguish between two types of contributions—additions (such as adding words to a co-authored paper) and deletions (such as removing extraneous words)—and show that individuals are especially prone to receive less credit from others than they believe they deserve when their contributions consist of taking something away rather than adding something. Participants who shortened some writing believed they improved it just as much as did participants who lengthened some, but were seen by others as having contributed less. Although one can hardly fail to notice one's own deletions, these contributions—like any contributions that, by their very nature, leave little trace of themselves—are easy for others to overlook.

Love Hurts (in More Ways than One): Specificity of Psychological Symptoms as Predictors and Consequences of Romantic Activity among Early Adolescent Girls

L.R. Starr, J. Davila, Catherine B. Stroud, P. C. C. Li, A. Yoneda, R. Hershenberg & M.R. Miller

Journal of Clinical Psychology, **68**, 403-420 (2012).

Because the ability to flexibly experience and appropriately express emotions across a range of developmentally relevant contexts is crucial to adaptive functioning, we examined how adolescent attachment security may be related to more functional emotional behavior during a relationship promoting interaction task. Data were collected from 74 early adolescent girls (Mean age 13.45 years; SD = 0.68; 89% Caucasian) and their primary caregiver. Results indicated that, regardless of the parent's interaction behavior and the level of stress in the parent-adolescent relationship, greater adolescent security was associated with more positive and less negative behavioral displays, including greater positivity, greater coherence of verbal content and affect, less embarrassment, and less emotional dysregulation in response to a situational demand for establishing intimacy with the parent. Implications for encouraging and fostering adolescents' capacity to respond to interpersonal contexts in ways that promote the relationship are discussed.

Spillover to Triadic and Dyadic Systems in Families with Young Children

Catherine B. Stroud, C.E. Durbin, S. Wilson & K.A. Mendelsohn

Journal of Family Psychology, **25**, 919-930 (2011)

Research has evidenced support for the spillover model, which asserts that parents' marital functioning influences their parenting and coparenting behavior in dyadic (mother-child and father-child) and triadic (mother-father-child) family contexts. However, few studies have simultaneously investigated the spillover model in both parenting and coparenting systems, preventing examination of whether spillover impacts both systems equally or differentially. Further, little research has examined whether quality of the marital system influences children's behavior toward their parents, as well as their parents' behavior, in dyadic interactions. We examined the spillover model using observational measures of parent and child behavior in parent-child dyadic interactions as well as coparenting in triadic interactions. We also explored parent and child gender differences in spillover effects. Participants were families with children aged 3 to 6 years ($n = 149$). Findings indicated that spillover occurs to multiple family systems, but the effects varied according to whose behavior (mother, father, child) was explored. In families of boys and girls, the marital system influenced warmth in triadic interactions, as well as fathers' responsiveness and children's responsiveness to mothers in dyadic interactions. Spillover effects were largely equivalent for girls and boys, but spillover to coparenting hostility in triadic interactions was limited to families raising girls. Parent gender also moderated associations between marital functioning and parent-child interactions: Spillover was significantly stronger for fathers' responsiveness (vs. mothers' responsiveness) and child responsiveness to mothers (vs. child responsiveness to fathers).

What I Like about You: The Association Between Adolescent Attachment Security and Emotional Behavior in a Relationship Promoting Context

R. Hershenberg, J. Davila, A. Yoneda, L.R. Starr, M.R. Miller, Catherine B. Stroud & B. Feinstein

Journal of Adolescence, **34**, 1017-1034. (2011)

Because the ability to flexibly experience and appropriately express emotions across a range of developmentally relevant contexts is crucial to adaptive functioning, we examined how adolescent attachment security may be related to more functional emotional behavior during a relationship promoting interaction task. Data were collected from 74 early adolescent girls (Mean age 13.45 years; SD = 0.68; 89% Caucasian) and their primary caregiver. Results indicated that, regardless of the parent's interaction behavior and the level of stress in the parent-adolescent relationship, greater adolescent security was associated with more positive and less negative behavioral displays, including greater positivity, greater coherence of verbal content and affect, less embarrassment, and less emotional dysregulation in response to a situational demand for establishing intimacy with the parent. Implications for encouraging and fostering adolescents' capacity to respond to interpersonal contexts in ways that promote the relationship are discussed.

Assessment of Effective Couple and Family Functioning: Prevailing Models and Instruments

Jay Lebow & Catherine B. Stroud

In Walsh, F. (Ed.), *Normal Family Processes: Diversity & Complexity*, 4th Ed., New York: Guilford (2011)

We live in a world in which research on mental health primarily focuses on individuals rather than families and on pathology rather than health. With the dominance of the medical model in the funding of large scale research, evidence based models of normal family functioning are dwarfed by innumerable models and measures of individual depression and other disorders in the DSM-IV-R. In this chapter, we assume a much different lens than that focused on individual pathology and look at the state of the art in the empirical assessment of family functioning. Each of these efforts creates a model of the dimensions crucial to family functioning and a set of scales or sub-scales to assess these dimensions. There have been many laudable efforts, though only a few have gained widespread usage. In this chapter, we provide a review of measures of family and couple functioning and discuss the strengths and limitations of the models.

Pubertal Timing

Catherine B. Stroud & Joanne Davila

In R.J. Levesque (Ed.), *Encyclopedia of Adolescence* (pp. 2252-2258). New York: Springer (2012)

There is a great deal of variation in the timing of pubertal maturation across adolescents. Pubertal timing refers to individuals' level of development relative to a defined group. There are both genetic and environmental contributions to the onset of pubertal maturation. A substantial body of research indicates that variations in pubertal timing have psychological, social, and health consequences (Ellis 2004; Hayward 2003; Mendle et al. 2007). In particular, research consistently demonstrates that early timing is associated with negative consequences among adolescent girls. The links between pubertal timing and social, psychological, and health outcomes are less consistent among adolescent boys. Directions for future research are highlighted.

Comparison of Two Rodent Models of Maternal Separation on Juvenile Social Behavior

Betty Zimmerberg & Kristin A. Sageser '04

Frontiers in Child and Neurodevelopmental Psychiatry, **2**, 1-10 (2011)

Early childhood deprivation is associated with an increased risk of attachment disorders and psychopathology. The neural consequences of exposure to stress early in life have used two major rodent models to provide important tools for translational research. Although both models have been termed Maternal Separation, the paradigms differ in ways that clearly shift the focus of stress between maternal and offspring units. The first model, here called Early Deprivation (ED), isolates pups individually while the dam is left not alone, but with a subset of littermates in the home nest ("Stay-at-homes"). The other model, here called Maternal Separation (MS), isolates the dam in a novel cage while the pups are separated together. In this study, these two early stress models were directly compared for their effects on social behaviors in male and female juvenile offspring. Although both models altered play behavior compared to controls, patterns of prosocial behaviors versus submissive behaviors differed by model and sex. Additionally, there were main effects of sex, with female ED subjects exhibited masculinizing effects of early stress during play sessions. Maternal behavior upon reunion with the isolated subjects was significantly increased in the MS condition compared to both ED and control conditions, which also differed but by a lesser magnitude. "Stay-at-homes" were tested since some laboratories use them for controls rather than undisturbed litters; they displayed significantly different sex-dependent play compared to undisturbed subjects. These results indicate that early stress effects vary by paradigm of separation. We suggest that MS produces greater stress on the dam and thus greater maternal mediation, while ED causes greater stress on the neonates, resulting in different behavioral sequela that warrant attention when using these models for translational research.