REPORT OF SCIENCE

AT

WILLIAMS COLLEGE

2012-2013

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

Williamstown, Massachusetts
2013

Cover Image:

This work from Satyan Devadoss (math), Hayley Brooks '12 and Kaison Tanabe '13, which began during a mathematics tutorial on phylogenetics, captures 15600 alums at Williams. The left side of the circle is broken in 15 parts, each representing a group of majors at Williams, and the right side of the circle is broken into 15 possible career categories. Each alum has an arc going from the left side to the right, with double majors having two arcs on the left (of half-thickness) combining into one resulting career.

Interactive features of this graphic, along with changes over a timeline, and visualizations of double-majors, can be found at http://web.williams.edu/math/devadoss/careerpath.html

This document is printed on recycled paper

Table of Contents

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 type 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 Center Director, 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. In 2012, more than 1/3 of Williams seniors majored in a science or mathematics discipline. The quality of the College's science programs has nurtured this interest and nearly all of those students continue in science. (SHOW LINK HERE) 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 fulltime research with Williams science faculty during the summer. Dozens of Williams students participated in conferences where they presented the results of their research, and more than 50 Williams students co-authored publications in peer-reviewed journals in the past academic year.

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 puts Williams near the top of all non-Ph.D-granting institutions. The large number of individual faculty grants, together with recent grants from the Sherman Fairchild Foundation, the Essel Foundation, endowed funds from 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.

MAJOR SCIENCE CENTER FUNDING

Kresge Foundation Equipment Grant

Williams was awarded a large 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, and also supports technical staff members who oversee the 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. Plans are underway this year to purchase a new transmission electron microscope with Kresge funds.

Sherman Fairchild Foundation Grant and BiGP program

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 ion trap mass spectrometer, a 9-color 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.

The interdisciplinary BiGP program represents a significant innovation in science at Williams over the past 10 years. By bringing together faculty members from five science departments—biology, chemistry, computer science, physics, and mathematics/statistics—the program has spurred the introduction of the emerging fields of bioinformatics, genomics and proteomics throughout the curriculum and into faculty research laboratories. Relevant courses include both sophomore- and senior-level biology tutorials on genomics, an upper-division math tutorial in phylogenetics, an advanced course on computational biology (cross-listed with physics and computer science), and a capstone course for the program. This capstone is modeled on the boldly interdisciplinary teamwork that characterizes biomedical research at leading institutions such as the Broad Institute (a joint venture of Harvard and MIT). The class meets for six to eight hours in the lab each week and for one hour in lecture. It focuses primarily on bioinformatics analysis and wet-lab investigations that inform each other as students engage in original research in functional genomics, computer programming, and proteomic analysis. This unique course structure creates a synergistic learning environment in which juniors and seniors majoring in biology, chemistry, computer science, statistics, and physics each contribute their own expertise to a semester-long research project focused on the development of colon cancer. The process is designed to empower students to take a leadership role in an authentic research endeavor. The instrumentation mentioned above, purchased with funds from the Sherman Fairchild grant, has led to novel laboratory experiments in seven introductory- and advanced-level courses and to research projects in several faculty labs, resulting in additional opportunities for cutting-edge research experiences for students.

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 IN THE SCIENCES

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 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 wide range of courses including those in cellular biology, immunology, biochemistry, molecular biology, developmental biology, physiology, animal behavior, neurobiology, ecology and evolution. Over the past few years several new courses have been added to our curriculum: Integrative Bioinformatics, Genomics and Proteomics (BIOL 319) as well as new literature-based senior-level courses dealing with topics of current research interest including Developmental and genomic evolution of animal design and two 400-level tutorials. Every course changes from year to year to emphasize the latest concepts and to introduce and integrate new techniques and instrumentation used in modern biological research. 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 Chemistry and Physics of Cooking (CHEM 116).

Computers 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 attempts to meet these varying interest through 1) its major program; 2) a selection of courses intended for those who are interested primarily in an introduction to computer science; 3) recommended course sequences for the non-major who wants a more extensive introduction to computer science in general or who seeks to develop some specific expertise in computing for application in some other discipline. 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. The Socio-Techno Web (CSCI 102) introduces many fundamental concepts in computer science by examining the social aspects of computing. Creating Games (CSCI 107) introduces important concepts in computer science through the design and analysis of games, and The Art and Science of Computer Graphics (CSCI 109) introduces students to the techniques of computer graphics.

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

CES maintains and operates the 2600-acre Hopkins Memorial Forest and its Rosenburg 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 building 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 The Co-Evoluton of Earth andLife (GEOS 101), An Unfinished Planet (GEOS 102); Global Warming and Natural Disasters (GEOS 103); and Oceanography (GEOS 104). 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.

The Department of **Mathematics and Statistics** is designed to meet two goals: introducing the central ideas of 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.

The **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 ature of science itself and upon science's relationship to society as a whole.

The Program in **Neuroscience** consists of five courses including an introductory course, three electives, and a senior course. In addition, students are required to take two courses, Biology 101 and Psychology 101, as part of the program.

Neuroscience (Neuroscience 201) is the basic course and provides the background for other neuroscience courses. Ideally, this will be taken in the sophomore year. Either Biology 101 or Psychology 101 serves as the prerequisite. Electives are designed to provide in-depth coverage including laboratory experience in specific areas of neuroscience. At least one elective course is required from among those cross-listed in Biology (Group A) and at least one is required from among those cross-listed in Psychology (Group B). The third elective course may also come from Group A or Group B, or may be selected from other neuroscience related courses upon approval of the advisory committee. The senior course, Topics in Neuroscience (Neuroscience 401) is designed to provide an integrative culminating experience.

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 individually with a faculty member in either experimental or theoretical research.

The **Psychology** Department offer a wide variety of curricular and research opportunities for 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 in the psychology department 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. The latest 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, Legal Studies, Public Health, and Neuroscience.

The role that **Science and technology Studies (STS)** have played in shaping modern industrial societies is generally acknowledged, but few members of those societies, including scientists and engineers, possess any understanding of how that process has occurred or much knowledge of the complex technical and social interactions that direct change in either science or society. The Science and Technology Studies Program is intended to help create a coherent course of study for students interested in these questions by providing a broad range of perspectives. Courses examine the history or philosophy of science and technology, the sociology and psychology of science, the economics of research and development and technological change, science and public policy, technology assessment, technology and the environment, scientometrics, and ethical-value issues.

The **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.

TUTORIALS IN THE SCIENCES

The tutorial program at Williams is in many ways one of its signature features. And for good reason. In these classes, pairs of students meet for intensive, weekly two-on-one interactions with faculty members, taking leadership roles in their own education. While the traditional format for such courses in humanities disciplines involves students writing and critiquing papers on a weekly basis, the various science departments at Williams have embraced the essential value of the tutorial format, and adapted it in a variety of discipline-specific ways. These include reading, presenting, and critiquing papers from the current scientific literature, or in other cases solving and then discussing and presenting solutions to challenging problem set questions on advanced topics. We find that the independence, critical thinking, and oral presentation skills demanded of students in these courses provide the ideal preparation for graduate study as well as a many other post-graduate activities.

Science Center Staff, Clockwise from Back row left: Dan Viall, Patti Travis, Nancy Piatczyc, Don Beaver, Tiku Majumder, Larry George, Michael Taylor, Alicia Romac, Norm Bell

WINTER STUDY 2013 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. Following are course descriptions for the 2013 WSP science offerings:

BIOL 10 Observational Drawing From The Natural World

This is a drawing course for science students and others who are interested in developing their skills in observing and drawing from nature. Much of the class work will deal directly with drawing from plant forms and specimens from the animal world and to this end we will be using an interesting collection of stuffed mounts and skeletons that belong to the Williams Biology department. We will also spend time in the Morley greenhouse. Beyond the subject matter at hand, assignments will also address and analyze the more formal aspects of drawing and two-dimensional design with outside assignments including independent visits to the Clark, the WCMA study collection and the Chapin Library of Rare Books.

BIOL 11 BioEYES : Teaching Fourth Graders about Zebrafish

BioEYES brings tropical fish to 4th grade classrooms in Williamstown and beyond, in a science teaching workshop. Elementary school students will breed fish in the classroom, then study their development and pigmentation during one week. Williams students will adapt BioEYES lesson plans to the science curriculum for the schools we visit, work with classroom teachers to introduce concepts in genetics and development, help the 4th grade students in the classroom, and assess elementary student learning. A final eight-page paper describing the goals and outcomes for each grade level is required. No zebrafish experience is necessary; during the first week students will learn to set up fish matings, and learn about embryonic development and the genetics of fish

pigmentation as well as practice teaching the 4th grade BioEYES lesson plans with hands-on experiments using living animals.

CHEM 16 Glass and Glassblowing

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

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.

CHEM 23 Introduction to Research in Organic Chemistry

In this course, students will engage in an experimental project based on the general aim of improving the role of polymers in drug delivery by expanding synthetic tools, incorporating both covalent and non-covalent self-assembly triggers, defining their materials properties on the basis of molecular structure, and improving their biocompatibility and degradability. Depending upon the project, students use techniques in organic synthesis, materials characterization, biochemical assays, and cell culture. Representative projects include the synthesis and evaluation of: (a) amino acid-based polymers as amphiphilic drug delivery vehicles; (b) polymers bearing targeting agents for improved cellular specificity; (c) temperature sensitive polymers for stimulus-controlled aggregation. These self-assembled materials are loaded with protein or small molecule drugs for anti-cancer therapies.

CSCI 12: Using a Computer to do the Math You Cannot Do

Math is an excellent tool to understand an idealized world, but in the ugly real world there are integrals that

cannot be solved analytically (e.g., the normal distribution), functions that need to be maximized without being differentiable or even continuous, equations that need to be solved when there is no closed-form solution (e.g., a fifth degree polynomial). In this course we will introduce the programming and math skills you need to handle such real life calculation problems. At the same time you will learn the basics of a programming language of your choice. We will use social media and peer-instruction for parts of the course for teaching, learning, evaluation and assessment.

CSCI 13: 3D Printer Construction: A Self-Replicating Printer

3D printing is a technology used to create three-dimensional objects from digital information. The field is expanding rapidly, creating vast opportunities for research and business. Low-cost 3D printing has the potential to put the capability for creating physical objects in every business and home, much in the way the personal computer changed the paradigm of computing from expensive, centralized mainframe computers to low-cost, widespread personal computers. One direction of development is pursuing an open-source approach to making the technology widely available. A central goal of this effort is the capability for 3D printers to "self-replicate". That is, for one printer to be able to create the parts required to assemble additional 3D printers. We will explore this technology and its implications for society by building an operational "RepRap" 3D printer. Additionally, we will investigate how 3D printing technology may disrupt the traditional manufacturing economy and create new opportunities. Time permitting, we will fabricate the parts required to build a "child" 3D printer. A presentation, including a demonstration of the printer, and documentation of the project on a web site will be required. The class will utilize a multi-discipline team approach with opportunities for concentration in basic mechanical and electrical fabrication, software, 3D object modeling/CAD, or web-based documentation.

WSP GEOS 25 Field Geology in the Colorado Front Range – the Geologic Evolution of the Southern Rocky Mountains

Rising 8000 feet vertically above Colorado Springs and the Great Plains, 14,000-foot Pikes Peak heralds the beginning, both topographically and geologically, of the Rocky Mountains. The region beneath the Peak vividly portrays one of the most complete records of geologic history in the West, spanning nearly 2 billion years. Precambrian granite plutons and their metamorphic wall rocks are the "basement" for a stratigraphic succession stretching from Cambrian to Pleistocene. Thickness and types of sedimentary layers, some tilted vertically, document repeated uplift and erosion of mountain ranges. Volcanism 40-20 million years ago produced flows of lava, glowing incandescent ash, and mud, as well as the major gold deposit at Cripple Creek. Fossil localities contain marine organisms, world-class dinosaur remains, and, at the Florissant Fossil Beds National Monument, one of the richest assortments of Tertiary plants and insects found anywhere.

This winter study project culminates in a 10-day field trip to explore this geologically rich and diverse region. The program begins with a week and a half at Williams, where daily meetings will introduce the material and methods needed for the field work to follow. Classes and labs will deal with rock types, geologic structures and landforms, the time scale, and topographic and geologic maps. During this time each student will select a particular topic or locale to review independently and to present to the entire group while on-site in Colorado.

In Colorado we will be based at the 6000-acre Colorado Outdoor Education Center, adjoining the Florissant Fossil Beds National Monument. Daily field trips on foot and by van will take us to key outcrops that provide field evidence for the geologic and topographic evolution of the region. Observations and measurements at each site will be recorded in field notebooks, documenting a first-hand introduction to the region's physical and historical geology.

MATH 25 The History, Geography and Economics of the Wines of France

In this course, during the first week in Williamstown, we will study the factors that have resulted in the French wine industry of today. The history of wine making in France is long, dating back to the Greeks and later the Romans. Not surprisingly, the first areas to be planted were the areas around present day Marseille, (Massalia in Ancient Greece) in Provence, and the areas just north farther up the Rhône river valley. We will study the history of wine in France from the Romans through the middle ages, the influence of monasteries on wine production, the impact of the French revolution and the evolution of the modern classification system in the 19th century which is still in place today. The late 19th century saw a series of catastrophes that had devastating effects on both the quantity and quality of wine produced. The solutions to these problems are varied and fascinating and resulted in the hybridization of American and French vines which exist to this day. Recent history includes the spread of quality wines to the Languedoc area which now rivals some of the more prestigious traditional areas of Bordeaux and Burgundy. Later, we will visit the Agricultural Research

Center (INRA) in Montpellier which both helped with understanding the Phylloxera epidemic of the 1850's, and also contributes to the continuing evolution of the quality of the Languedoc wine industry. Geography and climate play an essential and important role in grape growing. Due to its temperate and incredibly varied climates, France, while not holding a monopoly on fine wine production, is blessed with being able to grow a wide range of different styles of grapes whose sugar and acidity lend themselves to the production of quality wines. We will visit four different areas of French wine production: Bordeaux, Languedoc and the two oldest areas of the Rhône and Provence. During our first week we will also study the impact of global warming on the future of wine production in France and the potential economic impact. We will look at temperature data and study the relationship between temperature change and quality using statistical regression analysis. Finally, we will discuss the role of wine in French cuisine and the importance of wine to French culture. STRUCTURE OF THE COURSE: During the first week in Williamstown, we will read about the history of wine production, study the geography of France and perform various statistical analyses relating to quality, temperature and production. In particular we will study the relationship between price and quality as judged by experts for the 2000 Bordeaux vintage. Depending the ages of the students, we may do some wine tasting and discussion as well. Proposed itinerary Day 1: Fly from Albany to Paris, arriving in the morning. We will get acclimated and in the afternoon I plan to organize a lecture by a wine merchant who will give his perspective on the current state of the French wine industry (at the store Les Caprices de l'Instant). Days 2-4: Train to Bordeaux. We will visit the famous wine town of St. Emillion and visit several chateaux during our 3 days in this area. Possible chateaux to visit include Haut Brion (or if still being renovated La Mission Haut Brion), Chateau Pichon Longueville, Chateau Margaux and Chateaux Mouton-Rothschild. Visits will include tours of the facility and a history of each chateau, some of which date back to the 16th century. Days 5-7 We next travel to Montpellier the center of the Languedoc wine region. We will visit INRA (the agricultural research center) where we will talk with experts about the history of wine production in the area including the devastation of the Phylloxera epidemic as well as the evolution of the past 30 years which has seen the region go from an area which produced only table wine to some of the most prestigious wines of the world. We will visit several producers in the region, possibly Mas de Daumas Gassac, Domaine de La Grange des Pères and Château La Roque. Side visits will include a trip to Saint-Guilhem-le-Désert, one of the most beautiful medieval villages of France. Days 8-10 Next is the Rhône with possible stops in Hermitage for a visit to the cave of M. Chapoutier, the domaine of Trevallon in Baux les Provinces, an incredible wine that lost it's "appellation" for political reasons and it now a designated only as a "vin de table", but it sought after by chefs all over France, and at least one Chateauneuf du Pape vineyard, possible Beaucastel or Domaine de la Janasse. One day will be spent in Avignon to visit the Palais des Papes the papal site during the 14th century. From Marseille we will take the train back to Paris and then fly back to Albany on day 11 or 12.

PHYS 14 Electronics

Electronic instruments are an indispensable part of modern laboratory work throughout the sciences. This course will cover the basics of analog electronic circuits, including transistors and operational amplifiers, and will briefly introduce digital circuits. Students will build and test a variety of circuits chosen to illustrate the kinds of electronic devices and design problems a scientist is apt to encounter. Evaluation will be based on participation, completion of both laboratory work and occasional homework, and the quality of the final project or paper. Prerequisite: Mathematics 104 or equivalent calculus. No prior experience with electronics is required. Enrollment limit: 16 Cost to student: $50 for course packet and electronic parts. Meeting time: afternoons, for a mixture of lab, lecture, and discussion, providing ample opportunity for hands-on experience. In the last week, students will design and build a final project, or will write a 10-page paper.

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 student 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.

Students will be evaluated on the basis of regular attendance, completion of 4 laboratory exercised, and a holography laboratory project or a 10-page paper. Attendance at all classes and labs is required for a passing grade.

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, environmental studies, geosciences, history of science, mathematics and statistics, neuroscience, 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 proximity 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 annual publication of the Report of Science at Williams, and faculty lectures sponsored each semester by the local Sigma Xi chapter.

The programs based in the Science Center encompass the coordination of grant proposals by federal agencies and private foundations, the distribution of more than $450,000 of research funds annually. In 2012-2013, there were fifteen individual Williams College science faculty members with active NSF grants totaling more than $3.5 million 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 161 individuals at Williams in 2013. 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 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 divisions.

Summer Science Research Funding Sources 2013	10 week Student Positions
Allison Davis Research Fellowship - Chemistry (WCURF)	1.5
American Chemical Society	2
Arnold Bernhard Foundation Summer Fellowships	12
Bronfman Science Center Fund	3
Camille & Henry Dreyfus Foundation	2
Center for Environmental Studies	1
Class of 1951	6
Finnerty Fund - Applied Mathematical Research	4
Keck Geoscience	1
Keck Northeast Astronomy Consortium	2
Lowe 1973 Chemistry Fellowships	7
Markgraf JH 1952 Fellowships	6.3
Mellon Mays Undergraduate Fellowships	1
NASA	1
NSF grants to individual faculty	10
NSF/Small Program Mathematics	20
Petroleum Research Corporation - Chemistry	2
Science Center funds	36
Somers B & L 1948 Physics Internships	2
Summer Science Program Alums	11
Synott TW 3rd 1958 Physics Internships	1
Wege Markgraf Chemistry Fellowships	6.3
Williams Bicentennial Psychology Scholarship	1
Total number of 10 week stipends	139

2013 Summer Science Students and their Faculty Advisors

Astronomy

Gillian Beltz-Mohrmann	Steven Souza
Allen Davis	Jay Pasachoff
Kerry Hensley	Karen Kwitter
Muzhou Lu	Jay Pasachoff
Shubhanga Pandy	Jay Pasachoff
Zeeve Rogoszinski	Jay Pasachoff
Mona Sami	Steven Souza
Christina Seeger	Karen Kwitter

Biology

Brent Bomkamp	Derek Dean
Tendai Chisowa	Lois Banta
Sarah Cottrill	Heather Williams
Chiara DelPiccolo	Wendy Raymond
Jamie Dickhaus	Hank Art
Luke Dickhaus	David Smith
Simone Frank	Heather Williams
Racquel Gibson	Tim Lebestky
Allison Graebner	Matt Carter
Eric Hagen	Manuel Morales
Laurel Hamers	Tim Lebestky
Betsy Hart	Lois Banta
Kathleen Higgins	Claire Ting
Anna Hopkins	James Carlton
Elissa Hult	Joan Edwards
Iyer Manasi	Matt Carter
Kelsey McDermott	Steve Zottoli
Molly McEntee	Joan Edwards
Alexandra McInturf	Manuel Morales
Zach McKenzie	Tim Lebestky
Yoelkys Morales	Dan Lynch
Katerine Newcomer	James Carlton
Ashley Ngo	Martha Marvin
Reid Pryzant	Claire Ting
Rahul Sangar	Martha Marvin
Shelby Shote	Steve Swoap
Kairav Sinha	Wendy Raymond
Laura Stamp	Hank Art
Alice Stears	Hank Art
Melinda Wang	Lois Banta
Kaijie Zheng	Martha Marvin

Chemistry

Christopher Bravo	Charles Lovett
Todd Brenner	Sarah Goh
Jeff Brewington	Chris Goh
Craig Burt	Thomas Smith
Cecilia Castellano	Enrique Peacock-Lopez
Jorge Castro	Charles Lovett
Melissa Cendejas	Lee Park
Kyung JunChae	Enrique Peacock-Lopez
Tamuka Chidanguro	Chris Goh
Peter Clement	Lee Park
Nicolaas Crone	Sarah Goh
Rebecca Dryer	Jimmy Blair
Dylan Freas	Lee Park
Pushpanajali Giri	Charles Lovett
Christian Gronbeck	Thoman (& Richardson)
Ashley Kim	Thomas Smith
Willis Koomson	Charles Lovett
Won-Jun Kuk	Amy Gehring
Logan Lawson	Anne Skinner
Denise Lee Park	Sarah Goh
Brian Leland	Amy Gehring
Lillian Ma	Chris Goh
Justin Mangope	Stock Room
Miguel Mendez	Lee Park
Jessica Monterrosa Mena	Amy Gehring
Lilliana Morris	Chris Goh
Zaw-htut Naing	Thomas Smith
Austin Paul	Richardson & Thoman
Luxi Qiao	Sarah Goh
Amanda Schott	Thoman (& Richardson)
Joon Hun Seong	(Student to Leiden)
Anuj Shah	Enrique Peacock-Lopez
Kassandra Spiller	Anne Skinner
Rebecca Staff	Richardson & Thoman
Megan Steele	Amy Gehring
Colbert Tredez	Anne Skinner

Hector Trujillo
Areli Valencia
Scott Wieman
Shannon Zikovich

Computer Science

Sarah Abramson   Jeannie Albrecht
Kevin Chen   Andrea Danyluk
Klye Cheng   Tom Murtagh
Samuel Donow   Morgan McGuire
Carson Eisenach   Brent Heeringa
Daniel Evangelakos   Morgan McGuire
Joshua Geller   Andrea Danyluk
Emma Harrington   Stephen Freund

Geoscience

Johanna Eidmann   Mea Cook
Caroline Gregory   Lisa Gilbert
Quinn Griffin   Phoebe Cohen
Kalle Jahn   Ronadh Cox
Michelle Paradis   Phoebe Cohen
Will Wicherski   Ronadh Cox

Mathematics Statistics

Francisc Bozgan   Cesar Silva
Orsola Capovilla-Searle Colin Adams
Alan Chang   Steven Miller
Taylor Concoran   Steven Miller
Philippe Demontigny   Steven Miller
Tha oDo   Steven Miller
Jesse Freeman   Colin Adams
Paul Gallagher   Frank Morgan
David Hu   Frank Morgan
Dong Hwan   Steven Miller
Daniel Irvine   Colin Adams
Peihong Jiang   Susan Loepp
Anna Kirkpatrick   Susan Loepp
Archit Kulkarni   Steven Miller
Victor Luo   Steven Miller
Thomas Mack-Crane   Susan Loepp
Cesar Melendez   Cesar Silva

Charles Lovett
Chris Goh
Richardson & Racela
Jimmy Blair

Maggie Miller   Frank Morgan
Byron Perpetua   Frank Morgan
Samantha Petti   Colin Adams
Jaclyn Porfilio   Steven Miller
Kyle Pratt   Steven Miller
Faraz Rahman   Bernhard Klingenberg
Jirapat Samranvedhya   Steven Miller
Anthony Sanchez   Cesar Silva
David Stevens   Cesar Silva
Minh-Tam Trinh   Steven Miller
Samuel Tripp   Susan Loepp
Umang Varma   Steven Miller
Daniel Vitek   Colin Adams
Jane Wang   Cesar Silva
Ashley Weber   Colin Adams
Jake Wellens   Steven Miller
Sicong Zhang   Colin Adams

Physics

Nathan Bricault   Tiku Majumder
Julia Cline   Ward Lopes
Richard Eiselen   Ward Lopes
Alex Foucault   Fred Strauch
Jeremy Gold   Fred Strauch
Isaac Hoenig   David Tucker-Smith
Joseph Iafrate   Fred Strauch
Willis Kuelthau   Ward Lopes
Max LaBerge   Jeff Strait
Kamuela Lau   Michael Seifert
Brandon Ling   Michael Seifert
Sarah Peters   Tiku Majumder
Gabriel Samach   David Tucker-Smith
Corey Smith   Bill Wootters
Kirk Swanson   Bill Wootters
Gabby Vukasin   Tiku Majumder
Cheung Weng-Him   David Tucker-Smith

Psychology

Jenna Adams   Noah Sandstrom
Ellen Cook   Noah Sandstrom
Alida Davis   Zimmerberg & Moher

Jessica Fitts	Kate Stroud	Alyssa Quann	Kate Stroud
Nitsan Goldstein	Noah Sandstrom	Sarah Rosemann	Nate Kornell
Anna Lau	Jennifer Crosby Randall	Nitza Solis	Kate Stroud
Theresa Legan	Safa Zaki,	Meredith Sopher	Susan Engel
Si Young Mah	Safa Zaki	Katie Swoap	Kate Stroud
Fanny Mlawer	Marlene Sandstrom	Mattia Wruble	Nate Kornell
Ashini Patel	Susan Engel	Daniela Zarate	Betty Zimmerberg

Summer Science Research Poster Session: August 2, 2013

At the end of the summer, students (or teams) who were engaged in Summer Science Research can choose to present a poster highlighting the research they had been working on. Posters are reviewed by their peers and a winning poster is selected. This year 53 posters were presented in 8 departments. Posters are listed below:

Advisor(s)	Team	Title
J. Pasachoff	Allen Davis	"Single-Chord Stellar Occultation by 50000 Quaoar"
J. Pasachoff	Zeeve Rogoszinski	The Black Drop Effect At The 2012 Transit Of Venus
K. Kwitter	Kerry Hensley and Tina Seeger	"Slow and Steady Wins the Race? Sun-like Stars as Carbon Producers"
S. Souza	Gillian Beltz-Mohrmann and Mona Sami	Monitoring Variability in Massive Stars
C. Ting	Kathleen Higgins	Molecular Response of Prochlorococcus to Light Stress
C. Ting	Reid Pryzant	Prochlorococcus in Context: Metagenomic Analysis of Sargasso Sea Microbiomes
H. Art	Jamie Dickhaus, Alice Stears, Laura Stamp	It Huffed and Puffed and Blew our Forest Down
L. Banta	"Melinda Wang, Tendai Chisowa, Betsy Hart, Darcy Mishkind	Type 6-dependent secretion of a modulator of host defenses and biofilm formation in Agrobacterium tumefaciens
M. Morales & A. McInturf	Eric Hagen	Mutualism in the Morales Lab
T. Lebestky	Kairav Sinha	Effects of the dopamine receptor DopR1 on Drosophila grooming behavior
T. Lebestky	Laurel Hamers, Zach McKenzie	Dopaminergic Modulation of Endogenous Arousal in Drosophila melanogaster
J. Racela	Andrew Nemeth, Molly Pickel	Green River: East Branch Chemistry
J. Racela, D. Richardson	Scott Wieman	The accelerated extraction and determination of phosphorus from soils.

A. Gehring	Won-Jun Kuk, Brian Leland, Megan Steele	The Characterization of Streptomyces coelicolor Life Cycle
A. Gehring & E. Peacock-Lopez	John Chae	Constructing Artificial Genetic Networks: Minimal 2-Gene Oscillator
A. Skinner	Kassandra Spiller	Where Did Modern Humans First Evolve?
A. Skinner	Logan Lawson	The 'Spin' on the Dawn of Symbolic Thinking?
A. Skinner	Tre' Colbert	Acatina Shell Dating: This Thing is Old as Dirt!
C. Lovett	Chris Bravo, Willis Koomson, Hector Trujillo, Pushpanjali Giri, and Jorge Castro	The Quest for Inhibitors of the Bacterial SOS System
C. Goh	Lillian Ma and Tamuka Chidanguro	"Atom Transfer Radical Polymerization using Copper Complexes with Pyridine-based Ligands"
C. Goh	Lilliana Morris & Jeff Brewington	"Iron Catalysts and the Epoxidation of Unsaturated Fatty Acids"
D. Richardson, J. Thoman	Austin Paul, Amanda L. Schott	Bioaccumulation of PCBs in Hoosic River Crayfish
D. Richardson, J. Thoman	Christian Gronbeck and Rebecca Staff	Synthesis and Stereochemical Analysis of SP3-Hybridized Deuterocarbons
E. Peacock-Lopez	Anuj Shah	The Dynamic Behavior of Competitive Self-Replicating Molecules
E. Peacock-Lopez	Cecilia Castellano	Modeling the SCN-PVN-Pineal Circadian Path for Melatonin Release
T. Smith	Ashley Kim, Zaw-htut Naing	Working Toward the Synthesis of Jerangolid D
T. Smith	Craig Burt	Progress Towards the Synthesis of Enigmazole A
A. Danyluk	Josh Geller, Kevin Chen	Computational Identification of Individual Spotted Salamanders
B. Heeringa	Carson Eisenach	Visual Encoding
J. Albrecht	Sarah Abramson, Kelsey Levine	Detecting and Predicting Home Occupancy
M. McGuire	Dan Evangelakos, Samuel Donow, James Wilcox, Michael Mara	G3D Innovation Engine
S. Freund	Emma Harrington	Dynamic Escape Analysis for Data Race Detection
T. Murtagh	Kyle Cheng	Optimizing Computer management of Flash Memory
N. Piatcyzc	Rahul Sanger, Kelsey McDermott	Bugs and Us

P. Cohen	Quinn Griffin	3D Model of the Trace Fossil Treptichnus pedum
S. Miller, F. Strauch	Josef Iafrate	When Life Gives You Lemons - A Statistical Model for Benford's Law
J. Andrade, S. Miller	Alan Chang, Kyle Pratt, Minh-Tam Trinh	Number Theory in Various Settings
S. Miller	Archit Kulkarni, David Moon, Jake Wellens, and Thao Do	Sets with More Sums than Differences
S. Miller	Jaclyn Porfilio, Taylor Corcoran, Joseph Iafrate, Jirapat Samranvedhya	Benford Behavior of Dependent Random Variables
S. Miller	Phillipe Demontigny, Thao Do, Archit Kulkarni, David Moon, Umang Varma	Generalizing Zeckendorf Decompositions
M. Marvin	Kaijie Zheng	Expression of Small Heat Shock Protein Hspb7 and Fibronectin During Zebrafish Heart Development
David Tucker-Smith	Isaac Hoenig	Light Z' Bosons at the LHC
D. Tucker-Smith	Weng-Him Cheung	Indirect Detection of a Z' Model of Dark Matter
F. Strauch	Cesar Melendez	The Quantum Zeno Effect
G. Ranjit, P. Majumder	Gabby Vukasin	Measurement of Hyperfine Splitting and Isotope Shift of Thallium 203 and 205
G. Ranjit, P. Majumder	Nathan Bricault	Stark Shift Measurement in an Indium Atomic Beam Using Two-Tone Frequency Modulation Spectroscopy
G. Ranjit, P. Majumder	Sarah Peters	Design and Construction of an External Cavity Diode Laser
J. Strait	Max LaBerge	"The New Pulsed All Fiber Laser"
M. Seifert	Brandon Ling	Generalized Topological Defects in a Lorentz-violating Theory
M. Seifert	Kamuela Lau	"Lensing Effects in Lorentz Symmetry Breaking"
W. Lopes	Julia Cline and Willis Kuelthau	Evolution of Order in Diblock Copolymer Systems
W. Lopes	Richard Eiselen	Compensating for SLM Defects to Improve Holographic Optical Trapping
W. Wootters	Corey Smith, Kirk Swanson	Optimal Information Transfer

Summer Science Research Colloquia 2013

Lunch 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.

Speakers for summer 2013 were:

Jay Pasachoff, Astronomy Department	"Transits of Venus"
Duane Bailey, Computer Science Department	"Computational Fabric"
Cesar Silva, Mathematics & Statistics Department	Mixing and Chaos when Kneading Dough
Michael Seifert, Physics Department	"Lorentz Symmetry and How To Break It."
Karen Kwitter, Astronomy Department	"Galaxy Collisions and You"
Hank Art, Biology Department	Some Truly Disturbing News About the Hopkins Forest
Tiku Majumder, Physics Department	The Romance of the next decimal place.

Pre-First Year Summer Science Program

In its twenty-sixth summer in 2013, 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-one 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.

Faculty involved in the teaching for the Summer Science Program included Professors Charles Lovett and David Richardson (Chemistry), Professors Stewart Johnson and Cesar Silva (Mathematics), Professor Dan Lynch (Biology), Professor Cassandra Cleghorn (English), 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 under-represented 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.

2013 Pre-First Year Summer Science Program Participants

Students

Funmilayo D. Adejobi

Selena A. Castro

Cesar F. Dominguez

Ronald Govin

Yanira Guerra,

Maria G. Guzman

Justin A.Harris

Cecilia Hurtado

Luis Jaramillo

Jonathan N. MacDougall

Paula N. Mejia

Terrance Mensah

Kimthanh P. Nguyen

Gemma Porras Nielsen

Chloe M. Rogers

Richard A. Ruberto

Diana Sanchez

Jaqueline Serrano

Gabriela Lydia Suarez

Kelly Tellez

Sabrina N. Zaldana

Faculty

Cassandra Cleghorn

David Dethier

Stewart Johnson

Charles M. Lovett, Dir.

Dan Lynch

Lee Park

David Richardson

Cesar Silva

Tutors

Naomi Fields '16

Isabella Tillman '16

Miguel Mendes '16

Asvelt Nduwumwami '13

Students present their 2013 Summer Science Research posters in the Schow Science Library.

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 2012-2013 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 Jeannie Albrecht of the Computer Science Department at Williams College present two colloquia on one aspect of her research, the application of computational science to achieve enhanced domestic energy conservation. Her first talk focused on sensor-driven energy management for smart buildings; the second highlighted her work on flattening peak electricity demand in smart buildings.

In April, Susan Loepp, Professor of Mathematics, presented a talk entitled "Using Algebra to Protect Your Personal Information". Both fall and spring faculty lectures were followed by the usual lively and well-attended reception in the Science Center Atrium. This year Sigma Xi co-sponsored the keynote address of the Computer Science Department's 25th Anniversary celebration on April 19th. The speaker, Richard Ketcham '87 spoke on "Doing Earth Science with Computers, with a Dash of Williams Philosophy 101".

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 Derek Wood.

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 50 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 the their research projects are presented in the student abstracts section of this report.

Associate Sigma Xi members from the Class of 2013

Astrophysics

Alyssa C. Barlis

Muzhou Lu

Biology

Katharine H. Dusenbury

Michael A. Essman

Elizabeth E. Hwang

Ryan W. Jenks

Yiqin Jiang

Brian J. Kirchner

Grace S. Lapier

Geordie C. Lonza

Uttara Partap

Rebecca R. Shoer

Gordon P. Smith

Carrie M. Tribble

Chalita N. Washington

Jonathan E. Wosen

Chemistry

Bryn E. Falahee

Sarah L. Guillot

Sora Kim

Alexander J. Lou

Steven A. Mendoza

Computer Science

Jennifer M. Gossels

Donny Huang

April T. Shen

James R. Wilcox

Geoscience

Miranda L. Bona

Claudia R. Corona

Gabriel M. Lewis

Ian M. Nesbitt

Mathematics & Statistics

Jack T. Ervasti

Alexander H. Greaves-Tunnell

Zane K. Martin

Christopher P. Picardo

Benjamin B. Seiler

Philip D. Tosteson

Neuroscience

Sierra C. Germeyan

Emily J. Levy

Physics

Dylan P. Gilbert

David A. Kealhofer

Christina P. Knapp

Alice A. Sady

Nathan A. Schine

Roshan Sharma

Qiao Zhang

Psychology

Julia R. Bender Stern

Pacifique A. Irankunda

Alexander S. Rich

Daniel M. Silver

Effua E. Sosoo

Emmanuel J. Whyte

Academic Year Science Lunch Colloquia 2013

Presenter	Title
Tiku Majumder, Science Center Director	Welcome and Introductions
Steve Swoap, Biology	"What was the blood pressure of dinosaurs?"
Enrique Peacock-Lopez, Chemistry	"Artificial genetic networks"
Bernhard Klingenberg, Mathematics & Statistics	"On things that are thus and so"
Karen Kwitter, Astronomy	"Planetary nebulae: archives of past and future galactic history"
Bill Lenhart, Computer Science	"Constrained embeddings of trees"
Colin Adams, Mathematics & Statistics	Turning Knots into Flowers
Michael Mara, Computer Science	Image Space Photon Mapping
Wendy Wang, Mathematics & Statistics	Kernel density estimation
Phoebe Cohen, Geosciences	"Squeezing Science from a Stone"
Michael Taylor, Science Shop	"3-D Printing Comes to Williams"
Marsha Altschuler, Biology	"Big things in a small package"
Matt Gardner Spencer, Mathematics & Statistics	"Archimedes' Method"
Stephanie Boyd & David Dethier	Zilkha....if we care!!
Mark Mixer, Mathematics & Statistics	Symmetries of discrete objects
Jennifer Randall Crosby, Psychology	Here's Looking at You: Causes and Consequences of Targeted Social Referencing
April 16 - Jimmy Blair, Chemistry	"Building a key from scratch"
April 23 - Kevin Jones, Physics	"It's not cheating: copies better than the quantum limit"
April 30 - Amy Gehring, Chemistry	"From the Soil to the Medicine Cabinet: Controlling Antibiotic Production in Streptomyces coelicolor"

In Memoriam

The Biology department is sad to report that **Professor Bill DeWitt** passed away on May 3rd, 2013. He was the C. Carlisle and Margaret Tippit Professor of Biology. A member of the Class of 1961, Bill was a part of the biology department and the college since his return to Williams in 1967. The many students who knew and admired him include the large number he taught in Biology 101 and in his very popular Clocks senior seminar.

Our dear colleague, teacher, and friend, **Ollie Beaver**, died on December 7, 2012. Ollie joined the Department of Mathematics in Sept. 1979, and, for the next 33 years, played a major role in transforming the department and the college. From 1987 she was a driving force behind the renewed Summer Science Program, to which her commitment was complete and wholehearted. Her family, friends, colleagues, and students will deeply miss her positive attitude, good cheer, patience, and wisdom.

Recent graduate **Christopher "Leaf" Elliott '13**, a Geosciences major and Williams Outing Club climbing instructor, tragically drowned on July 24th, 2013 while conducting post-graduate research in Montana. Leaf's infectious smile and energetic personality will be missed by all who knew him.

ASTRONOMY

Faculty of the Astronomy Department included Jay M. Pasachoff, Field Memorial Professor of Astronomy, and Director of the Hopkins Observatory (on sabbatical leave at Caltech during the fall semester of 2012); Karen B. Kwitter, Chair and Ebenezer Fitch Professor of Astronomy; and Steven P. Souza, Instructor in Astronomy and Observatory Supervisor. Bryce A. Babcock who retired as Staff Physicist and Coordinator of Science Facilities, has continued at Williams as Associate of the Hopkins Observatory. Marcos Peñaloza-Murillo, Professor of Physics at the Universidad de los Andes in Mérida, Venezuela, finished the calendar year as a Fulbright Scholar. Marek Demianski from the Copernicus Institute, University of Warsaw, was Visiting Professor of Astronomy in the fall, during Pasachoff's sabbatical.

Jay Pasachoff continued his efforts into studying the June, 2012 transit of Venus. The ground-based efforts were discussed in last year's Science at Williams, and included observations from Haleakala, Sacramento Peak, and other sites around the world. Data reduction over the summer included alignment of Earth-based transit-of-Venus (E/ToV) coronagraph observations through a blue (B) filter that we obtained from Haleakala, with the equipment run by Dr. Babcock and Muzhou Lu '13, also in collaboration with Thomas Widemann of l'Observatoire de Paris à Meudon and Paolo Tanga of l'Observatoire de la Côte d'Azur à Nice, who built 9 identical coronagraphs distributed around the world for the project. Working on the images during the summer 2012 was especially Keck Northeast Astronomy Consortium Summer Fellow Eric Edelman, who worked to study such interesting transit phenomena as the black-drop effect and the Cytherean aureole. We discussed our results at the meeting of the Division of Planetary Sciences of the American Astronomical Society (AAS) in Reno, NV, in October 2012, and at the main AAS meeting in Long Beach, CA, in January 2013.

But though the June 5 transit was the last to be seen from Earth for over a century, if one was at different locations in the Solar System, other transits could be seen at other times. In particular, on September 20, 2012, a transit of Venus would have been visible to anyone on Jupiter (J/ToV), and Pasachoff, working with Glenn Schneider of the University of Arizona, Kevin Reardon '92 (now at the Sacramento Peak Observatory) and others, obtained 14 orbits (22 hours) of observing time with the Hubble Space Telescope to observe Jupiter in reflection. The data reduction, started during the year and still under

way, involves smearing out the high-resolution images obtained through ultraviolet and infrared filters to see if Jupiter dimmed by 0.01% for the 10 hour transit, as well as searching for a spectral response that would be caused by Venus's atmosphere. Since several exoplanet transits observed with telescopes on the ground and the Kepler mission in space have reported detections of exoplanet atmospheres, this Hubble project is an Earth-bound analogue. The high-resolution Jupiter images will also eventually be studied to analyze the motions of Jupiter's clouds.

Further, on December 21, 2012, a transit of Venus would have been visible if you were on Saturn (S/ToV). In collaboration with Scheider and Phil Nicholson of Cornell, a member of the Cassini team, Pasachoff participated in using NASA's Cassini spacecraft in orbit around Saturn to look at the Sun, again to search for an 0.01% dimming. Further, several of the 352 spectral channels on the instrument used, the Visual and Infrared Mapping Spectrometer, could have dimmed differentially, revealing Venus's atmosphere in this S/ToV, analogously to exoplanet measurements currently made by others. Data reduction by Matt Hedman of Cornell has preliminarily revealed an effect of the expected magnitude at the appropriate time, though this tentative detection has to be confirmed. We reported on this result and others about the E/ToV and the J/ToV at the AAS meeting in Indianapolis in June 2013.

Our ground-based expedition to observe the transit of Venus was supported by the Committee for Research and Exploration of the National Geographic Society. Our work on the J/ToV project is supported by a grant from NASA as a Guest Investigator through the Space Telescope Science Institute under NASA contract NAS 5-26555. These observations are associated with program #13067.

Also related to transits of Venus, Pasachoff continued his joint historical work with William Sheehan, a historian of science from Minnesota, on who discovered the atmosphere of Venus. They had shown in an earlier publication that the Russian polymath Mikhail Lomonosov, who is universally reported to have discovered Venus's atmosphere at the 1761 transit that he observed from St. Petersburg, had not actually seen the phenomena that we now know from recent observations show the atmosphere. A debate continues, with articles by Pasachoff and Sheehan and by others in Sky & Telescope, Physics Today, and the Journal of the Royal Astronomical Society of Canada.

Pasachoff and Babcock collaborated on additional projects that also each involved student participation in expedition research, an interesting scientific question, and Federal grant support:

At the October 2012 meeting of the Division of Planetary Sciences of the American Astronomical Society held in Reno, NV, Pasachoff, Babcock, and colleagues from MIT and elsewhere reported on observations of the occultation of a star by Pluto in May 2011. Participating in those observations were Pasachoff, Babcock, Matt Hosek '12 and Shubhanga Pandey '14. A major paper reporting on this work has been submitted to the Astronomical Journal. The work is supported by research grant NNX12AJ29G from NASA Planetary Astronomy. This 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 July 2015.

With support from this NASA Planetary Astronomy grant, on May 4, 2013, Babcock successfully observed the occultation of a star by Pluto using the Portable Occultation, Eclipse, and Transit Syatem (POETS) on a telescope in Santiago, Chile. The June 14, 2013, occultation of a 14.8-magnitude star was attempted by a summer team with Williams' 0.6m telescope. Preparations are being made for observations of a July 9 predicted occultation of a star by the large Kuiper-belt object Quaoar, also from Santiago. Babcock and Allen Davis '14, will carry out the observing. See http://www.stellaroccultations. info to gather links to the various work the Williams faculty and students have carried out to study the outer solar system through occultation of distant stars.

A major research effort involved observations of the total solar eclipse of November 2013 from sites in northeastern Queensland, Australia, supported by NSF grant AGS-1047726. Pasachoff led groups that, with collaborators, totaled nearly 50 people. The prime group of observers (including Pasachoff, Babcock, Lu, Rob Wittenmeyer '98, Alec Engell, Robert Lucas, and Ronald Dantowitz and Nicholas Weber) set up equipment at Miallo, north of Port Douglas. Aram Friedman, Michael Kentrianakis, and Amy Steele '08 (now a graduate student in astronomy at Wesleyan University, supported by the NSF grant) observed from Williams College sites at Trinity Beach in north Cairns, where the teams from NASA's Marshall Space Flight Center and the Academy of Sciences of Slovakia were operating in coordinated fashion. The main website for the eclipse is http://web.williams.edu/Astronomy/eclipse/eclipse2012/2012total/index.html; personnel are listed at http://web.williams.edu/Astronomy/eclipse/eclipse2012/2012total/personnel.

pdf. Steele participated with Jarita Holbrook (Pasachoff's predecessor as chair of the Historical Astronomy Division of the AAS), Alphonse Sterling of NASA, and Hakeem Oluseyi of the Florida Institute of Technology in making a movie about black astronomers at work.

In the event, the weather was largely cloudy, and a contingent that included Babcock, Lu, Dantowitz, Weber, and Engell decamped for a site on the Tablelands, about an hour west of the coast. They obtained satisfactory results, and scientific papers are now in preparation while data analysis is continuing. Pasachoff and Lucas obtained reasonable images from a helicopter high over Miallo. The people who remained at Miallo unfortunately saw little of the eclipse. The people at Trinity Beach had glimpses of the corona; videos are available at http://www.youtube.com/ansibletech.

Pasachoff worked with John Seiradakis and Aris Voulgaris of the Aristotle University of Thessaloniki, Greece, on data reduction and papers for Solar Physics about chromospheric and coronal spectra taken at the total eclipses, including the Queensland eclipse, following earlier collaboration about the Easter Island eclipse. The Seiradakis/Voulgaris sites near the Queensland coast were too cloudy to obtain data. Paul Gaintatzis and Thanasis Economou are additional coauthors, and the former has made a compound image of the Tablelands coronal images and is working on the spectra. The spectra from 2010 showed the decline in overall coronal temperature with the sunspot cycle while the spectra from 2012 show the higher coronal temperature as was expected at this maximum phase of the sunspot cycle; they provide a new way of determining the length of totality and of the flash spectrum through such spectral observations.

Pasachoff observed the annular solar eclipse of May 10, 2013, from a site 83 km north of Tennant Creek, Northern Territory, Australia. It was his 57th solar eclipse. http://web.williams.edu/Astronomy/eclipse/eclipse2013/

Pasachoff's grant from the Solar Research Program of the Atmospheric and Geospace Sciences Division of the National Science Foundation was used for scientific studies of the two central solar eclipses of 2012. The radio data collected in collaboration with Tom Kuiper of NASA's Jet Propulsion Laboratory from JPL's 34-m radio telescope at Goldstone; and with Dale Gary of the New Jersey Institute of Technology and Tim Bastian of the National Radio Astronomy Observatory; at the May 20 annular solar eclipse with the Jansky Very Large Array near Socorro, New Mexico, remains in reduction.

The Milham Planetarium continued in operation

under the supervision of Prof. Pasachoff with teaching Assistants Muzhou Lu `13, Allen Davis `14, Connor Dempsey `14, and Pushpanjali Giri `14. The planetarium had public shows on Friday nights and shows by appointment for school and other groups. A digital planetarium, the Ansible Microdome, was also available.

In anticipation of the August 2017, total solar eclipse that will cross the United States from Oregon to South Carolina, Pasachoff participated in a workshop at the American Institute of Physics headquarters in College Park, MD, in spring 2012 and a smaller, planning group for a MegaMovie made from images taken from across the U.S., with the group meeting at the High Altitude Observatory headquarters in Boulder, CO, in spring 2013.

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

Pasachoff continued 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 is now Chair (2013-2015) of the Historical Astronomy Division of the AAS. As such, he is involved in planning the sessions at National Harbor, MD, near Washington, DC, for the January 2014 meeting, and has added Historical Astronomy Division sessions jointly with the Division of Planetary Sciences at their Denver meeting in October 2013. He continues as U.S. National Liaison to Commission 46 on Education and Development of the International Astronomical Union. He is also head of the Program Group on Public Education at the Times of Eclipses and Transits of the Commission on Education and Development. See http://www.eclipses.info and http://www.transitofvenus.info. Pasachoff continues as representative of the AAS to the American Association for the Advancement of Science's Astronomy Division.

Pasachoff attended the two-week General Assembly of the International Astronomical Union, held in Beijing, China, in late August 2012. He participated in a special symposium there on Astrophysics from Antarctica, presenting a paper on eclipses from Antarctica. As Chair of the IAU's Working Group on Eclipses, he gave a report to the Solar Division. He visited the new radioheliograph in Inner Mongolia, and reported on its namesake, 19th-century Mongolian astronomer Mingantu, to the Historical Astronomy Division of AAS in January 2013. He blogged about the General Assembly and the radioheliograph in Mongolia for Sky and Telescope.

In January 2013, Pasachoff attended the 221st meeting of the AAS in Long Beach, CA, and in June, he attended the 222nd meeting in Indianapolis. He attended the AAS's Division of Planetary Sciences meeting in October in Reno, NV, in November 2013 and during the summer of 2013, worked on preparing papers for the Solar Physics Division's July 2013 meeting for Bozeman, Montana, presenting papers at each.

Pasachoff continued his work with Roberta J. M. Olson, Curator of Drawings at the New-York Historical Society, on the overlap of art and astronomy. For the eighth conference on The Inspiration of Astronomical Phenomena (http://www.insap.org) they prepared a paper on the eclipse of 1918 and other oil paintings of the artist Howard Russell Butler, paintings that once hung in the Hayden Planetarium of the American Museum of Natural History in New York. Pasachoff visited the dozen paintings in storage in New York City; in particular, new color imaging of the large triptych of the eclipse of 1918 was arranged for him while he visited.

Pasachoff continued as President of Williams College's Sigma Xi chapter and as the Williams representative to the NASA-sponsored Massachusetts Space Grant. He attended the Space Grant Consortium meeting at the Museum of Science in Boston in May 2013. With Space Grant support, he moderated a panel on Space Law for the Williams College Law Society in May 2013; the panel was arranged by Emanuel McMiller '14.

Pasachoff continues as an 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 was on the Council of Advisors of the Astronomy Education Review electronic journal until its demise. See http://aer.noao.edu/. Pasachoff continues as science book reviewer for The Key Reporter, the Phi Beta Kappa newsletter. He continues as advisor to the children's magazine Odyssey.

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 gave his seminar on Science, Pseudoscience, and the Two Cultures in spring 2013.

The Keck Northeast Astronomy Consortium (KNAC) Faculty Meeting was held at Middlebury College in fall 2012. Pasachoff, Kwitter, and Souza attended the KNAC faculty coordinating meeting at Vassar College in June 2013; Kwitter and Souza had run and attended the previous meeting at Williams College in July 2012.

Professor **Karen Kwitter** continues 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. She and colleagues Bruce Balick (U. Washington), Romano Corradi (Instituto de Astrofísica de Canarias), and Dick Henry (U. Oklahoma) have observed a total of 20 outer PNe in M31, two with the 10.4-meter Gran Telescopio Canarias (GTC). They found an enriched, solar-like abundance profile for these objects, which was unexpected since the ordinary stars in the same vicinity exhibit less chemical enrichment. One intriguing possible explanation for this anomaly is that these PNe are the result of a burst of star formation from already-enriched interstellar gas about 2 billion years ago in the wake of a close encounter between M31 and another nearby spiral galaxy, M33. To study this idea further, Kwitter and colleagues have been awarded additional time on the GTC in the fall of 2013 to observe several more PNe in the outskirts of M31; these data will form the basis of an honors thesis by Kerry Hensley`14. The team's work was featured in a press briefing at the June 2012 meeting of the AAS in Indianapolis.

Kwitter continued work with colleagues on their Hubble Space Telescope project to study the structure and composition of PNe in the Milky Way. In particular ultraviolet spectroscopic data reveals abundant ions of elements like carbon, which are difficult to detect in the optical region. The resulting ratios of carbon to nitrogen and to oxygen supply important constraints on the processes of evolution and nucleosynthesis inside PN parent stars. Kerry Hensley '14 is working with Kwitter for her honors thesis and will explore the spectroscopic characteristics of PNe in the outer regions of M31, combining newly-acquired GTC data with spectra already in hand. During the summer of 2013, Tina Seeger '15 is also working on PNe spectra.

Two of Kwitter's colleagues visited campus during the spring of 2012 and gave lectures in her Interstellar Medium class: Reginald Dufour (Rice University) visited in March and gave a lecture on analyzing the spectra of emission nebulae; and Bruce Balick visited in May and lectured on "The Hubble Space Telescope's Top Ten Discoveries."

Kwitter serves on the International Astronomical Union's Working Group on Planetary Nebulae. In September, she attended the KNAC Student Research Symposium at Middlebury College, and in November she represented Williams at the American Astronomical Society's biennial Chairs Meeting of Astronomy Departments in the US.

Steven Souza continues to conduct and supervise the astronomy observing program, indoor labs, and daytime observing. The Observatory teaching Assistants were Alyssa Barlis '13, Allen Davis '14, Dylan Gilbert '13, Jake Goldenring '15, Joe Iafrate '14, Muzhou Lu '13, Nate Saffold '14, and Chelsea Zhu '14. This year Souza hosted numerous observatory visitors, including planetarium groups, Family Days attendees, and student previews and prospectives. He continued to maintain and improve the observatory, installing a new weather webcam, and acquiring a new linear CCD camera for the spectrograph on our 0.6m DFM telescope with Kresge Foundation funding. Souza maintains department computer systems, and acts as department liaison with OIT and Facilities. He served as a first-year/sophomore advisor, and as a member of the Information Technology Committee.

Souza attended the Keck Northeast Astronomy Consortium (KNAC) Faculty Meeting in July 2012, the KNAC Student Symposium in September 2012, and the American Astronomical Society meeting in Long Beach, CA January 2013. He presented 2 lectures for the Osher Lifelong Learning Institute: "Imaging in Medicine and Astronomy: The World Inside" in September 2012; "Imaging in Medicine and Astronomy: The World Outside" in October 2012.

Souza continues his research effort to monitor variations in H-alpha emission in massive stars in open clusters, developing a semi-automated data processing pipeline on a dedicated server using the programming language Python. Using the new process he discovered three new variable stars, as described in two publications. In the summer of 2013 he worked with students Mona Sami '16 and Gillian Beltz-Mohrmann (Wellesley '16).

Class of 1960 Scholars in Astrophysics

Alyssa Barlis   Muzhou Lu   Alice Sady

DEPARTMENT COLLOQUIA

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

OFF-CAMPUS COLLOQUIA

Jay M. Pasachoff

Professor Pasachoff delivered colloquia at the following locations during the 2012-13 year:
Image Processing and Analysis Center, California Institute of Technology; Harvard Club of Beijing; Williams Club of Beijing; Western Academy of Beijing; University of California at San Diego; Caltech Planetary Sciences; Mareeba, Queensland, Australia; California Polytechnic Institute; Huntington Library, San Marino, CA; Pomona College; and Harvard College 50th Reunion.

POSTGRADUATE PLANS OF ASTRONOMY MAJORS

Alyssa C Barlis	Ph.D in Physics at University of Pennsylvania – detector development research
Markus D. Gonzales	unknown
Muzhou Lu	Teaching position prior to grad school in astronomy
Alice Sady	Ph.D in Physics at Johns Hopkins University; Clare Boothe Luce Fellow,

The view over the Pacific Ocean from the Williams College Eclipse Expedition's site at Miallo, Queensland, Australia, before the November 14, 2012, total solar eclipse.

BIOLOGY DEPARTMENT

Working closely with the many interdisciplinary programs on campus: The BIMO Program, the Neuroscience Program, the Environmental Studies Program and the BiGP Program, the Biology Department's goal is to provide students with the opportunity to do hands-on, one-on-one research with a professor in addition to offering state of the art academic courses. To that end the department had 22 honors students working in faculty labs this past year. Of these, 13 were inducted into the Sigma Xi Honors Society. For the academic year 2013-2014, the department has 21 students who will be doing honors work. The department is committed to providing a positive research and learning experience for all biology students. As a result of this commitment, several of our students were awarded grants or fellowships to pursue their studies after graduation. Jonathan Wosen received a Stratton Fellowship to further his studies. The department also has approximately 27 students doing summer research, either here at Williams or off campus. Amir Hay and Gabriel Stephens 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. Three of Professor Swoap's students, Uttara Partap '13, Christine Schindler '13 and Becca Maher '13 won the David Bruce Award at the American Physiological Society's Experimental Biology 2013 Conference. On February 6, 2013, a number of BIOL and/or BIMO alumni (Malin Pinsky '03, Adrianna San Roman '09, Devin Schweppe '07 and Natalie Stephens '03) 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, Uttara Partap and Elizabeth Hwang each received the Benedict Prize in Biology. Carrie Tribble received the Dwight Botanical Prize. Katharine Dusenbury received the Conant-Harrington Prize for exemplary performance in the biology major, and Gordon Smith received the William C. Grant, Jr. Prize for demonstrating excellence in a broad range of areas in biology.

This year the biology department welcomes two new faculty members. **Matt Carter** starts in the Fall 2013 semester as Assistant Professor. Matt comes to us following his post-doctoral research in

Professor **Marsha Altschuler** continued her research on chromosome copy number control in the ciliate Tetrahymena thermophila assisted by Grace Lapier '13 and Bryan Chow '13 during Summer 2012, and honors students Grace Lapier '13 and Emily Whicker '13 during the 2012-13 academic year. During Fall semester 2012 Professor Altschuler taught a senior seminar for majors (BIOL 416 Epigenetics) which explored, through a close reading/discussion of the scientific literature, non DNA based inheritance (such as stable protein conformations (prions), histone modifications, DNA methylation, and stable subcellular localization and cell architecture). During Spring 2013, as part of the Gaudino "Dangerous Courses" Initiative, she taught a new course for non-majors, BIOL 136 Studying Human Genetic Diversity Individuals, Populations, and "Races": Dangerous Biology. In this course students explored the impact of the new genomics era on our view of humanity: should studies emphasize differences or universalities? should we focus on individuals or groups? is there a biological basis for the concept of race? The class attended two extracurricular activities that dealt with topics related to the course content: a performance by rap artist Baba Brinkman ("The Rap Guide to Evolution"), and a colloquium by Sarah Tishkoff (U. Penn) entitled "Human Evolutionary Genomics: implications for human origins and disease." During WSP 2013, Professor Altschuler and Professor Maroja organized a Williams College DNA Diversity Project in which 36 Williams students donated DNA samples to trace their mitochondrial DNA ancestry. Nina Horowitz '14 and David Baker '13 carried out the DNA extractions and analyzed the sequence information. Twenty-eight different mtDNA haplotypes were identified among the 36 participants, underscoring the diversity of the Williams College student population.

Professor **Hank Art** returned from a sabbatical leave immersed in the Hopkins Memorial Forest database, to teach the newly redesigned BIOL 302 Communities and Ecosystems course that included extensive fieldwork not only in the Hopkins Forest, but on Mt. Greylock as well. In January, 2013, He and 7 students spent the Winter Study Period engaged in a hands-on, experiential education endeavor of working on a diversity of farms in the Central Coast of California, exploring firsthand the concepts of sustainability as practiced in California Agriculture. This course segued into a senior seminar BIOL/ENVI 422 The Ecology of Sustainable Agriculture.

In Spring, 2013 Professor Art taught the redesigned ENVI 102 Introduction to Environmental Science, a course that used the Hoosic River Watershed as the focus for examining local environmental issues that then were connected to the Hudson River, Atlantic Ocean, and global environment.

During the summer of 2013, Professor Art collaborated with a team of five students (Sarah Rowe '13, Claudia Corona '13, Eric Hagen '14, Laurel Hamers '14, and Ryan Buchannan '14) on a special survey of two old growth woodlots in Hopkins Forest and the quarter-acre permanent plots that were impacted by the extreme wind event of 29 May 2012. This field research, along with the HMF permanent plot 2010-2011 resurvey project, contributed to the senior thesis in Geosciences: Tree Growth and Climate: Changing Relationships in the Hopkins Forest, Williamstown, MA.

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 Elizabeth Hwang '13 and Abbi Davies '13, along with independent study student Connor Dempsey '13 and post-doctoral fellow Janis Bravo, pursued this line of investigation. They were joined in the lab by Sam Lewis '15 and Winter-study student Alison Smith '15, who investigated the possibility that *A. tumefaciens* uses its recently discovered Type 6 Secretion System (T6SS) to engage in inter-bacterial predation. Naomi Patterson '15 also contributed to this research project over the summer of 2012. At the annual international Crown Gall Conference, held this year in Hiram, OH, Janis Bravo and Abbi Davies presented a poster, and Lois Banta presented a talk on this research. Connor and Elizabeth also attended a Plant Biology Symposium at UMass Amherst in the fall.

During the fall semester, Professor Banta taught a new sophomore-level tutorial called "Dangerous Exposure: Environment, Immunity, and Infectious Disease. Students in this course read primary literature on the ecology and evolution of several recently re-emergent diseases such as influenza, Ebola hemorrhagic fever, and AIDS. Topics included transmission dynamics, epidemiological modeling of vaccination strategies, and wildlife reservoirs that contribute to human virus exposure. The course examined progress in preventing the parasitic disease malaria, as well as cholera and Dengue fever, and

why these diseases have proven so refractory to effective containment. Students also discussed the science behind the recent development of the vaccine against the human papillomavirus, which causes cervical cancer, and the intriguing and highly unusual transmissible cancers in dogs and Tasmanian devils. Finally, they explored the contributions of inadequate diagnostic capacities worldwide and broader issues of resource shortages in driving the global emergence of drug resistance in tuberculosis and other diseases. One common theme in each of these case studies was the interplay between the host immune response and the evolution of the pathogen. In Professor Banta's literature-based spring course, Cellular Regulatory Mechanisms (BIOL 306), the 14 students in the class carried out original research, using quantitative reverse-transcriptase PCR to test the hypothesis that the host plant's response to *A. tumefaciens* is under circadian regulation. They then designed independent projects, applying their knowledge from the discussion/literature component of the course to investigate the innate immune defenses mounted by mammalian cells against bacterial cell surface material.

Professor Banta presented a poster at an invitation-only workshop funded by the Howard Hughes Medical Institute. The goal of the workshop was to identify research problems that are well-suited for student-scientist partnerships, by highlighting computing infrastructure and data-mining/analysis tools that exist and those needed for the integration of genomics research into undergraduate education. One outcome of the workshop was the development of a set of learning objectives for bioinformatics and preliminary plans for a multi-institution metagenomics project.

During this academic year, Professor Banta served as a reviewer for the National Science Foundation, *Journal of Bacteriology*, *The Plant Cell*, and the Consortium for Plant Biotechnology Research. Within Williams, she served on the Biochemistry/Molecular Biology advisory committee, the Bioinformatics, Genomics and Proteomics advisory committee, and the Environmental Studies advisory committee; she also served as coordinator for the Global Health track of the International Studies Area of Concentration and Chair of the program in Public Health, which was approved by the faculty college-wide as the College's newest Area of Concentration in December. Finally, she is Secretary/Treasurer of the Williams College Chapter of the national science honor society Sigma Xi.

During this past year Professor **Dan Lynch** taught one section of BIOL 101 The Cell. In the spring he taught BIMO/BIOL/CHEM 322 Biochemistry II Metabolism

lecture and one laboratory section while two lab sections were taught by Melissa Daly. Lynch continued his research on plant sphingolipid biochemistry in the moss *Physcomitrella patens*. The moss provides certain advantages over typical flowering plants in studies of sphingolipid metabolism and function. Students working in the lab included Mike Essman '13 and Marissa Thiel '13, thesis research students in the biology department who characterized moss plants with altered long-chain base profiles as a consequence of RNAi knockdown of specific genes. During winter study, three BIOL 022 students, Daquan Daly '16, Salmaan Karim '15 and Cody Remillard '16 carried out research projects complementing ongoing work in the lab. Lynch was sole author on a commentary in *New Phytologist* and was co-author on a review article in *Current Opinion in Plant Biology*. He also served as a manuscript reviewer for *New Phytologist*.

In the summer of 2012, Professor **Joan Edwards** worked with Gordon Smith '13 and Evelyn Tran '14 studying pollinators in the field at Isle Royale Wilderness National Park. The project involved determining the flowerscape by mapping all of the flowering plants in a 24x24 m plot observing how pollinators foraged on this flowerscape. Our initial results show that all insects tend to 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 Tran, Tendai Chisowa '16 and Abby Kelly '16. Together we worked on the following three projects:

1. Explosive seed dispersal in *Oxalis sp.*, where we obtained close-up high-speed images (50,000fps) and began collecting comparative data among four different species of *Oxalis*.

2. Pollen dehydration/rehydration patterns. Working with Nancy Piatczyc in the EM facility, we obtained SEM videos that recorded changes in pollen as a function of hydration. We successfully captured images of American elm pollen.

3. Maps of arctic plants. We were able to put together detailed maps.

Professor Edwards taught Biology and Social Issues (BIOL 134) in the fall and Field Botany and Plant Systematics (BIOL 220) in the spring. She advised senior honors student Gordon Smith '13, who studied weight-based pollination in *Cornus canadensis*. We introduced different sized pollinators to cages and measured seed set as a measure of female plant fitness. A new field technique using long-term time-lapse cameras was

developed which captured all insects visiting a flower over its lifetime. Initial results show a wide variety of insect visitors (>63 different taxa) and high a variance among microhabitats.

Professor Edwards published two papers. One describes a species new to Isle Royale (*Packera insulae-regalis*). A second paper with Professor Luana Maroja and Hannah Matheny '12 on microsatellite markers for the bird's-eye primrose (*Primula misstassinica*) will be published in *Applications in Plant Sciences*.

Assistant Professor **Luana Maroja** continues to conduct research on the population genetics of threatened arctic plant species. The first genetic marker (microsatellite) development paper with student Hannah Matheny '12 is now in print and another will be submitted soon. Maroja has been awarded the Hellman research grant and will be collecting more plant specimens from the core of the species distribution in the Arctic to continue this research. Maroja has also done research in the genetics of Heliconius butterflies and published a paper with a student co-author, R. Alshuler '11 analyzing samples she collected in Panama in 2009-10. This year Maroja advised two honors students (Carrie Tribble '13 and Ryan Jenks '13) and three independent research students (Stan Monfront '13, Nina Horowski '14 and Daniela Zarate '15). Zarate will continue in the Maroja lab as an Allison Davis fellow this summer and the following year. Maroja will participate in the Evolution 2013 conference in SnowBird, Utah in June with Tribble who was awarded the NSF Evolution undergraduate diversity travel award. Maroja taught Genetics (BIOL 202) in the Fall and Evolution (BIOL 305) in the Spring. For the next academic year she will be on her junior leave and plans to do research at Cornell University on the genetics of hybrid zones and speciation.

In the summer of 2012, Professor **David Smith** worked with Beth Cornett '14 to continue his 30+ years of studies of the boreal chorus frog population on Isle Royale National Park. This is one of the longest records of any amphibian population. Professor Smith also collaborates with Josh VanBuskirk, who is currently at the University of Zurich and who was Professor Smith's second honors student at Williams. To date the project shows the frog populations have regular fluctuations, which may link to long-term climate cycles. Professor Smith's research examines factors that drive the population changes (e.g., climate, storms, predation, evolutionary history). These data are also important in monitoring effects of climate change and providing base line data for assessing any impacts should there be an environmental disasters (e.g. an oil spill from the nearby shipping lanes). Professor

Smith taught Ecology (Biology 203) in the fall and The Organism (Biology 102) in the spring.

Associate Professor **Claire Ting** taught Integrative Plant Biology: Fundamentals and New Frontiers (BIOL 308) in the fall semester. This course explored the diverse mechanisms that enable plants to thrive in vastly different habitats on Earth and recent advances in using plants as an energy resource, in biomedicine, and in agriculture. During the spring semester she taught the Biology Department core course, The Organism (BIOL 102). Through lectures, discussions of original research papers, and laboratories, this large, introductory course encouraged students to explore concepts and experiments addressing 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 the Sargasso Sea for metagenomic and metatranscriptomic analyses, and with the metagenomic sequence database they established for characterizing the Sargasso Sea microbiome.

Undergraduate students who participated in research in her laboratory this past year included Kate Dusenbury '13, who conducted her honors thesis research on the light-harvesting and carbon concentrating complexes in *Prochlorococcus*. Dusenbury's research identified specific differences in the evolution, structure, regulation, and expression of major photosynthesis genes/proteins. Her work lends support to the laboratory's hypothesis that although *Prochlorococcus* isolates exhibit close phylogenetic ties, they have evolved significant differences in their photosynthetic strategies that permit them to thrive

in specific ecological niches in the open oceans. In addition, Christie Black '15, Catherine Pang '14 and Ethan Borre '15 all worked as research assistants in the laboratory. Reid Pryzant '16 joined the Ting Laboratory as a BIOL 22 Introduction to Biological Research student during Winter Study and will continue as a research assistant during the summer. Kris Anderson continued for her third year as an NSF-funded research technician in the laboratory.

Professor **Heather Williams** was named the William Dwight Whitney Professor of Biology. She taught both the introductory and senior Neuroscience courses in the fall. The senior seminar was redesigned to focus on how the brain encodes and decodes language in both humans and in animal models. Professor Williams' work comparing song dialects in two populations of Savannah sparrows continued, and a paper on the cultural evolution of Savannah sparrow song over the course of three decades appeared in the journal *Animal Behaviour*, and was featured in *Science Daily* and a *Scientific American* podcast. Two students did honors work in her lab: Rebecca Shoer '13 investigated female zebra finches' responses to variations in song syntax, and Nicole Lou '13 studied the reorganization of song after regeneration of the motor nerve controlling the vocal organ.

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'. Melinda Wang '14 and Kelsey McDermott '14 worked as Research Assistants using the transmission electron microscope to study peculiar morphological features of Mauthner cells in the Trinidadian guppy. McDermott will continue on this project during the summer and fall. Zottoli published a paper entitled: " How the early voltage clamp studies of José del Castillo inform "modern" neuroscience that was published in *The Neuroscientist*. 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.

Class of 1960 Scholars in Biology

Maria Galvez	James Kinney	Grace LaPier
Zachary McKenzie	Emily Norkett	Catherine Pang
Christine Schindler	Melinda Wang	Olivia Wang

Class of 1960 Scholars for BIMO

Lauren Agoubi	David Lee	Yoelkys Morales
Connor Dempsey	Geordie Lonza	Anh Nguyen
Mike Essman	Zach McKenzie	Christine Schindler
Kathleen Higgins	Steve Mendoza	Samantha Teng
Son Le	Jessica Monterrosa	Areli Valencia
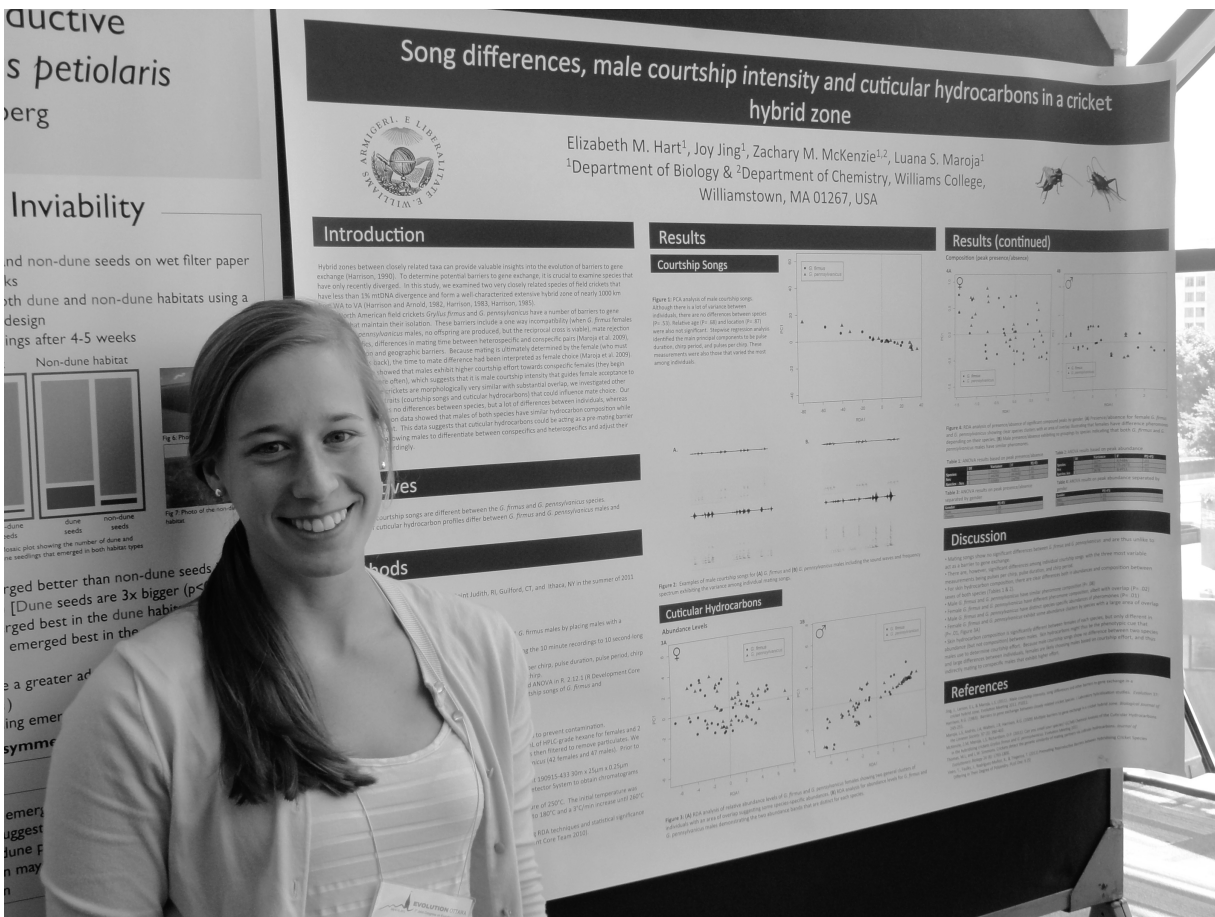
Elizabeth Hart from the Ting lab displays her poster at the Evolution 2012 conference in Ottawa Canada.

BIOLOGY DEPARTMENT COLLOQUIA

Joel Sachs, University of California, Riverside
"Evolutionary Origins and Stability of Proteobacterial Mutualisms"

Mark Tanouye, University of California, Berkeley
"Drosophila as a Model for Human Epilepsy: Suppressing Seizures by Mutation and by Drugs"
David Page, Whitehead Institute

"Rethinking the Rotting Y Chromosome"

Andy Feinberg, Johns Hopkins University
"The Epigenetic Basis of Common Human Disease"

Iruka Okeke, Haverford College
"Colonization Is Not Just Adherence: Interplay of Bacterial Surface Proteins of Enteroaggregative
Escherichia coli"

Alvaro Sagasti, University of California, Los Angeles

Gary Gillis, Mt. Holyoke College
"Do Toads Have a Jump on How Far They Hop: The Neuromuscular Control of Landing in Anurans"

Sarah Tishkoff, University of Pennsylvania
"Human Evolutionary Genomics: Implications for Human Origins and Disease"

Evan Preisser '93, University of RhodeIsland

Henry Wortis, Tufts School of Medicine
"Using Genetics to Understand Age-Related Loss of Immune Resistance to Infection"

Helen White, Havorford College
"The Impact of Oil on Deep-Water Ecosystems"

Richard Harrison, Cornell University
"On the Origin of Species: From Darwin to the 21st Century"

OFF-CAMPUS COLLOQUIA

Banta, Lois, Janis Bravo, Lauren Goldstein-Kral '12, Naomi Patterson '14, Abigail Davies '13, Elizabeth Hwang '13, Connor Dempsey '13, Greg McElroy '12, and Rosalia Deeken.
"Regulation of Host Defenses Triggered by the Agrobacterium Type 6 Secretion System."
33rd Annual Crown Gall Conference (Hiram, OH). Oral and Poster Presentation.

Banta, Lois, David Esteban, Doyle Ward and Bruce Birren.
"Metagenomic Analysis of Microbial Diversity in Winogradsky Columns"
HHMI Bioinformatics Workshop for Student-Scientist Partnerships (Chevy Chase, MD). Invited poster
presentation

Bravo, Janis, Lauren Goldstein-Kral '12, Naomi Patterson '14, Abigail Davies '13, Rosalia Deeken, and Lois Banta
"Modulation of Host Defenses by the Agrobacterium Type 6 Secretion System."
UMass Amherst Plant Biology Symposium-Poster presentation.

Edwards, Joan.
"How Plants Saved the World"
Williams College, a two lecture series for the OLLI Program. 17 and 24 October 2012.

"Botanical Explosions: The Evolutionary Impact of Ultra-fast Plants"
Isle Royale National Park. June and July 2012.

Tribble C., Maroja L.S.
    "Spatial and Temporal Population Genetic Structure in an Arctic Plant Disjunct Population"
    Evolution Conference 2013. Snowbird, Utah, June 2013.

Maroja L.S.
    "Skin Hydrocarbons, Calling Intensity and Mate Choice Between the Field Crickets *Gryllus firmus* and *G. pennsylvanicus*"
    Evolution Conference 2013. Snowbird, Utah. June, 2013.

Smith, David C.
    "The Population Dynamics of the Boreal Chorus Frog"
    Isle Royale National Park. July 2012.

Ting, Claire.
    "Minimal Genomes, Maximal Productivity: Microbial Strategies for Dominating the Open Oceans"
    Department of Biology, University of Massachusetts, Dartmouth.

Racquel Gibson '15 conducting *Drosophila* research in the Lebestky lab during Summer Science Research 2013.

POST-GRADUATE PLANS OF BIOLOGY MAJORS

David R. Baker Jr.	Medical School at Columbia University
Bryan H. Chow	Medical School at University of Michigan
Amanda R. Correnti	Unknown
William R. Craig	Unknown
Abigail C. Davies	Clinical Research Coordinator, Center for Women's Mental Health, Massachusetts General Hospital
Connor M. Dempsey	Joining the Benedictine religious order
Eric W. Dietsche	MD at New York Medical College
Kaitlin E. Dinet	Unknown
Laura K. Donnelly	Unknown
Devon M. Drew	Unknown
Katharine H. Dusenbury	Research Assistant, Boston Children's Hospital, Boston, MA
Michael A. Essman	Oxford University
Rebecca L. Fine	Unknown
Jessica J. Fitts	Unknown
Casey A. Greene	Unknown
Elizabeth E. Hwang	Research Assistant, Dana Farber, Boston, MA
Ryan W. Jenks	Trip Leader for Bold Earth Adventures (Golden, CO) and Field Assistant for "Socio-Ecology of small mammals" (Succulent Karoo, South Africa)
Yiqin Jiang	Associate Consultant, The Palladium Group, Lincoln, MA
Min Kyu (Caleb) Kim	Research Technician, Mass. General Hospital - Goldberg Lab, Cambridge, MA
Sora Kim	Research Associate, Broad Institute, Cambridge, MA
Brian Kirchner	Unknown
Jody S. Kremer	Unknown
Kristina R. Krone	Unknown
Audrey J. Kwon	Math/Science tutor in NYC.
Grace S.LaPier	Research Assistant, Daley Lab, Children's Hospital, Boston, MA
Emily J. Levy	Unknown
Geordie C. Lonza	Research Assistant for two years in the Wilson Lab, Pulmonary Center, Boston University Center for Regenerative Medicine, Boston, MA then to Medical School
Nicole J. Lou	Applying to medical school
Mark J. Lyons	Unknown
Rebecca L. Maher	Research Assistant for two years in the Zon Lab at Boston Children's Hospital, then to medical or graduate school
Kara L. McLaughlin	Unknown
Amy E. McLaughlin	Unknown
Stanislas F. Monfront	Research Assistant in NYC
Anh H. Nguyen	Service/outreach to homeless and underprivileged and applying to medical school

Stephanie Y. Owyang	Unknown
Uttara Partap	MPhil in Public Health at Cambridge University, UK
Christine E. Schindler	Post-bac IRTA Fellowship at the NIH for one year then to Medical School
Michael Semensi	Unknown
Rebecca R. Shoer	Research Assistant in an elephant cognition program in northern Thailand
Gordon P. Smith	Graduate School in Texas
Hrishikesh K. Srinagesh	Unknown
Henry K. Su	Research Analyst at the THANC Foundation in New York City
Samantha Teng	Biology Teacher, New York City Teaching Fellows, New York City, NY
Marissa Thiel	Consulting in Boston, MA
Seth A. Tobolsky	Matriculating to University of Rochester School of Medicine and Dentistry for the M.D. program
Carrie M. Tribble	Translational Research Summer Intern with the Genetic Alliance in Washington, DC then Fulbright Scholar in Cusco, Peru
Jennifer J. Turner	Unknown
Patsorn Udomritthiruj	Unknown
Chalita N. Washington	Research Assistant at the University of Maryland, Baltimore County, Baltimore, MD
Emily A. Whicker	Research Assistant at UMass Medical School in Worcester, MA
John R. Wickman	Harvard Medical School
Jonathan E. Wosen	Stanford University for a PhD program in immunology
Shirl G. Yang	Unknown

CHEMISTRY DEPARTMENT

The Chemistry Department had a fulfilling 2012-2013 academic year. We graduated 31 senior majors this year with 15 completing senior thesis projects. We are very pleased to announce a new face in the Chemistry Department. Dr. Becky Taurog, a biochemist, starts her appointment in July 2013. She will teach Biochemistry I: Structure and Function of Biological Molecules (CHEM 321) along with two sections of the associated laboratory in the fall, and Enzyme Kinetics and Reaction Mechanisms (CHEM 324) and Topics in Biochemistry and Molecular Biology (BIMO 401) in the spring. We are delighted that Dr. Taurog will begin her 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 2013, the John Sabin Adriance prize went to Christopher Corbett for outstanding work throughout his chemistry career. The James F. Skinner prize was awarded to Sarah Guillot for her distinguished achievement in chemistry and his future promise as a researcher. The Leverett Mears prize went to Nai Chien Yeat in recognition of both his abilities in chemistry and future in medicine. Erica Wu was awarded the American Chemical Society Connecticut Valley Section Award for her sustained scholastic excellence. Sora Kim was awarded the American Institute of Chemists Student Award for outstanding scholastic achievement, Michael Girouard was the recipient of the ACS Division of Inorganic Chemistry Undergraduate Award in Inorganic Chemistry, and Alexander Lou was the first recipient of the new ACS Division of Organic Chemistry Award.

Over the course of the academic year, a number of awards were presented to undergraduate chemistry students for outstanding scholarship. Lilliana Morris '14 received the Frank C. Goodrich 1945 Award for demonstrated excellence in chemistry research, and Peter Clement '14 was awarded the American Chemistry Society Analytical Division Award. Our newest award, the Skinner Award for Travel to a Professional Meeting, was given to Bianca Ulloa '14. Christopher Bravo '16 and Lucy Page '16 received the CRC Awards as the outstanding students in CHEM 151 and CHEM 155, respectively. Taylor Jackvony '16 was presented with the Raymond Chang First-Year Chemistry Award for her exceptional work in CHEM 153. Recognized for their achievement in organic chemistry, Shannon Zikovich '15 received the Polymer Chemistry Award and Claire Lidston '15 was the recipient of the Harold H. Warren Prize.

Associate Professor **Dieter Bingemann**, with the help of independent study student Nai Chien Yeat '13 and research assistants Kyle Bolo '14, Khan Shairani '15, 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. The team presented these results from both the single molecule experiments and computer simulations at the annual meeting of the American Chemical Society in August 2012.

In the fall, Bingemann taught Physical Chemistry: Structure and Dynamics (CHEM 361), using a new project-based approach which borrows heavily from tutorials. This method was was favorably received by a record-breaking number of students. In the spring, he taught Physical Chemistry: Thermodynamics (CHEM 366) using the same teaching approach. Also in the Spring, Bingemann team-taught Introduction to Environmental Science Methods (ENVI 102) with David Backus of the Geosciences Department and Hank Art from Biology.

During his first year at Williams, Assistant Professor **Jimmy Blair** taught Organic Chemistry: Intermediate Level (CHEM 251) in the fall and Chemical Biology: Discoveries at the Interface (CHEM 326), a new offering for the Department, in the spring. Professor Blair's research focuses on developing antibacterial agents targeting histidine kinases, which are enzymes involved in bacterial cell signaling pathways. Bacteria rely on these pathways to survive in their environment, and chemically disabling cellular signaling pathways may offer a novel mechanism for antibacterial action. Professor Blair was joined by thesis students Bryn Falahee '13 and Peter Young '13, who worked on chemical synthesis of potential histidine kinase inhibitors, production and purification of a essential histidine kinases and development of a biochemical assay to assess histidine kinase function. Work study student Liz Berggren '15 joined the

lab in Winter Study to work on histidine kinase protein production.

Associate Professor **Amy Gehring** continued teaching in the biochemistry curriculum this year, instructing Biochemistry I: Structure and Function of Biological Molecules (BIMO/BIOL/CHEM 321) in the fall and the capstone course Topics in Biochemistry and Molecular Biology (BIMO 401) in the spring. Gehring continued her service as the chair of the Biochemistry and Molecular Biology (BIMO) program. Some highlights of the year for the BIMO program were hosting seminars by distinguished scientists Dr. David Page (Director, Whitehead Institute) and Dr. Henry Wortis (Tufts University School of Medicine).

It was another busy year of research in the Gehring lab, as the group continues to work towards understanding the biochemical basis of antibiotic production and development in the model sporulating, antibiotic-producing soil bacterium, *Streptomyces coelicolor.* During the summer of 2012, Gehring was joined in this work by Emily Gao '13, Sora Kim '13, Jamie Baik '14, Jessica Monterrosa Mena '14, and Georgiana Salant '14. Gao and Kim continued on during the academic year as thesis students, studying the function of secreted proteases and protease inhibitors in the developmental cycle of the organism and investigating the role of a novel phosphodiesterase enzyme in the regulation of antibiotic production, respectively. They were joined by fellow thesis student, Devon Drew '13, who tackled a project to understand the function of the whiJ genes in the sporulation of *S. coelicolor.* Georgiana Salant '14 returned to the lab as an independent study student in spring 2013 to complete development of a luciferase reporter assay that the lab will be able to put to good use on a variety of projects in the future. Also beginning research projects at various times during the academic year were John Chae '16, Megan Steele '16, and Doug Wassarman '16. Gehring continued in collaboration with Professor Peacock-López on a project to visualize oscillations in bacterial gene expression via fluorescence microscopy; both Areli Valencia '14 and Lucy Page '16 contributed to this collaborative work over the course of the year.

Professor Gehring enjoyed several opportunities to interact with the larger scientific community. In the fall, she served on a grant review panel for the prestigious National Science Foundation CAREER award. In the spring, she participated on the thesis defense committee for a Ph.D. candidate at Brown University. She also continued work as a reviewer for the journals *Applied and Environmental Microbiology*, *Journal of Bacteriology*, and the *Central European Journal of Biology*.

On his return from AP leave at Cornell, Assistant Professor **Christopher Goh** taught Introductory Concepts of Chemistry (CHEM 151) in the fall semester, and Inorganic/Organometallic Chemistry (CHEM 335) in the spring. He also served as a reviewer for the Petroleum Research Fund and the Research Cooperation for Scientific Advancement, as a session-presider at the ACS National Meeting in New Orleans and as a participant in an ACS: Polymer Division Undergraduate Curriculum Workshop.

Over the summer 2012, Michael Girouard '13, Sarah Guillot '13, Michael Gold '14, Lilli Morris '13 and Fanny Trausel, (an exchange student from the University of Leiden, Netherlands), continued the group's research in the field of transition-metal mediated homogeneous catalysis. Guillot, Gold and Trausel expanded the work on copper-based atom transfer radical polymerization (ATRP) catalysts. These catalysts provide the power to dictate the composition and size of macromolecules and to precisely control their architecture. Applications are many-fold, and include the syntheses of new materials for packaging, automotives and medical uses. Guillot continued this work as a senior thesis student, and was joined over the Winter Study period by Tamuka Chidanguro '15 and Lillian Ma '15. The students demonstrated that changes in catalyst structure had a significant impact on catalyst performance. By adjusting the catalyst composition, a group of highly-active catalysts was developed. Meanwhile, Girouard and Morris expanded the project on the use of homogeneous iron catalysts for the oxidation of fatty acids and their derivatives. Fatty acids can be obtained from plant oils and represent a renewable resource for the polymer industry. The oxidation of this class of compounds by metal catalysts is of interest in the formation of resins. Girouard continued this research as an independent study project in the fall semester and Morris during Winter Study. The students' efforts and progress enabled Guillot and Morris to present their work at the national ACS conference in New Orleans in April 2013.

Associate Professor **Sarah Goh** and her family welcomed a new baby, Isabella Sophia, in July 2012. She took time out of her new mothering role to attend the ACS fall meeting in Philadelphia, PA in August, where she managed to catch up with Marc Richard (visiting faculty member '06-'07). She also presented research that included work from former thesis student Michelle McRae '12 and Olivia Foley '13, and also discussed the role of polymer chemistry in the undergraduate curriculum.

Professor Goh was on leave for the fall semester, but still worked with Lauren Agoubi '13 and Alex Lou '13,

mentoring their senior thesis projects. Lauren produced a library of mannose-displaying micelles and demonstrated their ability to undergo lectin binding recognition. Alex developed conditions to synthesize amino acid-containing copolymers, analyzing how the amino acid side chain affects a copolymer's ability to self-assemble. Bianca Ulloa '12 also worked in the laboratory as part of an independent study, investigating the specificity of lectin binding with respect to polymer molecular weight and sugar identity and density. Areli Valencia '14, Denise Park '15, Tony Huang '16, and Luxi Qiao '16 joined the lab as part of their Winter Study adventure. In the spring semester, Professor Goh taught laboratory sections associated with Organic Chemistry: Introductory Level (CHEM 156). Professor Goh and students traveled to the national ACS meeting in New Orleans in April. Agoubi, Lou, and Ulloa did a fabulous job presenting their research in the Undergraduate Polymer Symposium, and Lauren Agoubi won a travel award for her abstract!

Professor Goh also attended a workshop "Polymer Science Curriculum for the 21st Century" while in New Orleans. She is interested in curricular ideas to further develop Polymer Chemistry (CHEM 348) and its associated laboratory section. This year, she served as a reviewer for the National Science Foundation, Molecular Foundry at Lawrence Berkeley National Laboratory, and for the journals *Biomacromolecules*, *Langmuir*, *Journal of Polymer Science*, and *Journal of Applied Polymer Science*.

Professor **Lawrence J. Kaplan** taught Biophysical Chemistry (CHEM 367) in the fall and Chemistry and Crime (CHEM 113) in the spring semester. He continues to administer Chemistry Collaborations, Workshops and Communities of Scholars (cCWCS, the successor to the Center for Workshops in the Chemical Sciences) with his colleagues Professors Jerry Smith of Georgia State University, David Collard of Georgia Institute of Technology and Patricia Hill of Millersville University. Since its founding twelve years ago, the cCWCS has received major grants from the National Science Foundation and continues with the current collaborative grants to Williams, Georgia Tech, and Georgia State for approximately four million dollars for five years. The cCWCS sponsors workshops related to a wide range of 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 cCWCS 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 cCWCS 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. Deborah Morandi, Administrative Assistant of the Chemistry Department and Andrew Kung '12, assisted Kaplan in the organization and instruction of the workshop.

Kaplan organized and presided at a daylong symposium and a daylong forensic workshop sponsored by cCWCS at the 22nd Biennial Conference of Chemical Education at the Pennsylvania State University in State College, PA in July 2012. The symposium provided an opportunity for workshop alumni to present their accomplishments based upon their participation in previous forensic workshops. A number of colleagues assisted Kaplan in the instruction of the mini-workshops. Professor Michael E. Pugh (Bloomsburg University) introduced the participants to ballistic analysis of both bullets and cartridge casings; Professor Audra G. Sostarecz (Monmouth College) demonstrated fingerprinting techniques including the inkless fingerprinting system; magnetic fluorescent powder; ninhydrin; and Sudan black; Professor Carmen Valdez-Gauthier (Florida Southern College) coordinated a series of experiments involving the analysis of suspected powdered drug material and drugs in urine as well as tests for adulterants in urine; and Professor Renee Beeton (Adams State University) taught a unit involving the analysis of alcohol in breath and saliva using the Breathalyzer and Intoxilyzer as well as the Onsite alcohol test for alcohol in saliva.

Kaplan reviewed numerous papers for the *Journal of Chemical Education*.

During the past year Professor **Chip 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 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 28 years Lovett and Williams' students working in his lab have discovered more than 30 SOS genes and characterized their genetic regulation in response to DNA damage. 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. 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. In the past year Williams students have worked on various aspects of the project during the summer, during winter study, and during the academic year. The summer students, working as full time research assistants, included Roop Dutta '12, Willis Koomson '14, Christian Torres '12, Lovemore Makusha '13, Asvelt Nduwumwami '13, Moses Flash '15, Jared Nowell '15, and Kassandra Spiller '14. Makusha and Nduwumwami continued as honors thesis students during the academic year and Torres continued as an independent study student during the fall semester. Professor Lovett also supervised winter study research students Ashley Ngo '16, Christina Chen '16, Hector Trujillo '16, and Pushpanjali Giri '14.

Last summer, Professor Lovett taught the Chemistry lectures component of the Williams College Summer Science Program. Together with Professor David Richardson, he also taught in the eighth year of science camp for elementary school students and teachers. Professor Lovett served as a reviewer for the *Journal of Bacteriology,* and as a consultant for the Sherman Fairchild Foundation's Scientific Equipment Grant Program.

Professor **Lee Park** taught Concepts of Chemistry: Advanced Level (CHEM 153) in the fall semester and Instrumental Methods of Analysis (CHEM 364) in the spring term; she also continued development of a series of problem solving sessions aimed at first-year chemistry students, which were offered during the summer of 2012 as well as the fall of 2012. The Park Lab was busy this year, with 3 thesis students (Chris Corbett '14, Alejandro Gimenez '14, and Erica Wu '14) and a large and enthusiastic group of students from other years (Dylan Baker '15, Chelsea Boydstun '15, Dylan Freas '16, Vera Gould '14, Miguel Mendez '16, Joon-Hun Seong '14, and Felix Sun '14) all working on various aspects of the design, synthesis, and characterization of a series of novel conjugated oligomers that may find use in small molecule-based

organic electronics. The group has successfully prepared a number of new compounds which show interesting electronic and optical properties and may serve as robust n-type organic materials, and has developed some new approaches to the synthesis of pentacene-based derivatives as well. Park's primary contributions to the larger Williams community were as Chair of the Committee on Educational Policy, as a member of the Business Plan Advisory Board, and through participation in various campus events including Admissions Open House Sample Classes, WCMA Labeltalk 2013, a Family Days Panel, and a Women in Science Panel. Outreach to the community beyond Williams included organizing a visit by Berkshire Farm Institute students and delivering the keynote lecture at the Museum Institute for Teaching Science. Park also served the larger chemistry community as a continuing member of the Committee on Professional Training for the American Chemical Society, and as a reviewer for various journals and funding agencies (including ACS-Petroleum Research Fund, Research Corporation, the South Carolina GEAR program) and other academic institutions.

In 2012-2013 Professor **Enrique Peacock-López** taught Current Topics in Chemistry (CHEM 155) in the fall, and Foundation of Modern Chemical Science (CHEM 256) in the spring. During January, Peacock-López taught Introduction to Research: Physical Chemistry (CHEM 24). Last year and based on the theoretical observations, Michael Alcala '12, under the direction of Professor Amy Gehring, designed and constructed a Minimal 2-Gene Oscillator, which is a two-gene transcriptional activator-repressor artificial genetic network, derived from a previous artificial genetic network—the Repressilator (Elowitz, 2000)—that shows oscillatory behavior. Mr. Alcala's design used both a transcriptional repressor gene (tetR-lite) and a transcriptional activator gene (melR-lite), instead of three transcriptional repressor genes, and he attempted 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, but showed noisy signals. This stochastic behavior was studied by Steve A. Mendoza '13, who considered a relative simple synthetic transcriptional network in *E. Coli.* For his honors work, Mr. Mendoza analyzed the stochastic nature of our two-gene plasmid, which represents the smallest artificial gene network.

While continuing with his research, Professor Peacock-López, Ms. Gisela Demant, and instructor Ms. Cheryl Ryan (Hoosac Valley High School: 8 students) organized

and taught Advanced Chemistry labs at Williams College. These advanced chemistry students came five times during the year to perform some of the labs from the Williams Advanced Chemistry Lab Program and a newly developed organic synthesis. The latter experiment was implemented and adapted by Ms. 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-Lopez.

Finally, he has served as reviewer for the National Science Foundation, Nonlinear Dynamics, Nonlinear Analysis Series A: Theory Methods and Applications, *Journal of Physical Chemistry*, *Physica A*, and *Physics Letters A*.

In 2012-2013, Professor **David Richardson** pursued another full year of activity in the Chemistry Department. His teaching responsibilities for the year included Toxicology and Cancer (CHEM 341) with 26 students and Organic Chemistry, Intermediate Level-Special laboratory Section (CHEM 255) with 9 students in the fall semester and Organic Chemistry: Introductory Level (CHEM 156), in the spring semester with 153 students. The large enrollment in CHEM 156 necessitated teaching the course in two sections.

Professor Richardson continued his research with isolation of biologically active molecules from South East Asian plants, supervising studies conducted by work-study students Angelica Montenego-Tucker '16 and Amanda Walker '15 in collaboration with Professor Chip Lovett. He also continued a second collaboration with Professor Jay Thoman directed at the development of new methods for the synthesis of deuterofluorocarbons, supervising the efforts of work-study students Emily Fox '15 and Veronique Ignace '15. Beginning in the spring semester, Gordon Bauer '13, also began a senior honors thesis project in his lab studying the carbon mitigation effects of solar oven distribution projects in Central America. Professor Richardson continued his supervision and maintenance of the Department's 500 MHz nuclear magnetic resonance 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 grant reviewer for the American Chemical Society's Petroleum Research Foundation.

During July 2012 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. Together with Professor Janneke van de Stadt, he served as co-Chair of the College's Project for Effective Teaching (PET).

Dr. **Anne Skinner**, Senior Lecturer Emerita, has continued her active research program. In the summer of 2012 she spent two weeks in Tanzania at a site with early *Homo sapiens* fossils. In November she received a Senior Scientist Mentor grant from the Dreyfus Foundation to assist with analysis of the samples she brought back. Preliminary results from an earlier excavation were presented at the Society of Africanist Archaeology in Toronto in June 2012. In March 2013 she gave a keynote presentation on advances in ESR dating to the EPRBiodose 2013 meeting in Leiden, and in April she took part in the Archaeological Chemistry symposium at the ACS meeting in New Orleans, talking about how ESR dates can illuminate paleoclimates. In addition to the Dreyfus grant, she is a collaborator on a grant recently awarded by the Canadian Social Sciences Council for a project in Mozambique.

Professor **Tom Smith** spent his fifteenth 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 Menghan Zhao '13 worked toward the synthesis of a new marine natural product, enigmazole A. Mika Nakashige '13 also made progress on the ongoing synthesis of the myxobacterial antifungal agent, jerandolid D. In addition to his duties as Department Chair, Professor Smith taught Synthetic Organic Chemistry (CHEM 342) to 15 advanced students. The capstone project in this course was to analyze a total synthesis from the recent chemical literature and summarize the work in a classroom presentation and in a 20-page paper. These students learned an unbelievable amount of chemistry. It was a great semester.

Professor **Jay Thoman** was on sabbatical for the academic year. While most of his time was focused on writing, he returned to the chemistry lab to teach Glass and Glassblowing (CHEM 16) for Winter Study. During summer 2012, Thoman worked with Professor Dave Richardson, Gordon Bauer '13, and Andrew Bravo '15 to synthesize some new deuterofluorocarbon molecules. Rick Eiselen '14 and Scott Weiman '14 probed the

structure and dynamics of these new molecules and improved the experimental apparatus. During spring 2013, Claire Lidston '15 carried out molecular electronic structure calculations to test the conformational stability of the new deuterofluorocarbons and ones that we hope to synthesize in the future.

In service outside of the college, Thoman served as a reviewer for the American Chemical Society Committee on Professional Training and the Journal of Chemical Physics. He continues to serve as Chair of the Review Committee for the Chemistry GRE.
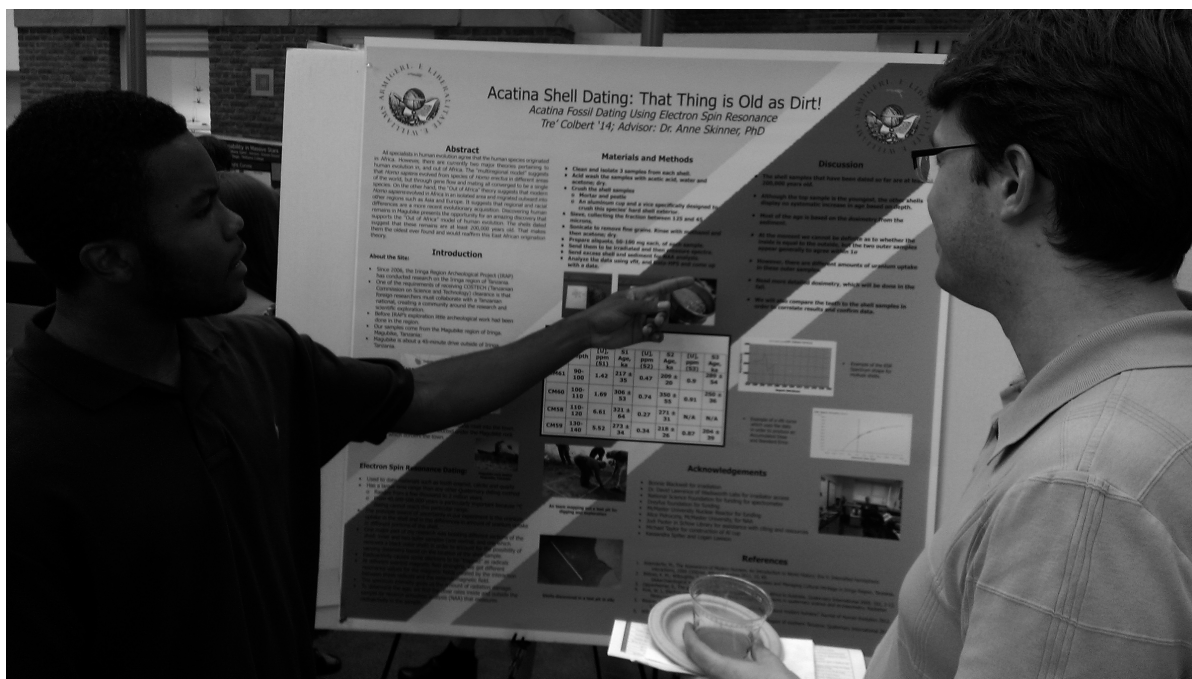
Tre' Colbert from the skinner lab explains his research to Prof. Seifert from the physics department.

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 Geoffrey Coates from Cornell University and Professor Robert Hamers from the University of Wisconsin-Madison were the 1960 Scholar speakers this year. Twelve students were selected by the faculty to be Class of 1960 Scholars during 2013 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 2013 are:

Class of 1960 Scholars in Chemistry

Gordon Bauer	Michael Gold	Lilliana Morris
Todd Brenner	Myya McGregory	Areli Valencia
Craig Burt	Zachary McKenzie	Scott Wieman
Peter Clement	Annie Moriondo	Anna Zhou

CHEMISTRY DEPARTMENT COLLOQUIA

Professor James Bobbitt, University of Connecticut, Charles Compton Lectureship
    "Oxoammonium Salts as Green Oxidants in Organic Chemistry"

Professor Geoffrey Coates, Cornell University, Class of 1960 Scholars
    "New Polymers from Old Monomers: Advances Enabled through Catalyst Design and Discovery"

Professor Susan Gillmor '96, George Washington University
    "How to Make a Polka-Dotted Vesicle: Cross-linking Perturbations on Lipid Bilayers and Their Implications in Cell Membrane Function"

Professor Jebrell Glover '95, Lehigh University
    "Caveolin: A Tale of Two Prolines"

Professor Robert Hamers, University of Wisconsin-Madison, Class of 1960 Scholars
    "Smart Electrodes for Renewable Energy: Diamonds are a Guy's Best Friend"

Professor Rein Kirss, Northeastern University
    "Phosphine Substitution in Cyclopentadienyl Ruthenium Phosphine Complexes: A Tale of Two Mechanisms"

Professor Mara Prentiss, Harvard University
    "Solving a 30 Year Puzzle: How RecA Recognizes Homology"

OFF-CAMPUS COLLOQUIA

Agoubi, Lauren L. '13, Bianca A. Ulloa '14, Michelle M. McRae '12, Olivia W. Foley '13, and Sarah L. Goh
"Synthesis of mannose-functionalized polymeric micelles"
245th ACS National Meeting, New Orleans, LA, April 2013
Abstr. Am. Chem. Soc., Polym. Div. 2013, 245, POLY-57

Bingemann, Dieter
"Correlations between Elementary Relaxation Steps in a Model Glass Former"
APS March National Meeting, March 2013

"Glass Dynamics through Sudden, Local Relaxation Events"
244th ACS National Meeting, Philadelphia, PA, August 2012

Gehring, Amy, Sora Kim '13, and Kenny Murgo '12
Poster: "Role of a Putative Phosphoesterase in Antibiotic Production by Streptomyces coelicolor"
Gordon Research Conference: Microbial Stress Response, Mount Holyoke College, July 2012

Goh, Christopher, Matthew Everhart '11, Michael Girouard '13, William McClain '09, and Lilli Morris '14
"Epoxidations of plant-based fatty acids and their corresponding esters by [Fe(BPMEN) (OTf)$_2$]"
245th ACS National Meeting, New Orleans, LA, April 2013

Goh, Christopher, Sarah L. Guillot '13, and Zachary D. Remillard '12
"Ligand donor effects of polydentate pyridine-amine ligands for copper(I) in the ATRP of styrene"

ACS Connecticut Valley Section Undergraduate Symposium, Central Connecticut State University, New Britain, CT, April 27, 2013

245th ACS National Meeting, New Orleans, LA, April 2013

Goh, Sarah L.
"Polymer chemistry in an undergraduate curriculum"
244th ACS National Meeting, Philadelphia, PA, August 2012
Abstr. Am. Chem. Soc., Chem. Ed. Div., 2012, 244, CHED-87

Kaplan, Lawrence J.
"Chemistry Collaborations, Workshops and Communities of Scholars (cCWCS)–II: Forensic Science at Williams College"
Poster at the 2013 TUES/CCLI PI Conference in Washington, D.C., January 23-25, 2013

"cCWCS Forensic Science Workshop as a Vehicle for Introducing Chemical Concepts to Motivate and Enhance Student Learning"
Innovative Forensic Applications for Teaching with an Emphasis on Chemical Principles at the 22nd Biennial Conference on Chemical Education, Penn State University, State College, PA, August 2, 2012

"Chemistry and Crime and the cCWCS Forensic Science Workshop for Introducing Chemical Concepts with a Forensic Flavor"
Engaging Students in Chemistry using Forensics: High School and Introductory College Programs. 22nd Biennial Conference on Chemical Education, Penn State University, State College, PA, August 1, 2012

"Chemistry Collaborations, Workshops and Communities of Scholars"
cCWCS: Developing Scholarly Communities to Transform Undergraduate Education: Forensic Science Scholars organized by L. J. Kaplan at the 22nd Biennial Conference on Chemical Education, Penn State University, State College, PA, July 29, 2012

Kaplan, Lawrence J. , Carmen Gauthier-Valdez, Audra G. Sostarecz, Michael Push, and Renee Beeton
"Forensic Science, An Introduction to the Analysis of Evidence: a cCWCS Mini-Workshop"
Two sessions presented at the 22nd Biennial Conference on Chemical Education,
Penn State University, State College, PA, July 31, 2012

Lou, Alexander J. '13, Nai Chien Yeat '13, Elizabeth E. Hwang '13, Charles A. Seipp '11, and Sarah L. Goh
"Synthesis of amino acid containing block copolymers"
245th ACS National Meeting, New Orleans, LA, April 2013
Abstr. Am. Chem. Soc., Polym. Div. 2013, 245, POLY-48

McRae, Michelle M. '12, Olivia W. Foley '13, and Sarah L. Goh
"Synthesis and self-assembly of amphiphilic glycopolymers"
244th ACS National Meeting, Philadelphia, PA, August 2012
Abstr. Am. Chem. Soc., Biol Chem. Div. 2012, 244, BIOL-89

Richardson, David P.
"Organic Pollutants in Local Waters: The Current State of PCB Pollution in the Hoosic River Watershed:
Facts, Questions and Discussion"
Berkshire Environmental Action Team's Green Drinks Program, North Adams, MA, April 10, 2013

Skinner, Anne R.
"ESR Dating of Mollusc Shells from the Iringa Region, Tanzania"
SAfA 2012, Toronto, Canada, June 22, 2012

"Looking for the First Settling of the New World"
"Thoughts on ESR Dating"
EPRBiodose 2013, Leiden, Netherlands, March 26, 2013

"Correlating Paleoclimate and Hominin Activity: ESR dating at the Kharga Oasis, Egypt"
245th ACS National Meeting, New Orleans, LA, April 8, 2013

Ulloa, Bianca A. '14, Lauren L. Agoubi '13, Michelle M. McRae '12, Olivia W. Foley '13, and Sarah L. Goh
"Recognition of mannose- and glucose-derived polymers"
245th ACS National Meeting, New Orleans, LA, April 2013
Abstr. Am. Chem. Soc., Polym. Div. 2013, 245, POLY-428

POST-GRADUATE PLANS OF CHEMISTRY MAJORS

Lauren Agoubi	M.S. in Advocacy and Activism, Fulbright Fellowship, Ireland
Caitlyn Clark	Work for Williams College Investment Office
Christopher Corbett	Research Assistant, Boston Children's Hospital, then medical school
Evan Dugdale	Work for Match Corps Middle School, Boston, then medical school
Paul Dyrkacz	Unknown
Bryn Falahee	Herchel Smith Fellowship to University of Cambridge, UK, M.Phil. in Translational Medicine and Therapeutics
Olivia Foley	Research Assistant, Fundacíon Ortiz-Gurdian, Managua, Nicaragua
Emily Gao	Volunteer at Episcopal Corps in NC, then medical school
Alejandro Gimenez	Horseshoe Farm Fellowship in AL, then medical school
Michael Girouard	Clinical Research Coordinator at the Medical Practice Evaluation Center, MA General Hospital, then medical school
Sarah Guillot	Analytical Specialist, Regeneron Pharmaceuticals, Rensselaer, NY
Tracy Hu	Unknown
Sora Kim	Research Associate, The Broad Institute, Cambridge, MA
Alexander Lou	Ph.D. in Chemistry, Northwestern University
Lovemore Makusha	Unknown
Justin Mangope	Unknown
Bianca Martinez	Intramural Research Technician Assistant for National Institute of Allergy and Infectious Disease, Bethesda, then medical school
Steve Mendoza	Ph.D. in Bioinformatics, SUNY Albany
Su-Gi Min	Teaching Fellow at St. George's School in Newport, RI
Mika Nakashige	Ph.D. in Chemistry, Dartmouth College
Jessica Ndungu	Intern, Fine Arts Conservation Group, LLC, New York, NY
Asvelt Nduwumwami	Teaching Chemistry at Deerfield Academy, Deerfield, MA
Blair Robinson	Field Team Leader, AmeriCorp NCCC FEMA, Vicksburg, MS
Felix Sun	Intern and Teaching Math/English at AGM Sports, Zaragoza, Spain
Scott Symonds	Associate Consultant, Trinity Partners in Waltham, MA
Christian Torres	Materials Characterization Technician at IQE Inc., then graduate school
Emily Ury	Unknown
Erica Wu	Market Analyst, Boston Biomedical Consultants, Waltham, MA
Nai Chien Yeat	M.D., Washington University School of Medicine in St. Louis
Peter Young	M.D., Columbia University College of Physicians and Surgeons
Menghan Zhao	Clinical Research Coordinator, Faustman Lab at MA General Hospital

COMPUTER SCIENCE DEPARTMENT

The Computer Science Department had a great year. We are pleased to report that Assistant Professor Jeannie Albrecht was granted tenure and will be promoted to Associate Professor as of July 1, 2013. Our outstanding students in our classes have participated in many research and independent projects including autonomous burrito-making robots, monitoring house electricity consumption to learn usage patterns, optimizing power usage in data centers, and improving search tree data structures. James Wilcox '13 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. James also received an NSF Graduate Research Fellowship to continue his studies in graduate school next year. In October April Shen '13, Abbie Zimmermann-Niefield '14, and Bryn Reinstadler '15, attended the Grace Hopper Celebration of Women in Computing in Baltimore, Maryland along with Profs. Albrecht and Danyluk.

The Computer Science Department turned 25 this year. To celebrate, we invited all alumni who majored in computer science to a two-day symposium focusing on the exciting contributions of our current and former students and faculty. About 100 alumni representing thirty different classes returned to campus in April for this event. More than fifty of them were kind enough to give lectures to our classes, discuss their passions in research talks, participate in career panels, and reflect on the future of Computer Science education. Kim Bruce, who was instrumental in the founding of our department and who is now growing the department at Pomona College, gave a wonderful keynote address on the role of Computer Science at liberal arts colleges. Other distinguished speakers included Rich Ketcham, A.J. Brush, Evan Sandhaus, and Josh Frankel. Two current honors students (April Shen '13 and James Wilcox '13) gave talks on the research they've been working on over the past year.

Our alumni have pursued many different careers. Some are academics, teachers, or researchers; some are entrepreneurs; some are artists; some are software engineers; some practice law, business, or medicine; and some have embarked on completely different (and sometimes surprising) paths altogether. We take great satisfaction in seeing them all thrive in such varied careers. This symposium not only celebrated the many achievements of the department and our alumni, but also fostered new connections among them and our current students and highlighted the myriad of doors open to those studying computer science at Williams.

This year Prof. **Jeannie Albrecht** continued to work with Prof. Prashant Shenoy, Prof. David Irwin, and Sean Barker '09 at UMass Amherst on techniques for using computing to decrease the energy impact of society. Using data generated from hundreds of sensors and power meters installed in her home, Albrecht explored ways to flatten peak energy demands and reduce overall energy consumption in residential buildings. Albrecht described some of the initial results obtained from this work during the Sigma Xi research lecture series in the fall. In addition, Albrecht advised Jennifer Gossels '13 on an honors thesis that explored occupancy detection and prediction techniques based only on aggregate power usage information in homes. Gossels ultimately found that occupancy could be detected and predicted with high levels of accuracy when historical data was available. Karlan Eberhardt '13 worked with Albrecht during the summer and fall of 2012 on a related project that studied the effectiveness of occupancy prediction using neural networks.

Albrecht advised honors student Tommy Gaidus '13 who studied another important aspect of energy management and computing. Motivated by the energy demands of society and increasing reliance on renewable and variable energy sources, such as wind and solar power, Gaidus developed a new sorting benchmark that defined a metric for evaluating how well a distributed sorting system performed in the presence of intermittent energy.

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 (Global Environment for Network Innovations, http://www.geni.net). Recently, Albrecht has been investigating ways to infuse the new technologies developed as part of the GENI project into classroom exercises and projects, particularly at the undergraduate level. Last July, Albrecht organized an NSF sponsored workshop at the 14th GENI Engineering Conference on Designing Tools and Curricula for Undergraduate Courses in Distributed Systems. Over 30 attendees from a variety of backgrounds, including top-tier research universities, liberal arts colleges, and industry, participated in the workshop. Albrecht also served on the program committee for the 2012 and 2013 GENI Research and Educational Experiment Workshop (GREE).

In the fall, Albrecht taught a new 100-level tutorial called The Socio-Techno Web. The course introduced students to fundamental concepts in computer science by examining the social aspects of computing, such as privacy, trust evaluation and propagation, and the economics and politics of Web information and online communities. Also in the fall, Albrecht and Prof. Andrea Danyluk co-supervised an independent study on Distributed Robotics with Owen Barnett-Mulligan '13, Donny Huang '13, and Alex Wheelock '13. The course culminated in a final demonstration of a distributed set of robots that cooperatively gathered ingredients from various locations and built a burrito.

Professor **Duane Bailey** was on sabbatical this past year and spent the year exploring his own scholarly pursuits. However, his sabbatical did not deter Duane from volunteering to co-organize our 25th Anniversary Symposium with Andrea Danyluk. The Department thanks both Duane and Andrea for all of their time and effort planning, coordinating and executing our symposium. It was a great success.

Professor **Andrea Danyluk** continued her research in machine learning, working on a number of different projects. She supervised the honors thesis of April Shen '13. Shen's work addressed the problem of classifier learning in complex data sets, where the data of a single class might be distributed irregularly throughout the feature space and where measures of distance as a proxy for similarity might be unreliable. April developed a new algorithm: the ensemble of prototype support vector machines (PSVMs) to learn an ensemble of classifiers that are tuned to different regions of the feature space describing the target classes of objects.

Danyluk continued a project on active learning in domains with highly skewed class distributions. As an example, consider classifying web pages as to whether they belong to female computer scientists. Of all the pages on the web, these make up just a very small percentage. Daniel Seita '14 worked with Prof. Danyluk on this during Winter Study. Danyluk also looks forward to working with students in summer 2013 on applying computational techniques to automatically identify individual spotted salamanders from digital images, a project she began several years ago in conjunction with faculty in our Biology Department.

Danyluk has been serving as a member of the steering committee for the ACM/IEEE Computer Science Curriculum 2013 (CS2013), whose goal is to develop international curriculum guidelines for undergraduate programs in computer science. They put out their "Ironman Report" in March 2013. This extensive document outlines the principles guiding the CS2013 process, commentary on desired characteristics of computer science graduates, professional practice, and institutional challenges, as well as the "body of knowledge," which describes topics and learning outcomes for 18 knowledge areas spanning computer science. The report also includes exemplar courses that faculty can use either "as is" or as a starting point for implementing their own courses. The final report is due to be completed by fall 2013. Danyluk is a member of the Liberal Arts Computer Science Consortium and is working to bring the concerns and sensibilities of liberal arts colleges to the CS2013 effort.

Danyluk also continues her work as a board member of the Computing Research Association's Committee on the Status of Women in Computing Research (CRA-W). As a member of CRA-W, her primary responsibility is to administer an undergraduate research grant program, but she also works to develop and disseminate resources on best practices for mentoring undergraduate research. She speaks regularly at mentoring workshops for women at all stages of the pipeline, from undergraduate through mid-career.

In addition to serving as Department Chair, Associate Professor **Stephen Freund** continues 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 Symposium on Software Testing and Analysis, as well as at IBM and University of Massachusetts, Amherst. With colleagues from Microsoft Research, Freund also presented an invited tutorial on dynamic analyses to detect concurrency errors at the International Conference on Runtime Verification in Istanbul, Turkey.

Last summer, Freund worked with James Wilcox '13 and Parker Finch '14 on optimizing dynamic race detectors to find defects in concurrent programs with lower run-time overhead. Wilcox continued that work his senior year, completing an honors thesis under Freund's supervision. Freund is also currently serving on the Programming Languages Education Board, the national committee in his research community that focuses on issues surrounding undergraduate education.

Associate Professor **Brent Heeringa** completed his seventh year in the Computer Science Department at Williams College. Heeringa taught Theory of Computation (CSCI 361)in the fall, and Algorithm

Design and Analysis (CSCI 256) and Introduction to Computer Science (CSCI 134) in the spring.

Working with Gordon Wilfong (Bell Labs) and Glencora Borradaile (Oregon State University), Heeringa published The Knapsack Problem with Neighbour Contraints in a special issue of Journal of Discrete Algorithms highlighting the best papers from the International Workshop on Combinatorial Algorithms.

Heeringa continued working with Donny Huang '13 on fundamental problems in data structures relating to the efficiency and optimality of binary search trees. With Brianne Mirecki '14 and Professor Nate Kornell from the psychology department, Heeringa also explored encodings of information that are more naturally suitable for humans.

Heeringa reviewed papers for *Information Processing Letters*, and *Algorithmica*. In addition he traveled to New Orleans for the Symposium on Discrete Algorithms and gave an invited lecture at Fairfield University in Fairfield, CT.

Professor **Bill Lenhart** spent the year on leave after having completed his term as Provost and Treasurer of the College. Bill spent the majority of his time re-establishing his research program in the areas of computational geometry and graph drawing. Much of Bill's work focuses on theoretical question related to the embedding of graphs in two and three dimensions. One joint research project, with colleagues Vida Dujmović, Will Evans, Sylvain Lazard, Beppe Liotta, David Rappaport, and Steve Wismath, involving the embedding of graphs in the plane on predetermined point sets with specified locations for both vertices and bend-points of edges, resulted in a publication in the journal *Computation al Geometry: Theory and Applications*

A second project considered the problem of computing a planar embedding of a tree onto a predetermined planar point set subject to the constraint that the vertices of the tree as well as the points in the planar point set were partitioned into labeled subsets which the embedding was required to respect. This work, with Fabrizio Frati, Marc Glisse, Beppe Liotta, Tamara Mchedlidze, and Rahmuna Islam Nishat, resulted in a paper presented by Bill at the 20th International Symposium on Graph Drawing (GD 2012) at the Microsoft Campus in Redmond, Washington.

Bill worked with several colleagues on the problem of computing three dimensional representations of graphs in which each vertex is realized by an axis-aligned "box" in 3-space and where the edge relationship between two

vertices is captured by box incidence. That is, two vertices are adjacent if and only if their respective boxes share a two-dimensional common boundary of positive area. The results of this work, a result of collaboration with David Bremner, Will Evans, Fabrizio Frati, Laurie Heyer, Stephen Kobourov, Beppe Liotta, David Rappaort, and Sue Whitesides, was also presented at GD 2012.

In addition to attending GD 2012 this past September, Bill was also invited to (and attended) the 2013 McGill-INRIA-Victoria Workshop on Computational Geometry at the Bellairs Research Institute of McGill University in Barbados and the 2013 Bertinoro Workshop on Graph Drawing at the Bertinoro International Centre for Informatics in Bertinoro, Italy.

Professor **Morgan McGuire** enjoyed teaching the largest sections of Computer Graphics (CSCI 371) and Creating Games (ARTS/CSCI 107) he's seen in six years. Both courses produced fantastic, creative final projects. The new CSCI 371 teaching materials from this year are now available beyond Williams as the The Graphics Codex app (http://graphicscodex.com) and the third edition of the Computer Graphics: Principles and Practice textbook (http://cgpp.net).

Prof. McGuire worked closely with research associate Michael Mara '12 visiting from NVIDIA. They traveled together to ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games 2013 in Orlando, Florida where Mara presented their new work on real-time lighting and McGuire gave the invited banquet talk. In July they travelled to the annual ACM SIGGRAPH to present work on digital publishing and cloud computing. They were joined in the lab by NVIDIA intern James Wilcox '13 and undergrad research assistants Dan Evangelakos '15 and Sam Donow '16.

Last May, McGuire joined 25 other leaders in computer graphics research to found the free, open access *Journal of Computer Graphics Techniques* (http://jcgt.org). This is the first reputable, peer-reviewed journal in this area to provide this level of accessibility. Open access to research is a hot topic today. Initiatives like *JCGT* strive to make humanity's scientific knowledge freely accessible to all, where in the past it has been restricted by publishers for profit. Williams hosts the *JCGT* website and McGuire is collaborating with OIT to permanently archive its publication at Williams under their digital institutional repository initiative.

Prof. **Tom Murtagh** continues to investigate techniques for effectively utilizing flash memory in file systems. Flash memories in use today typically include a "flash translation

layer" 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. During last summer, Tom worked with Abigail Zimmerman-Niefield '15, to explore strategies for buffer management within a flash translation layer designed to exploit locality in data reference patterns. This summer, Tom will be working with Kyle Cheng '16 on techniques that exploit semantic knowledge of file system operations to reduce the costs associated with reusing flash pages.

Each year the department participates in a special lectureship program funded through the generosity of the Class of 1960. This year, the department featured Professor Lorrie Faith Cranor (CMU) as our fall speaker and Dr. A.J. Bernheim Brush '96 (MicrosoftResearch) as our spring speaker.

Lorrie Faith Cranor is an international expert in privacy and security. As noted on her website, "Dr. Cranor has played a key role in building the usable privacy and security research community. She co-edited the seminal book Security and Usability (O'Reilly 2005) and was appointed a Privacy by Design (PbD) Ambassador by the Privacy Commissioner of Ontario, Canada. She has testified about privacy issues at a Congressional hearing and at workshops held by the U.S. Federal Trade Commission and Federal Communications Commission. In 2003 she was named one of the top 100 innovators 35 or younger by Technology Review magazine. She has received faculty research awards from IBM, Microsoft, and Google."

A.J. Bernheim Brush is leading researcher in the field of Human Computer Interaction. In 2010 she won the prestigious CRA-W Borg Early Career Award which is "given to a woman in computer science and/or engineering who has made significant research contributions and who has contributed to her profession, especially in the outreach to women." A.J.'s talk was held in conjunction with our 25th Anniversary event and was exceptionally well-attended.

A view across the science quad toward Morgan Hall and the Thompson Memorial Chapel.

As part of the Class of 1960 scholars program, fifteen students were invited to participate in these special events. This year's scholars were:

Class of 1960 Scholars in Computer Science

Owen Barnett-Mulligan '13	Donny Huang '13	Cody Skinner '13
Karlan Eberhardt '13	Brianne Mirecki '14	Alexander Wheelock '13
Kushatha Fanikiso '13	Lily Riopelle '14	James Wilcox '13
Thomas Gaidus '13	James Rosten '13	Qiao Zhang '13
Jennifer Gossels '13	April Shen '13	Abigail Zimmermann-Niefield '15

COMPUTER SCIENCE COLLOQUIA

Sharon Goldberg, Boston University
"Finding Incentives to Secure Internet Routing"

Dr. Nathan Hodas '04, University of Southern California
"Using Social Network Data to Understand Human Behavior"

Allen Downey, Olin College
"Complexity, Computation and Science in the 21st Century"

Computer Science Faculty, Williams College
"Everything You Need to Know About Graduate School"

Lorrie Faith Cranor, Carnegie Mellon University
"Spoofing Operating System Security Interfaces to Study User Security Behaviors"

Sameer Singh, University of Massachusetts, Amherst
"Machines That Read: Extracting Knowledge From Raw Text"

Josh Brauer and Emily Yu '11, Epic
"Mobile Development"

Jeannie Albrecht, Williams College
"Flattening Peak Electricity Demand in Smart Buildings"
"Sensor-Driven Energy Management for Smart Buildings"

John Rieffel, Union College
"Growing and Evolving Soft Robots"

Deepak Ganesan, University of Massachusetts, Amherst
"Ubiquitous Sensing of Human Behavior"

Brent Heeringa, Williams College
"When Pretty Good is Good Enough: A Tour of Approximation Algorithms"
Faculty Lecture Series at Williams

Derek Nowrouzezahrai, University of Montreal
"Rendering is an Artist's Nightmare (and a Researcher's Dream)"

Jeannie Albrecht, Williams College
"It's Not Easy Being Green (Yet)"
Daring Change: Imagining Williams' Future

COMPUTER SCIENCE STUDENT COLLOQUIA

Michael Littman, Brown University
    "Modular Approaches to Computer Programs for Language Games"

A.J. Bernheim Brush '96, Microsoft Research
    "Home Automation: Is it Finally Ready For the Mainstream?"

Andrea Danyluk, Williams College
    "Computer Science Education: Evolution of the Williams Computer Science Curriculum"
    The 25th Anniversary Symposium of Computer Science at Williams

Tim Oates, University of Maryland Baltimore County
    "Blood Transfusions and Vampire Bats: Finding Patterns in Time Series"

Karlan Eberhardt '13
    "Energy Monitoring on Android"

Kush Fanikiso '13
    "Social Software, How Technology Can Better Humanity"

Parker Finch '14
    "FastTrack: Now Leaving Footprints"

Thomas Gaidus '13
    "Cloud Based Solutions for Alternative Asset Fund Managers"

Emma Harrington '15
    "Springsteen and Computer Science"

Donny Huang '13
    "Dynamic Optimality"

Brianne Mirecki '14
    "Unhackable Encoding in Human Memory"

Daniel Seita '14
    "Text Simplification"

James Wilcox '13
    "ChickenCoop: Two Kinds of Inference for a Cooperability Effect System"

Abbie Zimmermann-Niefield '15
    "Log Based Schemes and Flash Memory"

Donny Huang '13
    "Implementing Online GreedyFuture"

Thomas Gaidus '13
    "Energy-Aware Distributed Sorting Systems"

Jennifer Gossels '13
    "Home Occupancy Detection and Prediction"

April Shen '13
    "Prototype Support Vector Machines: Supervised Classification in Complex Datasets"

James Wilcox '13
    "Optimizing Dynamic Race Detection in Array-Intensive Programs"

COMPUTER SCIENCE OFF-CAMPUS COLLOQUIA

Jeannie Albrecht
> "Distributed Application Management with Gush"
> Fairfield University REU, Fairfield, CT, July 2012.
>
> "Bringing Big Systems to Small Schools"
> NSF Workshop on Distributed Systems Education, Boston, MA, July 2012.
>
> "Curriculum Workshop Report"
> GENI Engineering Conference 14, Boston, MA, July 2012.
>
> "Sensor-Driven Energy Management for Smart Buildings"
> Hiram College, Hiram, OH, March 2013.
>
> "Distributed Application Management with Gush"
> Hiram College, Hiram, OH, March 2013.

Andrea Danyluk
> "Undergraduate Research Experience Internships"
> "If I'd Only Known: Advice for Junior Faculty"
> Grace Hopper Celebration of Women in Computing, Baltimore, MD, October 2012.
>
> "Building Your Professional Network, Mentors, and Collaborations"
> "Strategies to Help with Promotion to Full Professor"
> CRA-W Cohort of Associate Professors Project, San Francisco, CA, November 2012.
>
> "Time Management"
> CRA-W Career Mentoring Workshop for Faculty in Undergraduate Computing Programs, Denver, CO, March 2013.
>
> "ACM/IEEE Computer Science 2013 Exemplar-Fest"
> "Making the Most of Undergraduate Research"
> SIGCSE 2013, Denver, CO, March 2013.

Stephen Freund
> "Cooperative Concurrency for a Multicore World"
> IBM Programming Languages Day, Hawthorne, NY, June 2012.
>
> "Dynamic Analyses for Concurrency"
> International Conference on Runtime Verification, Istanbul, Turkey, September 2012. (Tutorial presented with John Erickson and Madan Musuvathi.)
>
> "Dynamic Analyses for Data Race Detection"
> University of Massachusetts, Amherst, MA, March 2013.

Brent Heeringa
> "Approximating Optimal Binary Decision Trees"
> Fairfield University, Fairfield, CT, August 2012.
>
> "When Pretty Good is Good Enough: A Tour of Approximation Algorithms"
> Williams Alumni Talk, San Francisco, CA, January 2013.

William Lenhart
"Point-set Embeddability of 2-Colored Trees"
20th International Symposium on Graph Drawing (GD 2012), Microsoft, Redmond, WA, September 2012.

Morgan McGuire
"The Augmented Artist"
ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games, Orlando, FL, March 22, 2013.

"Indirect Lighting Computed in the Cloud"
ACM SIGGRAPH Conference on Computer Graphics and Interactive Techniques, Anaheim, CA, July 2013.

"Join the Digital Text Revolution"
ACM SIGGRAPH Conference on Computer Graphics and Interactive Techniques, Anaheim, CA, July 2013.

POST GRADUATE PLANS OF COMPUTER SCIENCE MAJORS

Owen Barnett-Mulligan	Fiksu
Karlan Eberhardt	Paramedic school, Washington D.C.
Kushatha Fanikiso	Software development position
Thomas Gaidus	Microsoft
Jennifer Gossels	Graduate school at Princeton University, NJ
Donny Huang	Graduate school at University of Washington, WA
James Rosten	Fiksu
April Shen	Graduate school at University of Washington, WA
Cody Skinner	Cogo Labs
Alexander Wheelock	Teach for America, Newark, NJ
James Wilcox	Graduate school at University of Washington, WA
Qiao Zhang	Graduate school at University of Washington, WA

Students in the environmental Studies program make stream measurements during the summer of 2013

GEOSCIENCES DEPARTMENT

This has been an exciting year in the Geosciences Department. Following the retirement of Markes Johnson last year, we welcomed new faculty member Phoebe Cohen in 2012, who came to us via Harvard (Ph.D.) and MIT (post-doc). Phoebe's interests in paleobiology and the earliest evolution of organisms bring a new dimension to the department, and we are excited to have her as a colleague. Phoebe's hire means that for the first time in its history, Williams Geoscience has an equivalent number of women and men on the faculty. And, also for the first time, the department has a female chair: Rónadh Cox took the position in July 2012. We are also excited that Lisa Gilbert was awarded tenure; and that Dave Backus (who has taught in the department numerous times on a visiting basis) was formally appointed lecturer. From the teaching perspective the department was a little shrunken this year, as Mea Cook and Paul Karabinos were both on leave and pursuing their research. The rest of us managed to keep the flag flying, however, and we hustled the class of 2013 toward graduation while nurturing the class of 2014 and welcoming in a new batch of majors in the class of 2015. The department continues to thrive, with diverse research projects and new courses adding breadth and depth to the ways that we interact with students. We will welcome Mea and Paul back for the coming academic year and plan to move forward with energy and enthusiasm.

The Geosciences Dept. had 10 senior majors this year with 6 of them completing theses. Each of them gave a presentation on their work at the end of the spring semester, with Gabriel Lewis '13being awarded the Freeman Foote award for best thesis presentation. The David Major Fund provided field camp scholarships for Johanna Eidmann '14 to attend the Lehigh University field camp and Nari Miller '12 to attend the Albion College field course during the summer of 2012. That fund also supported Nari Miller's expenses to attend the annual AGU meeting in San Francisco where she gave a poster presentation of her thesis work. Sarah Rowe '13 was awarded the David Major Prize for outstanding geosciences senior. The Sperry Family Fund in Geosciences supported Miranda Bona '13 in her field research during the summer with Prof. Lisa Gilbert at Williams-Mystic. The McAlleenan Fund covered expenses for Gabriel Lewis to attend the annual Geological Society of America meeting in October in Denver and Ian Nesbitt '13 to attend the NE Geological Society of America meeting in March in New Hampshire.

Assistant Professor **Phoebe Cohen** started her position at Williams College in July of 2012. Phoebe spent the summer preparing her new lab facility in Bronfman, gearing up for teaching Co-evolution of Earth and Life (GEOS 101) in the fall semester, and exploring the Berkshires. In the fall, Nakita VanBiene '15 and Kim Kipligat '16 helped her get her new lab in Bronfman set up and began processing rock samples to search for microscopic fossils. Phoebe attended the national meeting of the Geological Society of America in Charlotte, NC, in October where she gave a presentation on enigmatic algal fossils from Mongolia. At this meeting, Phoebe also received the Geological Society Subaru Outstanding Woman in Science award, presented to a woman that has impacted the field of the geosciences in a major way based on their Ph.D. research. Unfortunately, this award did not come with a free car. In the spring, Phoebe taught Paleobiology (GEOS 212 / BIOL 211) and added Cody Remillard '16 to her lab group to continue the search for ancient life in rocks from around the world. In May, she attended a National Science Foundation workshop on Scientific Drilling and the Evolution of the Earth System at the University of Oklahoma in Norman, OK. In addition to her teaching and research, Phoebe has also been instrumental in working with our new web master Ahmad Green-Hayes '16 to redesign and upgrade the Geosciences website. This summer, Phoebe will travel to the rocky coast of Newfoundland for a week of field work and will spend the rest of the summer in her lab working with Research Assistant Quinn Griffin '14, as well as getting Michelle Paradis '14 started on her senior thesis Keck project. This year, Phoebe served as a reviewer for the National Science Foundation, Petroleum Research Fund, *Journal of Paleontology*, *Nature Geoscience*, and *Nature Communications*.

In summer of 2012 **Rónadh Cox**, with Leaf Elliott '13 and Kalle Jahn '14, went back to the west coast of Ireland to continue measuring boulder ridges as part of her ongoing project to understand how storm waves move giant blocks. She will continue this work in Summer 2013, when she goes to the Shetland Islands. Kalle Jahn '14 will also be on that trip, and the work will form the basis for his senior thesis. Accompanying them as a field assistant will be Will Wicherski '15. The group looks forward to cold, rainy and windy weather in the north Atlantic; but the scenery and geology promise to be spectacular.

At GSA in November 2012 Rónadh presented ongoing work on erosion in Madagascar, and Ny Riavo Voarintsoa (Malagasy student who spent the academic year at Williams) presented the results of her portion of this project in a poster. A paper on this work, co-authored by Ny Riavo, Rónadh, and colleagues, came out in the *South African Journal of Geology*. Rónadh continues as a Science Editor for *Geology*, and is also a member of the Geological Society of America's Publications Committee. In July of 2012, she became chair of the Geosciences Department and that has kept her busy all year.

Lisa Gilbert has been promoted to Associate Professor with tenure. Thesis student Miranda Bona '13 spent the summer of 2012 and winter study 2013 in Gilbert's laboratory in Mystic, developing a new method for measuring permeability of crystalline rocks with image analysis. Gilbert and Bona presented their research at the annual meeting of the American Geophysical Union in San Francisco in December. Gilbert and former thesis student Susan Schnur (Williams-Mystic Fall 2006; now Ph.D. student at Oregon State University) published their work on a preserved seamount in California in the journal *Geochemistry, Geophysics, Geosystems* in December. Schnur and Gilbert are now collaborating on a new study of some enigmatic South Atlantic seamounts; Bryce Mitsunaga '13 in the summer of 2012 and Michael Semensi '12 in the fall of 2012 assisted with the preparation and physical properties measurements of samples from about 50 seamounts. Caroline Gregory (Williams-Mystic Spring 2013; Hamilton '14) and InterRidge postdoctoral researcher Emanuele Fontana from the University of Milan will spend the summer of 2013 in Gilbert's lab to study the structural and petrophysical character of the lava/dike boundary of oceanic crust from several drill holes and the Troodos Ophiolite in Cyprus.

In addition to her seafloor research, Gilbert is part of two NSF-funded collaborations related to geoscience education: a major national effort to develop interdisciplinary teaching materials related to sustainability science and natural hazards and another effort to understand and improve the motivations and attitudes of introductory geoscience students. Gilbert participated in meetings of these groups at Carleton College in Minnesota and University of Colorado-Boulder and was lead author of a paper appearing in the *Journal of Geoscience* education in November.

Emeritus professor **Markes Johnson** and research scientist Gudveig Baarli attended the Fourth International Rhodolith Workshop Sept. 17-21, 2012, at the University of Granada in Granada, Spain. They delivered two presentations reporting on their research regarding the taphonomy of unattached coralline red algae in the Cape Verde Islands. They also attended the Third Annual Meeting for International Geoscience Programme Project 591 and post-conference field trip on Early Palaeozoic Global Change, held June 9-19, 2013, at Lund University, Sweden. Markes presented a paper on the change from Late Ordovician to Early Silurian faunas in the mid-western USA. Gudveig gave a paper on Lilliputian faunas from the Lower Silurian of Norway.

During the fall semester, Markes completed the manuscript for a new book on the landscapes and geology of islands and peninsular shores of the Gulf of California. The project is accepted for publication by the University of Arizona Press and now under production for release in early 2014. In March 2013, Markes and Gudveig rejoined the Portuguese-Spanish research team for the third season of paleontological fieldwork in the Cape Verde Islands. Focus of the season's project was on fossil rhodoliths from the islands of Sal and Maio, in particular extensive beach-rock deposits.

Professor of Geosciences Paul Karabinos was on leave during the academic year. He continued research on his 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 attended the National meeting of the Geological Society of America in Charlotte, North Carolina in November, 2012, where he gave an invited presentation at a Pardee Symposium entitled "Digital Geology Speed-Dating: an Innovative Coupling of Interactive Presentations and Hands-On Workshop (Digital Posters)." He gave another presentation in a theme session called "Dynamics of Gneiss Domes, Core Complexes, and Orogenic Plateaux." He was co-author with James Hibbard on a presentation is a session entitled "Earthscope and Geoprisms in Eastern North America: Ongoing Endeavors and a Look Ahead."

This year Professor **Bud Wobus** advised senior thesis student Johnny Ray Hinojosa '13 and was a junior co-advisor (with Lisa Gilbert at Mystic) for Miranda Bona '13. Hinojosa's thesis was a study of chemical inheritance and geothermometry for some unusual alkaline volcanic rocks in the Neogene Powder River Volcanic Field of NE

Oregon. Sponsored by the Keck Geology Consortium, the project began with four weeks of field work the previous summer, when Wobus visited the group. Hinojosa gave poster and oral presentations at the 26th Keck Geology Symposium at Pomona College in April, where Wobus represented Williams (for the 26th year) on the Keck Board of Representatives. Bona's thesis involved measurements of permeability in basalt lavas of the ocean crust using samples from drill cores obtained from one leg of the Integrated Ocean Drilling Program when Prof. Gilbert was on board. Bona gave a preliminary report of her findings at the December meeting of the American Geophysical Union in San Francisco, with Gilbert and Wobus as junior authors. As usual, Wobus also organized reunions for Williams geology alumni at the AGU meeting and at the Geological Society of America meeting in Charlotte, NC, in October.

The highlight of the year for Prof. Wobus was the winter study project he lead on the Geology of the Colorado Front Range. The project concluded with 8 days of field trips in Colorado for the 10 students involved (see section on Winter Study Offerings near the front of this volume). This summer he will begin advising Eloise Andry '14 on her REU study of volcanic centers in the San Francisco Volcanic Field, northern Arizona, and will lead a Williams alumni trip from the Black Hills and Badlands of South Dakota to Yellowstone and the Tetons. During alumni reunion weekend he will again lead "Williams Rocks," a geological tour of the campus to see what the college is built "in, on, and of."

Class of 1960 Scholars in Geosciences

Claudia Corona	Gabriel Lewis	Michelle Paradis
Christopher Elliott	Ian Nesbitt	David Rapp
Johnny Ray Hinojosa		

GEOSCIENCES COLLOQUIA

Dr. Daniel Fornari, Woods Hole Oceanographic Institute
     "New Insights into Mid-Ocean Ridge and Arc Volcanic and Hydrothermal Systems"

     "Exploring Inner Space – Deep Ocean Science and Engineering in the 21st Century"

Dr. Will Ouimet '01, University of Connecticut
     "Not So Fast: Slow Erosion and Low-Relief Topography in the Southern Central Range, Taiwan"

Dr. David Jones, Amherst College
     "Glaciation, Extinction, and Microbes: Sulfur Isotopes from the Ordovician-Silurian Boundary"

Dr. Peter Howd '79, U.S. Geologic Survey
     "Geoscientists Loose in Society: Some Tips for Success"

Dr. Caleb Fassett '02, Mt. Holyoke College
     "Erosion, Sedimentation and Landform Evolution on Mars"

Matt Art '00, e4sciences
     "Rewarding Geoscience Careers: Environmental Engineering"

Dr. Sara Pruss, Smith College
     "Life After Snowball: A New Record of Eukaryotes from the Neoproterozoic of Namibia"

Dr. Brandon Dugan, Rice University
     "Origin, Evolution, and Impacts of Large Submarine Landslides"

GEOSCIENCES STUDENT COLLOQUIA

Will Wicherski '15
> "Causes and Consequences of Norwegian Oil"

Miranda Bona '13
> "Distribution of Permeability in a Complete Section of Upper Oceanic Crust: IODP Hole 1256D"

Claudia Corona '13
> "Geochemical Response of Two Adjacent Alpine Streams, Green Lakes Valley, in a Low-Snow Year"

Johnny Ray Hinojosa '13
> "Geochemistry and Geothermometry of Mid Miocene to Pliocene Alkalic Rocks of the Powder River
> Volcanic Field"

Gabriel Lewis '13
> "Using Geophysical Techniques in the Critical Zone to Determine the Presence of Permafrost"

OFF-CAMPUS COLLOQUIA

Rónadh Cox
> "Tracking 20th Century Lavaka Development in Central Madagascar Using Air Photo and
> Satellite Image Analysis"
> Geological Society of America Annual Meeting, November 2012

> "Investigating the Role of Bedrock Geology and Slope in Controlling Lavaka (Gully) Distribution
> in Central Madagascar"
> Geological Society of America Annual Meeting, November 2012

Lisa Gilbert
> "Geologic Evolution of the Hawaiian Islands"
> Pine Point School, February 14, 2013

> "The Oceanography of Whales and Whaling"
> Mystic Seaport, Education and Interpretation Education, February 26, 2013

> "Hurricane Hazards and Risks: Module Development"
> Carleton College, InTeGrate Meeting, May 21, 2013

Markes Johnson
> "Coastal Dunes with Carbonate Content Dominated by Rhodolith Debris from the Pleistocene of Maio and
> São Nicolau (Cape Verde archipelago)"
> Fourth International Rhodolith Workshop (Granada), Sept. 19, 2012

> "Charles Darwin and Pleistocene Onlaps of Rhodolith Limestone Against Rocky Shores Around Santiago
> Island (Cape Verde archipelago)"
> Fourth International Rhodolith Workshop (Granada), Sept. 19, 2012

> "North American Turnover from Mollusk-Dominated Depauperate Zone (Late Ordovician) to Brachiopod-
> Dominated (Early Silurian) Faunas"
> Project 591 Annual Meeting, Lund University, Sweden, June 11, 2013

Paul Karabinos

     "Digital Geology Speed-Dating: an Innovative Coupling of Interactive Presentations and Hands-On Workshop (Digital Posters)"
     Geological Society of America Annual Meeting, November 2012

     "Dynamics Of Gneiss Domes, Core Complexes, And Orogenic Plateaux"
     Geological Society of America Annual Meeting, November 2012

R. A. Wobus

     "500 Million Years of Local Geological History in About an Hour"
     Northern Berkshire Mineral Club, North Adams, MA

Gabriel M. Lewis '13

     "Using Geophysical Techniques in the Critical Zone to Determine the Presence of Permafrost"
     Geological Society of America Annual Meeting, November 2012

Ian M. Nesbitt '13

     "A Comparative Study of Snowmelt-Driven Water Budgets in Adjacent Alpine Basins, Niwot Ridge, Colorado Front Range"
     NE Geological Society of America Meeting, March 2013

POSTGRADUATE PLANS OF GEOSCIENCES MAJORS

Miranda L. Bona	Environmental consultant at Iris Environmental, Oakland, CA
Claudia R. Corona	On to the next great adventure!
Christopher M. Elliott	Field camp at YBRA; undecided
Johnny R. Hinojosa	Pursuing a career in the oil and gas industry
Gabriel M. Lewis	Leading backpacking and sea kayaking trips in Alaska for Overland this summer; teacher's assistant for Frontier's Study Abroad in New Zealand this winter; hiking entire length of Pacific Crest Trail spring and summer 2014; graduate school for geophysics fall 2014
Bryce A. Mitsunaga	YBRA field camp this summer; undecided
Ian M. Nesbitt	Summer field research with D. Dethier in Colorado; undecided
David M. Rapp	Unknown
Sarah E. Rowe	Analyst in the distressed corporate debt investment division of Guggenheim Partners, New York

MATHEMATICS AND STATISTICS DEPARTMENT

Our dear colleague, teacher, and friend, Professor Olga R. (Ollie) Beaver, who passed in December, was a mainstay of our department and the College. For founding and sustaining the Summer Science Program for admitted students from varied backgrounds and much more, Ollie received the second national Louise Hay Award of the Mathematical Association of America in 1991. We have created an annual Olga R. Beaver Prize in Mathematics for a student for contributions to our department. Ollie's Memorial Minute delivered by Prof. Susan Loepp at the February faculty meeting may be found at: http://math.williams.edu/professor-beavers-memorial-minute/

Former Professor Edward B. Burger is the new President of Southwestern University. He received an honorary degree at Commencement here. We also bid farewell to our visiting faculty, Andrey Glubokov, Mark Mixer, and Matt Gardner Spencer. Satyan Devadoss has been promoted to Full Professor.

Our student Putnam Exam team, Carlos Dominguez '13, Jared Hallett '14, and Wei Sun '13, coached by Prof. Steven Miller, placed in the top twenty for the third year in a row. Vu Le '14, Heidi Chen '14, Michael Flynn '15, and Yang Lu '14, advised by alum Ted Murphy and Prof. Frank Morgan, took second place in the CQA Investment Challenge. Zhang Qiao '13, Roshan Sharma '13, and Wei Sun '13 received honorable mention in COMAP's Mathematical Contest in Modeling. Williams defeated Middlebury in the annual Green Chicken mathematics competition, with top scorers Jared Hallett '13, Samantha Petti '15, and first years Jack Bequeaith '16 and Sam Donow '16, coached by Prof. Miller. Jared also won a Goldwater Scholarship.

We are now one of the largest departments in the College, with a record 68 new junior majors, tied for second with English, behind only Economics (87). We have 31 students in our SMALL research program this summer, just behind last year's record 33.

On April 6, 2013, some 500 mathematicians, students, and friends attended the Hudson River Undergraduate Mathematics Conference, which was back at Williams for its 20th anniversary It was organized by Professors Allison Pacelli and Mark Mixer. The invited address was given by Professor Manjul Bhargava of Princeton, introduced by Zane Martin '13. There were over 200 other talks including 60 by Williams students.

Over one hundred local 10th graders attended our annual MathBlast, dedicated this year to the memory of founder Prof. Beaver. Students and teachers each chose three thirty-minute workshops by Williams faculty, ranging from statistics to the shape of the universe.

We hired two new assistant professors: statistician Briana Heggeseth, a new PhD from UC Berkeley, interested in applications to public health, and applied mathematician Julie Blackwood, from a post-doc at Michigan, interested in applications to ecology. We also appointed new visiting assistant professors Michael Biro, Holley Friedlander, and Ed Hanson.

We are very proud of the accomplishments of our majors. The Rosenburg Prize for outstanding senior was awarded to Carlos Dominguez '13 and James Wilcox 13. Erich Trieschman '13 received the Goldberg Prize for best colloquium, on the best strategy for finding your way out of a forest. Will Speer '13 received the Wyskiel Award in teaching. Carson Eisenach '14 received the Morgan Prize in applied mathematics, and Marty Clarke '14 received the Morgan Prize in teaching. Faraz Rahman '14 received the Kozelka Award for outstanding student of statistics. Zane Martin '13 received the new Beaver Prize for department service. Benjamin Demeo '15 and Samantha Petti '15 received 1st and 2nd Benedict Prizes for outstanding sophomore. Carlos Dominguez '13 and Jared Hallett '14, members of our recent top-20 Putnam teams, received the Witte Problem Solving Prize. Joy Jing '13 and James Wilcox '13 received the colloquium attendance prize. Incidentally, Wilcox also received a National Science Foundation graduate fellowship, and Alec Tunnel-Greaves '13 a Herchel Smith fellowship.

We would like to thank the Students of Mathematics and Statistics Advisory Board (SMASAB): Craig Corsi '14, Philippe Demontigny '14, Katy Golvala '13, Alec Greaves-Tunnell '13, Jared Hallett '13, Joy Jing '13, Zane Martin '13, Sandra Shedd '13, Kirk Swanson '14, Philip Tosteson '13, Samuel Tripp '14, and James Wilcox '13.

Professor **Colin Adams** was on leave for the 2012-13 academic year. In summer, 2012, he worked with six students and one postdoc on knot theory as part of the SMALL undergraduate research program. They proved that every knot can be placed into a projection that resembles

a daisy, called a petal projection. Numerous open questions are generated by this fact, which should prove fruitful for many future research groups. Adams co-organized the UnKnot Conference II in July, at Denison University, an undergraduate knot theory conference, and received an NSF grant to support the conference.

Adams gave talks at a variety of institutions, including the Oberwolfach Research Institute in Germany at a conference on physical knot theory. At the Joint Meetings in January in San Diego, he co-presented a minicourse on teaching an applied topology course. He also produced and performed in mathematical theater at the meetings.

Adams served as co-principal investigator on an NSF grant that funds regional undergraduate math conferences around the U.S. He began his term as an advisory board member for the GTM and UTM series of Springer-Verlag and served on the editorial board of both *Involve* and the *Journal of Knot Theory and its Ramifications*. He is currently chair of the George Polya Lecturer Committee and chair of the Frank and Brennie Morgan Undergraduate Research Award Committee.

Professor **Satyan Devadoss** had a wild and crazy year. His research is in the areas of topology and geometry, on which he gave several invited talks from coast-to-coast. He was an organizer for the Mathematics Research Community on Discrete and Computational Geometry, a week-long research group which met at Snowbird, Utah. For his contributions, Devadoss was honored as an inaugural Fellow of the AMS this year.

With students, he supervised a SMALL research group on Phylogenetics in summer 2012, taking them to Ohio State for a mathematics conference. His work with Hayley Brooks '12 and Kaison Tanabe '13 resulted in a major-career graphic on Williams alums which was cited by Forbes, Kiplinger, Business Insider, Washington Monthly, and others. Devadoss also appeared on a few radio shows as well (in Vermont and Chicago), which were surreal experiences.

On the Williams front, Professor Devadoss chaired the hiring committee for the department, along with serving on the CEP, and the Committee on Technology in Education. He gave several talks, to Williams alums, to neighboring schools, at WCMA, and to general audiences, including speaking at Daring Change, the tribute to President Jack Sawyer. He's looking forward to his sabbatical next year at Stanford.

Dick 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. He advised Ben Seiler '13 and Jack Ervasti '13 on their theses and co-advised Chris Picardo '13 on his. He continued serving as the representative of the Council of Sections to the Board of Directors of the American Statistical Association. He also took 10 students to France in January for his Winter Study course "The History, Geography and Economics of the Wines of France (MATH 25)."

Professor **Thomas Garrity** spent the year at the University of Michigan at Ann Arbor while on sabbatical. He continued his research in number theory. His book *Algebraic Geometry: A Problem Solving Approach*, with co-authors Richard Belshoff, Lynette Boos, Ryan Brown, Carl Lienert, David Murphy, Junalyn Navarra-Madsen, Pedro Poitevin, Shawn Robinson, Brian A. Snyder and Caryn Werner, was published by the American Mathematical Society in February. 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). His book *Electricity and Magnetism for Mathematicians: A Guided Path from Maxwell to Yang-Mills*, has been accepted for publication by Cambridge University Press. He spent most of July of 2012, as he will for July 2013, at the Park City Mathematics Institute (PCMI) in Park City, Utah, as a member of PCMI's steering committee. In July he gave a talk at PCMI. In October, he gave two talks at Hillsdale College. Also in October, he gave a talk in the University of Michigan's Geometry and Physics seminar, while in December he gave a talk in the University of Michigan's algebraic geometry seminar. In January he spoke in the continued fractions special session at joint meetings of the AMS-MAA in San Diego. In February he spoke at Penn State, The Behrend College. In March he presented, with Colin Adams, The Great Pi/E Debate and gave a colloquium lecture at the University of North Carolina at Asheville. In April, he gave two talks at the University of Toledo, one in the several complex variables seminar and the other in the department colloquium. He also spoke in April at the University of Michigan at Flint.

Professor **Stewart Johnson** continues his research in dynamical systems, modeling, and optimal control. He is currently developing computational methods for optimal control problems, and investigating massively parallel computing platforms. Prof. Johnson took over as chair of the Mathematics and Statistics Department this year.

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

Associate Professor **Bernhard Klingenberg** was

co-presenter in a two-day short course on ordinal categorical data modeling at the Deming Conference in Atlantic City and at the Joint Statistical Meetings in San Diego, where he also gave an invited talk on simultaneous inference with binary data. He presented a similar talk at the Statistics Department of the University of Milan in Italy. During the year, Prof. Klingenberg published on the topic of computers in education and, together with Ville Satopää '11, a paper on comparing margins for multivariate binary data that appeared in Computational Statistics and Data Analysis. He presented lectures on analyzing 2x2 contingency tables and on related topics at Colby College and at various occasions at Williams. Prof. Klingenberg continued to serve as a statistical consultant for the pharmaceutical industry and small businesses around the US and locally for students and faculty at Williams. For the Williams MathBlast event for high school students, Prof. Klingenberg gave a talk on whether one can distinguish if milk or tea was poured first into a cup.

Professor **Susan Loepp** continued to enjoy her research in commutative algebra. In the last year, she had two papers accepted into refereed mathematics research journals, both papers joint with undergraduate students. She also advised the senior honors thesis of Philip Tosteson '13.

Loepp served as the 2013 SMALL director. In November 2012, Loepp attended the Field of Dreams conference in Phoenix, Arizona. The FOD conference is particularly aimed at underrepresented minorities in the mathematical sciences. At the conference, Loepp served on a panel for directors of summer mathematics programs, and set up and manned a table for SMALL at the REU fair. In January, Loepp attended the National Mathematics Meetings in San Diego, where she enjoyed attending research talks in commutative algebra.

Associate Professor **Steven Miller** was glad to return from sabbatical, teaching Probability and Linear Programming in the fall, two sections of Multivariable Calculus in the spring, winter studies on cryptography and (joint with Professor Strauch in Physics) Star Trek, as well as independent studies both semesters. He supervised Joy Jing's, '13 thesis on Benford's law, co-supervised (with Professor De Veaux) Chris Picardo's '13 thesis on PITCHf/x and clustering, was the second reader for Scott Sanderson's '13 thesis on computability, and had 9 summer REU students. He continued his research in number theory, random matrix theory, probability and other fields, with 9 papers appearing in print, several more accepted, and with his students gave over 30 talks, including the keynote address to the Massachusetts Math

Teachers Association. 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 'A-ha' moments in math and science to junior high and high school teachers in the Teachers as Scholars program, has written several modules on mathematics and computation for high school units, and has finished or had 4 books go under contract.

Students in Professor Miller's Math 416 did projects; the picture above is from Greg Eusden '13, Mike Ormsbee '13, Alex Rich '13, Will Speer '13 and Alex Wheelock '13, who found the cheapest diet available through PeaPod meeting the US RDA.
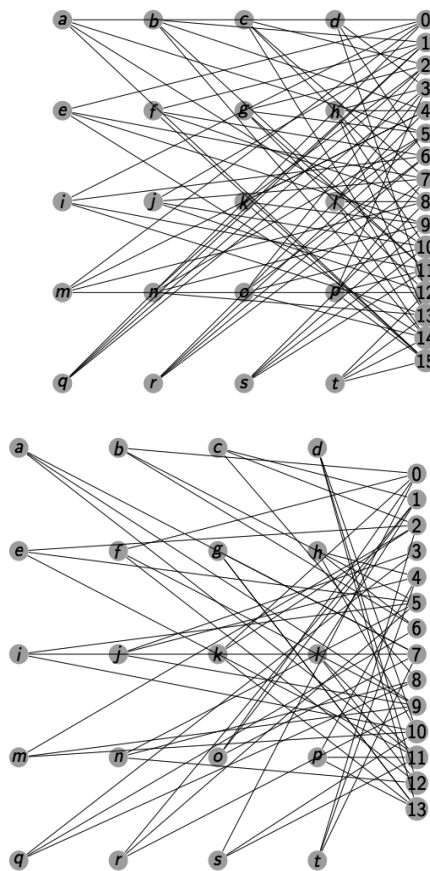
The above graphs solve a real world scheduling problem, solved by Miller's spring independent study on linear programming (Carson Eisenach '14, Victor Luo '14, Caroline Miller '14 and David Stevens '14). The assignment came from a school district which needed to schedule teams and judges for a debate tournament. The left is the team assignment, the right the judges. We proved you

need at least 13 judges and found a feasible solution using just 14 (the district's solution required 16).

Professor **Frank Morgan** is continuing his study of minimal surfaces, densities, and tilings with a number of collaborators and his undergraduate research Geometry Group.

Associate Professor **Allison Pacelli** continued her research in algebraic number theory. She developed and taught a new course for non-majors called The Beauty of Numbers, and is writing an accompanying text. Pacelli has also become involved in professional development for elementary and secondary school teachers as part of the new Common Core Curriculum that has been adopted in most states. She volunteered at the Williamstown Elementary School in October, and introduced teachers there to Singapore Math.

Pacelli was the Chair of the Steering Committee for the 20th Annual Hudson River Undergraduate Mathematics Conference (HRUMC), which was hosted at Williams College on April 6, with over 200 talks in nearly 20 parallel sessions. Over 400 students and faculty from over 40 institutions attended the conference. Manjul Bhargava gave the keynote address.

Pacelli was the recipient of an MAA Dolciani Mathematics Enrichment Grant to begin a new one-week math camp at Williams for mathematically gifted high school students. The first year of the Williams College Math Camp will take place on campus in July 2013.

Professor **Cesar Silva** started the summer as director of the SMALL program, where he supervised a group of six students in research in ergodic theory, and also taught in the Summer Science Program. He also co-organized a conference at Williams in Ergodic Theory, funded by an NSF grant, the Hagey Family Chair and by the Dean of the Faculty's office. There were 16 speakers including speakers from France, Israel, Mexico, Poland, South Korea, and Ukraine. Two of his undergraduate research students gave talks at this conference.

In the academic year he taught Real Analysis, where he used a draft of the book he is writing, *Chaos and Fractals, and Topology*.

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."

Silva gave several talks including the mathematics colloquium at the University of North Carolina in November.

He was a member of the Review Committee of the Mathematics Department at City College New York. He published a paper in Nonlinearity coauthored with his students and based on research in the SMALL program, and submitted other works that are in the process of being reviewed.

Associate Professor **Mihai Stoiciu** spent his sabbatical year at the University of Wisconsin Madison, where he worked on projects in Approximation Theory and Probability. At Madison, Stoiciu gave two seminar talks and two colloquia and participated in the Analysis and Probability Seminars, as well as in the RTG Seminar on mathematical fluid mechanics and applications.

During the year, Stoiciu was invited to give scientific talks at the Institute for Mathematics and Applications Minneapolis, at the 9th AIMS Conference on Dynamical Systems, Differential Equations and Applications in Orlando, at University of Minnesota, University of Alabama, Queen's University in Kingston Ontario, at Harvard University, and at Michigan State University. During February and March, Stoiciu visited several research institutions in Europe and gave talks at Ludwig-Maximilians University in Munich, Germany, at Institut de Mathematiques de Bordeaux, Bordeaux, France, and at Universite de Cergy-Pontoise, Cergy-Pontoise, France.

In May 2013, Stoiciu participated, as a member of the AMS Menger Prize Committee in the International Science and Engineering Fair (ISEF) and was also a member of the Special Judging Team, which awarded the 2013 Intel ISEF Grand Awards. After a year of traveling to several research institutions and conferences, Stoiciu is excited to return to Williams College in July 2013.

Assistant Professor **Qing (Wendy) Wang** just completed her first year at Williams College, and she has been greatly enjoying her life at Williams. She taught two sections of Intro Stats (STAT 101) in the fall semester and an upper-level Bayesian Statistics course (STAT 341) in spring. During the past year, she continued her collaboration with Dr. Bruce Lindsay from Penn State University and resubmitted a paper on U-statistics and cross validation to *Statistic Sinica*. She presented her completed research work at the Joint Statistical Meetings in August 2012 and the Eastern North American Region (ENAR) spring meeting in March 2013. In addition, she is finishing up a paper on kernel density estimation. She is going to present her newly conducted research as an invited speaker at the IMS-China International Conference on Statistics and Probability which will take place this summer in Chengdu, China.

MATHEMATICS COLLOQUIA

Colin Adams, Williams College
  "Triple Crossing Number of Knots"

  "Arts and Crafts 101: How to Tie Knots into Flowers"

  "Volumes of Hyperbolic Knot Complements"

  "Turning Knots Into Flowers"

Timothy Austin, New York University
  "Partial Difference Equations Over Compact Abelian Groups"

Elizabeth Beazley, Williams College
  "Core Partitions, Alcoves, and the Affine Grassmannian"

Vitaly Bergelson, Ohio State University
  "Combinatorial Richness of Multiplicatively Large Sets"

Manjul Bhargava, Princeton University
  "How Likely is it for a Polynomial to Take a Square Value?"

Julie Blackwood, University of Michigan
  "Rabies Transmission Dynamics Among Vampire Bats in Peru"

Ryan Blair, University of Pennsylvania
  "Big Problems in Splicing Knots"

Andrew Bray, University of California, Los Angeles
  "Tectonics and Tessellations: Residuals for Spatial Point Processes"

Satyan Devadoss, Williams College
  "Posets and Polytopes"

  "Tapping into Curiosity"

  "Understanding the Grid"

  "MathBlast"

  "Daring Change: Honoring Jack Sawyer"

Matthew Gardner Spencer, Williams College
  "The Nottingham Group"

Courtney Gibbons, University of Nebraska
  "A Variety of Ways to Solve a Problem"

Andrey Glubokov, Williams College
  "Quantum Plane"

Brianna Heggeseth, University of California, Berkeley
  "Calculated Clustering-An Application to Childhood Growth Trajectories"

Bernhard Klingenberg, Williams College
  "On a Null Variance Estimator for the Mantel-Haenszel Risk Difference"

Sarah Koch, Harvard University
"Matings of Polynomials"

Kathryn Lindsey '07, Cornell University
"Fractal Cats and the Endless Possibilities for Julia Sets"

Susan Loepp, Williams College
"Characterizing Generic Formal Fibers"

"Completions of Hypersurface Domains"

"Using Algebra to Protect Your Personal Information"

"Completions and Polynomial Rings"

Steven Miller, Williams College
"From Random Matrix Theory to L-Functions"

"Mind the Gap: Distribution of Gaps in Generalized Zeckendorf Decompositions"

"Cookie Monster Meets the Fibonacci Numbers. Mmmmmm -- Theorems"

Mark Mixer, Williams College
"Symmetric Tessellations of Flat Manifolds"

"Symmetric Polytopes: A Combinatorial Viewpoint"

Frank Morgan, Williams College
"Tilings and Isoperimetric Problems"

"Optimal Pentagonal Tilings"

"The Soap Bubble Geometry Contest"

"My Huffington Post Blog"

"Convex Body Isoperimetric Conjecture"

Entrance to the science atrium and Schow Science Library.

65

Jill Pipher, Brown University
    "Mathematics and Computers: Amazing Interactions Old and New"

Michael Rosen, Brown University
    "Class Groups in Cyclic p – Extensions of Number Fields"

Alexei Rybkin, University of Alaska, Fairbanks
    "What Do Tsunami Waves and Quantum Mechanics Have in Common?"

Cesar Silva, Williams College
    "Mu-Compatible Metrics and Notions of Measurable Sensitivity"

    "On Notions of Measurable Sensitivity"

    "Examples of Ergodic and Mixing Maps on the P-adics"

    "Fractals and Natural Shapes"

Qing Wang, Williams College
    "Cross-Validation and a U-statistic Model Selection Tool"

    "Using the Median Can Be Dangerous"

    "Kernel Density Estimation"

MATHEMATICS STUDENT COLLOQUIA BY 2013 GRADUATES

Liam Abbott '13
    "The EM Algorithm: Using Hidden Variables to Find MLEs"

Elise Baker '13
    "Calculating Power in Multicameral Voting Systems"

Dhyan Adler-Belendez '13
    "The Infinitude of Primes and Bertrand's Postulate"

Andrew Bishop '13
    "College Football Rankings: Using Directed Networks and Random Walks to Solve the Dilemma of a Multi-Billion Dollar Industry"

Kyle Bolo '13
    "Picking up Where the Greeks Left Off: Confronting the Unsolved Geometrical Questions of Their Time"

Ryan Brand '13
    "Evolutionary Dynamics and Universal Grammar"

Lucas Casso '13
    "Convex Polytopes in Higher Dimensions"

Christopher Corbett '13
    "Swimming Upstream: The Benefits of Fish Schooling"

Evan DeDominicis '13
    "Game Theory, Fixed Points, and Football?"

Tara Deonauth '13
    "How to Guard an Art Museum"

Carlos Dominguez '13
    "Quaternions and Lagrange's Four-Square Theorem"

Jack Ervasti '13
    "Using Convexity to Approximate Bond Price Change"

Gregory Eusden '13
>"History and Concepts Behind the Max-Flow, Min-Cut Theorem in Graph Theory"

Kushatha Fanikiso '13
>"Mathemagic: What Happens at the Intersection Between Magic and Math?"

Jalynne Figueroa '13
>"Authentication in the Digital Age"

Christopher Fogler '13
>"Curve Reconstruction: From Triangles to Pixar"

Jeffrey Fossett '13
>"Introduction to Latent Semantic Analysis"

Kevin Garcia '13
>"God's Number: Fewest Moves to Solve the Rubik's Cube"

Katy Golvala '13
>"Intervention Analysis and Its Applications"

Jennifer Gossels '13
>"Linear Programming and Baseball Elimination Numbers"

Alexander Greaves-Tunnell '13
>"Elliptic Curve Cryptography"

Yiming Guo '13
>"Optimizing Blackjack Playing Strategy With 'Lucky Bucks'"

Charles Hammond '13
>"An Introduction to Survival Analysis"

Wen Han '13
>"Buffon's Needle"

Julian Hess '13
>"The Exterior Algebraic Formulation of Maxwell's Equations"

Kam Shan Ho '13
>"Hall's Marriage Theorem and Matchings in Graphs"

Joy Jing '13
>"Magic and Math: Seeing Through Lies"

Casey Jones '13
>"Lottery Tickets, Green Cards, and Random Generators"

Daeus Jorento '13
>"The U.S. Treasury, Ebay and Craigslist: Auctions and the Revenue Equivalence"

Andrew Kelly '13
>"Kronecker's Theorem and the Question of the Reflected Ray"

Christina Knapp '13
>"Curvature"

Meghan Landers '13
>"The Infinitude of Primes"

Shirley Li '13
>"Extensions to the Carpenter's Rule Conjecture"

Joe Long '13
>"From Counting Eggs to Keeping Secrets: How the Chinese Remainder Theorem Can Help You"

Guannan Lu '13
 "The Friendship Paradox"

Julio Luquin '13
 "Land Ho! Choosing the Perfect Map"

Zane Martin '13
 "Elementary, My Dear Bertrand"

Madeleine Mitchell '13
 "Cooperation Within Competition: Match-Rigging in Sumo Wrestling"

Becky Miller '13
 "Congruent Numbers: From Right Triangles to Elliptic Curves"

Eugene Murphy '13
 "What Are the Chances? Using Bayesian Statistics to Estimate a Proportion"

Kristine Nakada '13
 "Topology and Combinatorics of the Soccer Ball"

Nicholas Neumann-Chun '13
 "Life: Discrete or Continuous"

Mai Okimoto '13
 "Tetrahedra in Polyhedra"

Michael Ormsbee '13
 "A Brief Introduction to Elliptic Curves"

Christopher Picardo '13
 "Order Statistics and the German Tank Problem"

Tejesh Pradhan '13
 "The Wallet Paradox"

Alexander Rich '13
 "Four Degrees of Separation: Small World Networks and Why They Matter"

Eric Robinson '13
 "The Fitch and Sankoff Algorithms for Plant Phylogenies"

Scott Rodilitz '13
 "A Two Card Cover-Up Game"

Chance Rueger '13
 "Pythagoras at the Bat"

Scott Sanderson '13
 "Hilbert's Nullstellensatz: An Introduction to Algebraic Geometry"

Roshan Sharma '13
 "The Weierstrass Representation Always Gives a Minimal Surface"

Benjamin Seiler '13
 "Fractals in Finance: Price Jumps and a Peculiar Smile"

Sandra Shedd '13
 "Lost in the Woods: Phylogenetic Trees, Splits, and Applications"

April Shen '13
 "Of Groups and Graphs"

William Speer '13
 "Musical Actions of Dihedral Groups"

Wei Sun '13
    "Twenty Questions, Huffman Code and Youtube"

Kaison Tanabe '13
    "Sponges (Coxeter-Petrie)"

David Taylor '13
    "Machine Learning and Bootstrap Random Forests"

Philip Tosteson '13
    "Counting Primes (L-Functions)"

Philip Treesh '13
    "Chaos, Waterwheels, and the Lorenz Equations"

Erich Trieschman '13
    "Lost in a Forest"

Thomas Vieth '13
    "Traffic Flow"

Rhys Watkins '13
    "A Proof of Sphere Packing in 2D"

Peter Watson '13

    "The Two Envelopes Paradox: Is There a Correct Solution"

Alexander Wheelock '13

    "A Lattice-Based Cryptosystem for a Quantum Force"

James Wilcox '13
    "Sequences of Convergents of Continued Fractions"

Off-Campus Colloquia

Colin Adams

    "Blown Away: What Knot To Do When Sailing"
    Museum of Mathematics Math Encounters Series, New York City
    Sampson Lectures, Bates College
    University of Michigan
    Mathematical Theater, Ohio MAA Sectional Meeting, Denison University

    "Why Knot Workshop"
    Museum of Mathematics Math Encounters Series, New York City

    "Triple Crossing Number for Knots"
    Unknot Conference II, Denison University, Granville, OH
    Sampson Lectures, Bates College

    "Turning Knots into Flowers"
    University of Tennessee, Knoxville, TN
    Oberwolfach, Germany

    "How to Make Math Fun"
    University of Tennessee, Knoxville, TN

    "Petal Number for knots and Links"
    Columbia University

    "Why Knot"
    University of Michigan

    "The Great Pi/e Debate"

Parsons Lecture, University of North Carolina

"Mathematically Bent Theater"
Joint Mathematics Meetings, San Diego, CA

"Research with Undergraduates Panelist"
Joint Mathematics Meetings, San Diego, CA

"Applied Topology Minicourse"
with Robert Franzosa, Joint Mathematics Meetings, San Diego, CA

Satyan Devadoss

"REU Conference, Keynote Speaker"
Mount Holyoke College

"Martha Davenport Heard Lecture"
Wellesley College

"AMS Session in Discrete Geometry of Polytopes"
"AMS Session in Moduli Spaces in Algebraic Geometry"
Boston College

 "Computational Geometry Seminar"
University of Utah

 "Veritas Forum"
Ohio State University
University of Utah

Richard De Veaux

"JMP Explorers' Series: Exploring Interactive and Visual Data Mining"
Salt Lake City, Utah
Portland, Oregon
Orlando, Florida

 "JMP Explorers' Series: Effective Graphics Displays for Decision Making"
Washington, DC

"Presentational Skills Workshop"
Joint Statistics Meeting, San Diego, CA

"Workshop on Successful Data Mining"
Intel Corporation, Portland, OR
MAA Math for America Workshop, New York City

"What Data Mining Teaches Me About Teaching Statistics"
Pioneer Statistics Meeting, Lexington, KY
Decision Sciences Institute, San Francisco, CA

"Data Mining: Fool's Gold? Or the Mother Lode?"
Halmos Lecture, MAA, Washington, DC
Williams Alumni Talk, Ponte Vedra, FL
Williams Alumni Talk, Vero Beach, FL
Loeb Lecture, Washington University
Banquet Keynote, Kappa Mu Epsilon National Meeting, Topeka, KS
ASA Webinar
Union College

"Play it Again Sam: Resampling and Simulation in Business Statistics"
DSI Conference, Charleston, NC

Thomas Garrity

"On Factoring Polynomials"
Park City Mathematics Institute

"Using Physics to Understand Numbers"
Hillsdale College

"Mathematics is Truth: Or Is It?"
Hillsdale College

"On a Thermodynamic Classification of Real Numbers"
Geometry and Physics Seminar, University of Michigan, Ann Arbor
University of Toledo

"On the Hermite Problem and Multi-Dimensional Continued Fractions"
Algebraic Geometry Seminar, Ann Arbor

"Cubic Irrationals and Periodicity Via A Family of Multi-Dimensional Continued Fractions"
Continued Fractions Special Session, AMS-MAA Joint Meetings, San Diego, CA.

"On Writing Numbers"
Penn State, The Behrend College
University of North Carolina, Asheville

"The Great Pi/E Debate"
with Colin Adams, Parsons Lectures, University of North Carolina, Asheville

Bernhard Klingenberg

"Ordinal Categorical Data", two-day Short Course with Alan Agresti
Joint Statistical Meeting, San Diego, CA
Deming Conference on Applied Statistics, Atlantic City, NJ

"Simultaneous Inference for Dose Selection with Binary Responses"
University of Milan
Joint Statistical Meetings, San Diego, CA

"On Things That Are Thus and So"
Colby College

Susan Loepp

"Protecting Your Personal Information: An Introduction to Encryption"
Abramson Colloquium, Bridgewater State University

Steven Miller

"Eigenvalue Statistics for Toeplitz and Circulant Ensembles"
with Gene Kopp, Murat Kologlu '12 and Karen Shen, Second Institute of Mathematical Sciences Asia Pacific
Rim Meeting, Tsukuba, Japan

"Cookie meets the Fibonacci Numbers. Mmmmmm – Theorems!"
Middlebury College
Wesleyan College
Brown University

"Low-Lying Zeros of Cuspidal Maass Forms"
with Levent Alpoge, Quebec-Maine Number Theory Conference

"Determinantal Expansions in Random Matrix Theory and Number Theory"
with Nicholas Triantafillou, Quebec-Maine Number Theory Conference

"Distribution of Summands in Generalized Zeckendorf Decompositions"
Special Session on Additive and Combinatorial Number Theory, AMS Sectional, Akron, OH
AMS Session on Number Theory, I, Joint Meetings of the AMS.MAA, San Diego, CA

"Most Sets are Balanced in Finite Groups"
Presented by Kevin Vissuet, Special Session on Additive and Combinatorial Number Theory, AMS Sectional, Akron, OH
"Low-Lying Zeros of GL(2) L-Functions"
University of Michigan
AMS Special Session on Arithmetic Statistics, I, Joint Meetings of the AMS/MAA, San Diego, CA
Quebec-Vermont Number Theory Seminar
"Benford's Law, or: Why the IRS Cares About Number Theory"
Brown University

"Distribution of Summands in Generalized Zeckendorf Decompositions"
given by Rachel Insoft and Amanda Bower, MAA General Contributed Paper Session: Research in Number Theory, I, Joint Meetings of the AMS/MAA, San Diego, CA

"Distribution of the Longest Gap in Positive Linear Recurrence Sequences"
given by Shiyu Li and Philip Tosteson '13, MAA General Contributed Paper Session: Research in Number Theory, I, Joint Meetings of the AMS/MAA, San Diego, CA

"When Almost all Generalized Sumsets are Difference-Dominated"
given by Virginia Hogan, MAA General Contributed Paper Session: Research in Number Theory, I, Joint Meetings of the AMS/MAA, San Diego, CA

"When Almost all Generalized Sumsets are Difference-Dominated"
given by Virginia Hogan, CANT

"Coordinate Sum and Difference Sets of D-Dimensional Modular Hyperbolas"
given by Amanda Bower, CANT

"Most Sets are Balanced in Finite Groups"
given by Kevin Vissuet, MAA General Contributed Paper Session: Research in Number Theory, I, Joint Meetings of the AMS/MAA, San Diego, CA

"Determinantal Expansions in Random Matrix Theory and Number Theory"
given by Nicholas Triantafillou, MAA General Contributed Paper Session: Research in Number Theory, II, Joint Meetings of the AMS/MAA, San Diego, CA

"Low-Lying Zeros of Maass L-Functions"
given by Levent Alpoge, MAA General Contributed Paper Session: Research in Number Theory, II, Joint Meetings of the AMS/MAA, San Diego, CA

"Distribution of the Longest Gap in Positive Linear Recurrence Sequences"
given by Shiyu Li and Philip Tosteson '13, MAA General Contributed Paper Session: Research in Number Theory, I, Joint Meetings of the AMS/MAA, San Diego, CA

"Surpassing the Ratios Conjecture in the 1-Level Density of Dirichlet L-Functions"
given by Daniel Fiorilli, AMS Session on Elliptic Curves, L-Functions, and Number Fields, Joint Meetings of the AMS/MAA, San Diego, CA

"Generalized Sum Difference Sets and d-dimensional Modular Hyperbolas"
given by Victor Luo '14 and Amanda Bower, AMS Session on Undergraduate Research in Combinatorics and Number Theory, Joint Meetings of the AMS/MAA, San Diego, CA

"From the Manhattan Project to Elliptic Curves"
Dartmouth College

"Aha Moments in Mathematics (Part I)"
Continuing Education Lectures to Junior High and High School Teachers, Teachers As Scholars Program
Boston, MA

"Aha Moments in Mathematics (Part II)"
Continuing Education Lectures to Junior High and High School Teachers, Teachers As Scholars Program
Boston, MA

"From M&Ms to Mathematics, or, How I Learned to Answer Questions and Help My Kids Love Math"
Keynote Address to the Association of Teachers of Mathematics in Massachusetts, Spring Conference

"Why More is Better: The Power of Multiple Proofs"
Session on High School Mathematics, Association of Teachers of Mathematics in Massachusetts, Spring Conference

"When Almost All Sums are Difference Dominated"
Number Theory Seminar, University of Illinois

"Benford's Law, Values of L-Functions and the 3x + 1 Problem, or: Why the IRS Cares About Number and Ergodic Theory"
Ergodic Theory Seminar, University of Illinois

"Random Matrix Theory and Low-Lying Zeroes of GL(2) L-Functions"
Random Seminar, University of Illinois

"Mind the Gap: Distribution of Gaps in Generalized Zeckendorf Decompositions"
CANT

Frank Morgan

"Isoperimetric Problem with Density"
Granada

"Baserunner's Optimal Path
NEMATYC

"Densities in Geometry, including Isoperimetric Problems and the Poincare Conjecture"
Princeton

"Soap Bubbles and Mathematics"
University of Oklahoma
University of New Haven

"Optimal Pentagonal Tilings"
University of Oklahoma
Fordham University
Moravian College Student Conference
Muhlenberg

"My Huffington Post Blog"
San Diego Joint Mathematics Meetings

"Soap Bubbles, Tilings, and Other Partitioning Problems"
Pitt Michalik Lecture
University of Pennsylvania

"The Log-Convex Density Conjecture"
Lehigh Geometry Topology Conference

Allison Pacelli

"Mathematics & The Common Core"
Williamstown Elementary School Professional Development Series

"Thinking Through the Common Core"
with Ed Burger, Professional Development Series, Monticello Central School District

Cesar Silva

"On Measurable Sensitivity for Nonsingular and Measure-Preserving Systems"
University of North Carolina

"Mixing-Like Notions for Infinite Measure-Preserving Transformations and Conservativity of Products"
AMS Meeting, University of Mississippi, Oxford

"Mixing-Like Notions and Rational Weak Mixing for Infinite Measure-Preserving Transformations"
Carolina Dynamics Conference, University of North Carolina, Chapel Hill

Mihai Stoiciu

"Advances in Random Matrix Theory"
Institute for Mathematics and Applications, Minneapolis, MN

"Dynamical Systems and Spectral Theory"
9th AIMS Conference on Dynamical Systems, Differential Equations and Applications, Orlando, FL.

"Probability Seminar"
University of Minnesota
Harvard University

"Analysis Seminar"
University of Wisconsin
Institut de Mathematiques de Bordeaux, France
Michigan State University

"Probability Seminar"
University of Wisconsin

"Probability and Math Physics Seminar"
University of Alabama

"Free Probability and Random Matrices Seminar"
Queen's University, Kingston, ON, Canada

"Analysis and Probability Seminar"
Ludwig-Maximilians University, Munich, Germany

"Mathematical Physics Seminar"
Universite de Cergy-Pontoise, Cergy-Pontoise, Franc

"Mathematics Colloquium"
University of Alabama

"Math Circle Colloquium"
University of Wisconsin

"Math Club Colloquium"
University of Wisconsin

Qing Wang

"Cross Validation and a U Model Selection Tool"
Joint Statistical Meetings 2012, San Diego, CA
ENAR Spring Meeting 2013, Orlando, FL

"Subsampling and Extrapolation Techniques in Bandwidth Selection"
IMS-China International Conference on Statistics and Probability, Chengdu, China

Postgraduate Plans of Mathematics Majors

Liam Abbott	Unknown
Dhyan Adler-Belendenz	Unknown
Elise Baker	Unknown
Andrew Bishop	Working at the Exeter Group, an IT Consulting firm in Boston, MA.
Kyle Bolo	Working as a Technical Engineer at the Medical Software Company, Epic.
Christopher Corbett	Working at Boston Children's Hospital while applying to medical school
Ryan Brand	Unknown
Lucas Casso	Unknown
Jack Chen	Unknown
Chris Corbett	Unknown
Evan DeDominicis	Unknown
Tara Deonauth	Unknown
Carlos Dominguez	Working as a Trader at Jane Street Capital
Jack Ervasti	Working as an Analyst in the Global Market Solutions Group at Credit Suisse in New York City
Gregory Eusden	Working for a management consulting company called the Parthenon Group in Boston, MA.
Kushatha Fanikiso	Unknown
Jalynne Figueroa	Unknown
Christopher Fogler	Unknown
Jeffrey Fossett	Unknown
Kevin Garcia	Unknown
Katy Golvala	Unknown
Jennifer Gossels	Pursuing a Ph.D. in Computer Science at Princeton University
Alexander Greaves-Tunnell	Reading for a M. Phil. In Computational Biology at Emmanuel College, Cambridge
Danny Guo	Unknown
Charles Hammond	Attending medical school at Wayne State University School of Medicine in Detroit, MI.
Wen Han	Working in investment banking in Hong Kong
Julian Hess	Unknown
Kam Shan Ho	Unknown
Joy Jing	Volunteering with HIV/AIDS outreach in Kenya for the summer, then working for an internet start-up incubator named Cogo Labs in Cambridge as a Quantitative Data Analyst.
Casey Jones	Unknown
Daeus Jorento	Unknown
Andrew Kelly	Unknown
Christina Knapp	Unknown
Meghan Landers	Unknown

Shirley Li	Unknown
Joe Long	Unknown
Guannan Lu	Pursuing a Ph.D. in Organizational Behavior
Julio Luquin	Unknown
Zane Martin	Unknown
Becky Miller	Working at Audax Private Equity Group in Boston, MA.
Madeleine Mitchell	Working as an Associate at Fidelity Capital Markets in Boston, MA.
Eugene Murphy	Unknown
Kristine Nakada	Teaching math and coaching soccer as a UPENN Teaching Fellow at Northfield Mount Herman School, then pursuing a Masters in Education at the University of Pennsylvania
Mai Okimoto	Unknown
Michael Ormsbee	Unknown
Christopher Picardo	Working as a Business Analyst at McKinsey and Co. in Seattle, WA.
Tejesh Pradhan	Unknown
Alexander Rich	Pursuing a Ph.D. in Cognitive Psychology at NYU
Eric Robinson	Unknown
Scott Rodilitz	Teaching high school math and coaching cross country
Chance Rueger	Unknown
Scott Sanderson	Working for a software company in Cambridge, MA.
Benjamin Seiler	Working as an Analyst in the Securities Division at Goldman Sachs
Roshan Sharma	Unknown
Sandra Shedd	Pursuing a Ph.D. in Earth, Atmospheres, and Planetary Science at MIT
April Shen	Pursuing a Ph.D. in Computer Science at the Univ. of Washington
William Speer	Teaching Fellow at Phillips Andover Academy
Wei Sun	Unknown
Kaison Tanabe	Unknown
David J. Taylor	Unknown
Philip Tosteson	Unknown
Erich Trieschman	Consulting for Booz Allen Hamilton in the VA/DC area
Thomas Vieth	Unknown
Rhys Watkins	Consulting in the Cloud Analytics Depart. for Booz Allen Hamilton
Peter Watson	Unknown
Alex Wheelock	Unknown
James Wilcox	Pursuing a Ph.D. in Programming Languages at the University of Washington, Seattle on an NSF Graduate Research Fellowship.

NEUROSCIENCE DEPARTMENT

The neuroscience program at Williams College continues to alter the synaptic connectivity of its concentrators through engaging course work and hands-on research experiences. Our students take courses that exploring topics ranging from the molecular to the social. Students conducting research with neuroscience faculty have explored topics ranging from neurochemical influences on arousal in Drosophila to cultural and genetic influences on social behavior in songbirds.

Administratively, **Noah Sandstrom** has taken over as Chair of the Neuroscience. In October, 2012, Professor Sandstrom was named President of Faculty for Undergraduate Neuroscience (FUN), an international organization committed to neuroscience education and research training at the undergraduate level. In addition, the program was granted its first faculty position, filled by Martha Marvin, Lecturer in Neuroscience. Finally, we are excited to welcome Assistant Professor **Matt Carter** to the program in the fall. Professor Carter uses a variety of sophisticated techniques including optogenetics to study the neural circuitry underlying behavior in rodents.

Thirteen graduating seniors completed the neuroscience concentration in 2013 with seven completing honors thesis. Sierra Germeyan '13 was awarded the Patricia Goldman-Rakic Prize in Neuroscience for 2013.

The Neuroscience Program Class of 1960 Scholars program co-sponsored a variety of speakers during the year. In addition, students participating in the program attended the 13th Annual Symposium of the Center for Neuroendocrine Studies at the University of Massachusetts.

Martha Marvin investigates the role of small heat shock proteins in preventing birth defects. The model organism she uses is the zebrafish, a small tropical fish that develops rapidly. This family of genes protects embryos from environmental stress, but also serves essential developmental roles. Dr. Marvin is particularly interested in the role of a tissue called the yolk syncitial 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.

Reduced levels of two small heat shock proteins, hspb7 and hspb12, cause both left-right asymmetry and heart migration defects in zebrafish embryos. Independent study student Audrey Kwon '13 created many molecular probes to explore the mechanisms by which these two proteins support normal development. Jonathan Wosen '13 showed that the heart valve defects caused by loss of hspb7 depend on processes that happen very early in development, days before the valves actually form.

Dr. Marvin teaches the laboratories for Neuroscience 201 and also taught two lab sections of Physiology, BIOL 205. She advised one honors student and one independent study student this year, along with three research assistants. She again co-taught a Winter Study course called Project BioEyes, which trains Williams students to teach genetics and development, and also engages local 4th and 11th grade students in scientific investigation. This year the program was expanded to Greylock Elementary School in North Adams.

OFF-CAMPUS COLLOQUIA

Martha Marvin

"Cardiac Laterality, Migration and Morphogenesis Depend Upon Small Heat Shock Proteins"

with M.W. Springel, J.E. Wosen, Y. Ji, J. Zuflacht, P. Marin, J. Lahvic, L.D. Hutson, & J. Amack.

Weinstein Cardiovascular Development Conference, Tucson, AZ. May 2013 (poster)

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 remarks, "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."

Twenty-one Physics and Astrophysics majors graduated in June. Seven will begin graduate work in science or math, two will be conducting science research, and three will teach chemistry, astronomy and geophysics. This proves again what good preparation these majors are for many professions.

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

In Fall 2012, Williams hosted the New England Section meeting of the American Physical Society. This brought one hundred and forty-six researchers and teachers to campus for a wonderful event featuring the latest from the Large Hadron Collider, nanoscale devices, and quantum information. MIT's Seth Lloyd also provided an entertaining dinner talk on quantum mechanics entitled, "Quantize This!"

Lawrence Krauss also visited in February to talk about his best-selling book, "*A Universe from Nothing*".

Professor Bill Wootters presented a Faculty Lecture "Why the Universe likes the Square Root of Negative One." And the colloquium series brought back Drs. Nathan Hodas '04, Rob Cooper '06, and Andrew Speck '00. In addition to talking about their research, they also met with students to discuss the paths of their careers.

Professor and Chair **Daniel Aalberts** developed and offered a new tutorial course called Facts of Life (PHYS 231T) exploring birth, death, sex, cities, language, networks, complex systems, and growth with computational and statistical methods. In the spring, he taught Computational Biology (PHYS/CSCI 315).

In the Aalberts Lab, Julian Hess `13 worked on the BindigoNet algorithm to compute net RNA binding free energy, including the mean unfolding costs of the target mRNA. Aalberts also continues to collaborate with John Hunt (Columbia Univ) on methods to enhance gene expression.

Emeritus Professor **Stuart Crampton** gave several talks to students and church groups about the relationship of science to religion. He continues to serve as a scientific consultant to the Murdock Trust, a foundation supporting science in the five northwest states. He is an Emeritus Director of Research Corporation for Science Advancement, America's oldest foundation devoted exclusively to science.

Professor **Kevin Jones** continues a close association with the Laser Cooling and Trapping Group at the National Institute of Standards and Technology (NIST) in Gaithersburg, MD. Working with NIST scientists he published a paper in Physical Review Letters, the section of one of the major international physics journals reserved for results of particular interest and importance. The paper describes the scientific demonstration of a novel optical image amplifier. Quantum mechanics places limits on the minimum amount of noise that any amplifier must add to a signal. The arrangement that Jones and colleagues describe "hides" that unavoidable quantum noise in a part of the signal that is not important for image amplification and thus the amplifier is effectively "noiseless." The principle of such an amplifier has been understood for some time and demonstrated for simple patterns of a dot or two. The novelty of their implementation is that the amplifier can operate on a complex image. While still far from a practical device for everyday use, this work is a demonstration that it is possible to construct such a device under laboratory conditions.

The work of Jones and his NIST colleagues was the subject of two news articles in the scientific press. Each week the editors of The Physical Review select a few papers that they judge to be of particular importance and intrinsic interest and highlight these in the online news publication Physics: Spotlighting Exceptional Research. Jones's work was selected as one of the spotlighted articles in July. The editors of the interdisciplinary science journal *Nature* invite experts to write short News and Views articles describing selected scientific advances to a general scientific audience. The noiseless optical amplifier developed by Jones and his colleagues was the subject of a November News and Views article.

Assistant Professor **Ward Lopes** taught Quantum Physics (PHYS 301) in the fall and Foundations of Modern Physics (PHYS 142) in the spring. This past year, in his laboratory, Alyssa Barlis '13 and Mir Henglin '13

completed their thesis projects. Barlis worked to characterize the performance of a holographic optical trapping system. Holographic Optical Trapping (HOT) uses optical forces to move small objects (like cells or viruses) instead of mechanical forces (like directly touching the object with tweezers. It is capable of moving hundreds of objects at a time and it uses holograms to direct the light used in the process. Barlis took apart and rebuilt the system in the Lopes lab, optimizing the performance of the system as part of the rebuilding. She was able to achieve preliminary data on the system's performance. This work will be continued in the coming year by Richard Eiselen '14. Henglin '13 worked on a system of molecules that form stripes on their own. Mir created a number of thin film samples of these molecules and studied the patterns in the stripes that formed. Since the stripes in one section of the film do not know about the stripes in other sections of the film at the time when the stripes form, the molecules do not form a well ordered pattern. Instead, the pattern looks more like finger prints. As the sample is heated, the sample obtains a higher degree of order by moving and annihilating defects. Henglin studied this process. In the Summer 2013, work on this project will be continued by Julia Cline '15 and Willis Kuelthau '15.

Prof. Lopes continues work in collaboration with the Selvin laboratory at the University of Illinois on various methods of improving optical microscopy and with Professor Ronadh Cox in the geosciences department on the influence of storm waves on boulder deposits along the western coast of Ireland

During the 2012-13 academic year, Professor **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 taught Electricity and Magnetism (PHYS 201)and its associated laboratory to a group of 25 students in the fall of 2012. He continued to pursue diode laser and atomic physics experiments in his research lab, teaming up with senior thesis students Nathan Schine '13 and David Kealhofer '13, and current postdoc Dr. Gambhir Ranjit. Ranjit 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 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). Nathan Schine completed an experiment to precisely measure the Stark shift (atomic energy level shift in a large static electric field) in an atomic beam of indium. Schine collected and analyzed data, constructed and optimized many optical, electronic, and vacuum related systems, and performed numerous simulations and calculations related to the frequency-modulation spectroscopy technique used in this experiment. He and previous thesis students on this project (Andy Schneider '12, and Tony Lorenzo '11) were co-authors along with Dr. Ranjit and Prof. Majumder on a *Physical Review A* article describing this work which appeared in April, 2013.

David Kealhofer '13 completed his thesis this spring as well. His project involved using two diode laser systems (IR, UV) to excite thallium atoms contained in a heated (500ºC) quartz cell in a two-step fashion to measure hyperfine structure and the isotope shift in an excited state of thallium-203 and thallium-205. Substantial amounts of data were taken and analyzed, and the group expects to complete the final analysis and publish the results this summer. David accompanied Prof. Majumder to Quebec City, Canada to the annual APS Division of Atomic, Molecular, and Optical Physics (DAMOP) conference at which David presented a poster on his thesis work, and Prof. Majumder gave a talk on the indium Stark shift work, as well as chairing a session on Precision Measurements, and participating in the DAMOP program committee planning meeting.

Both Nathan and David are headed to Physics Ph.D. programs, at U. Chicago, and U.C. Santa Barbara respectively. We wish them luck! Incoming thesis students Nathan Bricault '14 and Gabby Vukasin '14, as well as rising senior Sarah Peters '14 will join Dr. Ranjit and Prof. Majumder this summer to continue and follow up on both experimental efforts. Dr. Ranjit will be leaving the group in August to pursue another research position, and we wish to acknowledge the important contributions he has made to this research group, the student researchers, and the department over his 2 ½ years at Williams. Good luck, Gambhir!

Visiting Assistant Professor **Michael Seifert** continued his theoretical work into possible violations of Lorentz symmetry, the symmetry between space and time that

underlies Einstein's theory of relativity. His current research deals with structures known as "topological defects" that can arise in these theories, and with their gravitational phenomenology. During the summer of 2012, Seifert worked with Kamuela Lau '14 to investigate the bending of light rays in the presence of these topological defects, with an eye towards their observational signatures. He also worked with Brandon Ling '15 in an attempt to classify the various types of topological defects that can arise when Lorentz symmetry is broken. Both Lau and Ling will again be working with Prof. Seifert in the summer of 2013, and Lau will continue as Prof. Seifert's thesis student for the 2013-14 academic year.

During the 2012-13 academic year, Seifert taught "Classical Mechanics" (PHYS 411T), an advanced tutorial class, and "Electromagnetism and the Structure of Matter" (PHYS 132). He was also invited to give a pedagogical lecture on Lorentz symmetry violation and gravity at the "IUCSS Summer School on the Lorentz- and CPT-violating Standard Model Extension", in Bloomington, IN.

Professor **Jefferson Strait** and his students build and study optical fiber lasers that produce 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.

Max LeBerge '14 will work with Strait during the summer of 2013 building and testing a new fiber laser pumped with laser diodes. They will incorporate new optical fibers designed for transoceanic communication that should give unprecedented control over the dispersion in the laser.

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** returned from leave for the 2012-13 year. He taught the Seminar in Modern Physics (PHYS 151) in the Fall and Statistical Mechanics and Thermodynamics (PHYS 302) in the Spring, each for the first time. For PHYS 151, he developed a new unit on cosmology including the modern interpretation of our expanding universe. For PHYS 302,

he started a new laboratory on superconductivity using an apparatus with the amusing acronym Mr. SQUID. He also taught a new Winter Study course with Professor Steven J. Miller in Mathematics on "The Science of Star Trek", resulting in the visit of theoretical physicist and cosmologist Lawrence M. Krauss, author of The Physics of Star Trek.

Strauch continued his theoretical work in superconducting quantum circuits, quantum algorithms, and other applications to quantum information processing. A new project, in collaboration with Kurt Jacobs at the University of Massachusetts Boston has been funded by the National Science Foundation in the amount of $180,000. Strauch continues to publish in *Physical Review Letters*, *Physical Review A* (with Teng Jian Khoo '09 and Steven R. Jackson '10). During the year he advised senior thesis students Roshan Sharma '13, and Qiao Zhang '13. For the summer of 2013, he will be working with Joe Iafrate '14, Cesar Melendez '14, Jeremy Gold '14, and Alex Foucault '15.

In the fall semester Associate Professor **Dave Tucker-Smith** taught a new course, Introduction to Particle Physics (PHYS 321), which culminated in a discussion of the Higgs particle recently discovered at the Large Hadron Collider (LHC). In the spring, Tucker-Smith taught Vibrations, Waves, and Optics (PHYS 202). Williams students Dylan Gilbert '13 and Alice Sady '13 began research with Tucker-Smith during the summer of 2012, studying how models of new physics can be tested at the LHC and other experiments. Gilbert and Sady continued their work through the academic year and presented their results in senior honors theses. Both Gilbert and Sady will begin working within the CMS collaboration of the LHC when they begin their PhD physics studies in the fall. Tucker-Smith will begin working with Isaac Hoenig '14, Gabriel Samach '15, and Weng-Him Cheung '15 on particle physics projects in the summer of 2013.

Professor **Bill Wootters** has been working this year with thesis student Christina Knapp '13 on a theoretical project concerning the two fundamental classes of particles in physics, bosons and fermions. Fermions, such as electrons and quarks, obey the Pauli exclusion principle, whereas bosons, such as photons, do not: there is no limit to the number of identical bosons that can occupy the same quantum state. It is well known that a composite particle containing an even number of fermions can act like a boson, and in 2005 the physicist C. K. Law hypothesized that this behavior occurs when the components are highly entangled (in the quantum mechanical sense of the word). Knapp found evidence in support of Law's

hypothesis, demonstrating a close relation between the components' entanglement and the number of composite particles that can share a quantum state. She presented a poster on her work at the fall meeting of the New England Section of the American Physical Society.

During the winter study period and spring semester, Prof. Wootters participated in a faculty reading group on philosophy and physics, organized by Prof. Keith McPartland of the philosophy department. The group's readings have covered many topics, including the relation between quantum entanglement and special relativity. Also in the spring semester, Prof. Wootters gave a lecture in the Faculty Lecture Series, on the role of imaginary numbers in quantum theory.

Class of 1960 Scholars in Physics

Alyssa C. Barlis	David A. Kealhofer	Nathan A. Schine
Dylan P. Gilbert	Christina P. Knapp	Roshan Sharma
Mir Henglin	Muzhou Lu	Qiao Zhang
	Alice A. Sady	

PHYSICS DEPARTMENT COLLOQUIA

[Colloquia are held jointly with the Astronomy Department.]

Daniel Aalberts
Panel discussion about the Michael Frayn play "Copenhagen"

Theater Department, January 2013

Thomas Allison, Stony Brook University
"High Brightness Extreme Ultraviolet Frequency Combs via Intracavity High-Order Harmonic Generation "

Natalya Benko, Williams Children's Center
"Science with Grandma "

Robert Cooper, '06, Princeton University
"Stay on Target! The Origins of Persistence in Amoeboid Motility"

Jeff Bary, Colgate University
"The Importance of Being Duplicitous: "Why Binarity Matters"

Paul Cadden-Zimansky, Bard College
"Pencil + Tape = Topological Computation? – The New Two-Dimensional Universe of Graphene"

Allen Downey, Olin College
"Complexity, Computation and Science in the 21st Century"

Elizabeth Freeland, Benedictine University
"Searching for New Physics: Neutral B-mixing and Lattice Quantum Chromodynamics "

Angel Garcia, RPI
"Molecular Dynamics Simulations of RNA tetra loops "

David Hanneke, Amherst College
"A Programmable Quantum Information Processor "

Nathan Hodas '04, University of Southern California
"Using Social Network Data to Understand Human Behavior "

Lawrence Krauss, Cosmologist and Best Selling Authoer, Arizona State University
"A Universe from Nothing"

Lawrence Krass, Arizona State University
"Cosmology as Science? From Inflation to Eternity "

Michael J. Person, MIT
"The MIT-Williams Program of Occulation Studies: Pluto and Other Objects in the Solar System "

Michael Seifert
"Topological Lorentz Defects"

APS New England Section Meeting, November 2012

Andrew Speck, '00, Schlumberger-Doll Research Center, Cambridge, MA
"Downhold Fluid Analysis at Schlumberger: Current Status and Future Prospects "

David Tucker-Smith
"Big News from the LHC"

Summer Science Lunch Talk, 2012

Sebastian Will, Harvard-MIT Center for Ultracold Atoms, Massachusetts Inst. of Technology
"Dipolar Molecules: A New Player in the World of Ultra Cold Quantum Matter "

Bill Wootters
"Why Does Nature Like the Square Root of Negative One?"

Faculty Lecture Series, February 2013

Lily Yang, Naval Research Laboratory
"Building a Quantum Network from Self-Assembled Quantum Dots and Photonic Crystals "

Nathan Bricault '14 discusses his summer research project with Professor Tiku Majumder.

OFF-CAMPUS COLLOQUIA

Daniel P. Aalberts
"A universal formula for RNA loops"
New England Complex Fluids meeting, June 2013

Tiku Majumder
"Precise atomic beam polarizability measurement in the indium 5P1/2 →6S1/2 410 nm transition"

Majumder, P.K. , N. A. Schine '13, and G. Ranjit.
"Precise measurement of the 7P1/2 hyperfine splittings and isotope shift in 203Tl and 205Tl using two-step laser spectroscopy"

Contributed talk, APS Division of Atomic, Molecular, and Optical Physics Meeting, Quebec City, CA, June 2013

David Kealhofer '13, G. Ranjit, and P.K. Majumder.
contributed poster, APS Division of Atomic, Molecular, and Optical Physics Meeting, Quebec City, CA, June 2013

"Heavy metal, cheap lasers, and tests of fundamental physics"
Univ. of Maryland / Joint Quantum Institute, April 2013

Michael Seifert
"Dynamical Tensors, Gravity, and the SME",
IUCSS Summer School on the Lorentz- and CPT-violating Standard Model Extension, Bloomington, Indiana, June 2012

"Lorentz Symmetry Violation and Gravity"
Department of Physics, University of Guelph, Guelph, Ontario, Canada, May 2013

"Lorentz Violation and Topological Defects"
Sixth Meeting on CPT and Lorentz Symmetry, Bloomington, Indiana, June 2013

Fred Strauch
"Interfacing Superconducting Qubits and a Resonator Qudit"
American Physical Society March Meeting, Baltimore, MD, March 2013

David Tucker-Smith
"MET searches versus SUSY and WIMPs"
Chicago Workshop on LHC Physics in the Higgs Era, University of Chicago, 2012

Bill Wootters
"Why Does Nature Like the Square Root of Negative One?"
Dartmouth College, March 2013

Also presented at Conference entitled, "Dechoherence and Friends"
University of Waterloo, Waterloo, Canada, May 2013

POSTGRADUATE PLANS OF PHYSICS MAJORS

Alyssa C. Barlis	Ph.D in Physics at University of Pennsylvania – detector development research
Ari S. Benjamin	Teaching 10th Grade Chemistry in Mexico City, then Ph.D at Northwestern Univ.
Gregory D. Eusden	Consultant with Parthenon Group, Boston, Massachusetts
Dylan P. Gilbert	UC San Diego in high energy experiment and starting with a CMS group there
Mir Henglin	
Julian M. Hess	
David A. Kealhofer	UC, Santa Barbara, Ph.D in physics
Andrew R. Kelly	
Christina P. Knapp	Ph.D program at UC, Santa Barbara,
Gabriel M. Lewis	Teaching Asst for New Zealand Frontier program and then Geophysics Grad School
Muzhou Lu	Teaching position, prior to grad school in astronomy
Joshua A. Revkin	
Alice A. Sady	Johns Hopkins University, Clare Boothe Luce Fellow, Ph.D
Nathan A. Schine	University of Chicago, Ph.D program in Physics
Benjamin B. Seiler	Goldman Sachs, New York
Charles H. Sellars	Junior research analyst at The Research Board in NYC
Roshan Sharma	Ph.D at Columbia University in Applied Mathematics program
Olivia Uhlman	
Qiao Zhang	Ph.D program in Computer Science at the University of Washington, Seattle

PSYCHOLOGY DEPARTMENT

The psychology major at Williams College attracts a large number of students with diverse interests and aspirations. Our students follow a curriculum that teaches them not only what we know about mind and behavior, but also how we know it, using experiential teaching as our core pedagogy. Students learn how to use the methods of scientific inquiry to critically observe and evaluate behavior, and construct from experimental evidence the implications for larger questions about human behavior. Students take a range of courses spanning the sub-disciplines of neuroscience, cognition, development, education, clinical, and social psychology. Psychology faculty work closely within the Neuroscience and Cognitive Science Programs and the Program in Teaching, and we welcome the new Public Health Program to our affiliated coursework.

Psychology students have multiple opportunities to conduct research collaboratively with professors. Some of these are empirical projects within required 300-level level lab courses, and others are in work-study or research assistant positions or as more formal independent studies. The culminating research experience is the year-long senior honors thesis. In 2012-2013 students, eight students conducted thesis research, on topics such as "Is Curiosity Contagious? Effects of Peer Interaction on Children's Curiosity", "Predictors of Stress Generation Among Adolescent Girls: Coping, Rumination, and Personality", and "'Looking' for Intention and Harm in Judgments of Discrimination". Their projects are listed in the Student Abstracts section of this report. Some of our majors completed their research experiences by presenting their research at national or international scientific conferences and by co-authoring journal publications. 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") met to discuss recent journal articles and plan social events.

The faculty of the Psychology Department continued their varied and productive teaching and research programs, as detailed below. We were happy to host two visitors this past year, Alicia Hofelich from the University of Michigan, and Jeremy Cone from Cornell University. We wish them well as they continue their academic careers at the University of Minnesota and Yale University, respectively. Next fall we will again welcome two visitors, Alison Shawber Sachet from the University of Oregon,

and Laura Sockol from the University of Pennsylvania. They will enhance our curricular offerings in developmental and clinical psychology. This summer also sees the arrival of a new faculty in developmental psychology, Mariko Moher. Mariko comes to us from a postdoctoral position at Harvard University, having completed her doctorate at John Hopkins University. Her research and teaching on cognitive development in infants and toddlers will be a welcome addition to this area of high student interest in our department. Finally, our curriculum was enhanced by the introduction of several new courses, including *Childhood in Context* (PSYC 338) by Susan Engel, *Temperament and Biobehavioral Development* (PSYC 337) by Amie Hane, *Cognition and Education* (PSYC 327) by Nate Kornell, and *Child Psychopathology* (PSYC 350) by Marlene Sandstrom. Our students also had the opportunity to take a new clinical psychology course from local practitioner Dr. Nicole Harrington on *Anxiety Disorders* (PSYC 359). This course was part of the new Gaudino Initiative, "Dangerous Courses", as was the new tutorial Neurobiology of Danger taught by Betty Zimmerberg.

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 Emeritus **Phebe Cramer** continues her research on identity, narcissism, and defense mechanisms, as these change throughout the life span. She also continues her studies of the Borderline Personality Disorder. She was invited to publish a review of her work in the Argentinian journal, *Subjetividad y Procesos Cognitivos*.

This year, she was able to complete the data gathering phase of a study of the Williams Class of 1997. These alums were studied when they were Freshmen and again in Senior year, and now in this follow-up study, to explore how personality changes post-graduation.

She has continued her work as Associate Editor of the *Journal of Research in Personality*, and as Consulting Editor for the *Journal of Personality Assessment*. In addition, she has been an invited ad hoc reviewer for research papers submitted to multiple professional journals. She

has also provided guidance and research assistance to a number of colleagues and graduate students from other educational institutions who requested help in using her coding method for the detection of defense mechanism use.

Assistant Professor **Jennifer Randall Crosby** published her research on the influence of members of minority groups on judgments of discrimination in Basic and Applied Social Psychology. Crosby also attended the annual conference of the Society for Personality and Social Psychology in New Orleans, LA, where she presented two posters, one based on her research on targeted social referencing, and one poster co-authored with Jordan Mickens '12 entitled, "'Standing' against prejudice: How we view those who respond to bias." With honors thesis student Esther Cho '13, Crosby investigated how individual differences and situational factors affect interest in intent and harm in discrimination judgments, and how these factors affect where people look when viewing an interracial interaction. Crosby also continued her research with Professor Ken Savitsky on how members of underrepresented groups experience situations in which their group membership is relevant. This research was assisted by Lillian Audette '15, Jack Bissell '16, Patrick Blizzard '13, Nathan Finan '13, Caleb Kim '13, Steven Kiesel '15, Jesse Rodriguez '16, David Rosas '16, Anuj Shah '15, Ayanna Smith '13, and Jane Youngberg '13.

This past year, Senior Lecturer **Susan Engel** published an essay in the New York Times, When They're Grown, The Real Pain Begins, and appeared on The Today show to discuss the essay. She published an article in Educational Leadership, *The Case for Curiosity*, as well as a chapter in *The Oxford Handbook of the Development of Imagination* (edited by Marjorie Taylor), titled "Flux and Flow in Children's Narratives". She wrote the afterword for the 25th Anniversary of the publication of Vivian Gussin Paley's classic work on children's play, *Boys and Girls: Superheroes in The Doll Corner*, published by Chicago University Press. She participated in a small international meeting of early childhood educators and developmental psychologists in Billund, Denmark, to discuss promoting good early childhood practices around the world. She participated in a roundtable, sponsored by the Helix Center/New York Psychoanalytic Society, "Ignorance and Curiosity". She also blogged on children's minds for *Psychology Today*.

Engel supervised an independent study with Jennie Harding '13, in which they conducted a study examining what children learn about one another through gossip. She also supervised an Honor's thesis with Dan Silver, "Is Curiosity Contagious: The Effects of Peer Interaction on Children's Curiosity".

The Program in Teaching hosted a lecture from Mike Winerip, Pulitzer Prize winning journalist for the New York Times, titled Is Reform Killing Education?

Teaching Lunches included presentations by Jesse Carpenter, High School Coach and English Teacher, and Kathy Erickson, High School Math Teacher, and recipient of the 2012 Presidential Medal for Excellence in Teaching. There were also presentations by Karen Cole, United Way Teen Prevention Specialist: Helping Teens Stay out of Trouble and Sarah Becker, Director of the Williams College Early Childhood Center: What do young Children Need? The program also hosted a roundtable discussion on whether all students should go to college.

Associate Professor **Amie Hane's** research examines social and emotional development from infancy through middle childhood and integrates multiple levels of analysis, including behavioral, electrophysiological, and neuroendocrine methodologies. She conducted several studies in her laboratory this year in conjunction with students Julia Bender Stern '13, Sarah Rosemann '13, Fanny Mlawer '14, Elizabeth Eades '15, and Adlyne Harris '15. Professor Hane worked with senior honors thesis student Julia Bender Stern on research examining maternal relationship representations and preschoolers' physiological responding to stress.

Professor Hane continues to work in conjunction with colleagues at the University of Maryland and Columbia University. 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. Together with collaborators at the University of Massachusetts, Amherst, Hane submitted a grant to the NIH to fund a large-scale, longitudinal study to examine the efficacy of a prenatal intervention program designed to reduce depression in pregnant women. This grant is under review. This year Professor Hane published original research in the journals *Infancy* and *Social Development*. Her research was presented at the biennial meeting of the Society for Research in Child Development in Seattle, Washington. Chelsey Barrios '12 presented her honors thesis research on neonatal stress responding during bathing at this conference. 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, including *Archives in Pediatrics, Attachment and Human Development, British Journal of Developmental Psychology, Child Development, Developmental*

Psychology, Development and Psychopathology, Emotion, Infancy, Journal of Abnormal Child Psychology, Journal of Child Psychology and Psychiatry, Journal of Family Psychology, Journal of Reproductive and Infant Psychology, Journal of Research in Personality, Psychological Review, and *Psychological Bulletin*. She also reviewed grants for the National Science Foundation this year.

Professor **Laurie Heatherington** and her students continued research on change processes in psychotherapy, including therapeutic alliance in couple and family therapy (in collaboration with colleagues at SUNY Albany and Universidad de La Coruña, Spain), the role of social cognitive factors in interpersonal relationship difficulties, 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 thesis students pursued their own research projects on the role of social media, attachment and social capital in adjustment to college (Emmanuel Whyte '13), and on examining local terms and explanations for mental illnesses, and treatment outcome expectancies in rural Burundi (Pacifique Irankunda '13).

She served as President of the North American chapter of the Society for Psychotherapy Research (NASPR), and Co-Chaired the Planning Committee for an April 2013 academic symposium on recovery from major mental illness, celebrating the 100th anniversary of Gould Farm, which was also attended by three current students.

At the 2012 International Society for Psychotherapy Research Conference in Virginia Beach, she and students/former students Marissa Pilger '11, Emmanuel Whyte '13 and Jennifer Morrison '12 presented a paper on family relationship and attributions about children's ADHD related behaviors; she also directed a roundtable discussion of journal editors, and was a panelist in a structured discussion on research relating to corrective experiences in psychotherapy. She published, with co-authors, studies in *Clinical Psychology: Science and Practice*, and *Journal of Counseling Psychology*, as well as a book chapter on managing negative reactions to clients in family therapy.

Professor Heatherington continued to serve on the Editorial Boards of *Psychotherapy Research, Journal of Family Psychology, Psychotherapy: Theory, Research, Practice, and Applications, Journal of Counseling Psychology, and Journal of Clinical Psychology: In Session* and did ad-hoc reviewing for several other journals and publishers. She served as an external reviewer for the Bucknell University Psychology department, and 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, where she also directs an ongoing fourteen year program evaluation & long term outcomes study.

Professor **Saul Kassin** was on reduced time while serving as a Distinguished Professor at the John Jay College of Criminal Justice in New York. Continuing to focus on policy reform and matters concerning wrongful convictions, Kassin 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 published the 9th edition of his textbook, *Social Psychology* (with Steven Fein and Hazel Markus); addressed the National Innocence Project Network on false confessions at its 2013 policy meeting in New Orleans; gave a keynote speech at the March 2013 Meeting of the Eastern Psychological Association entitled "Why Confessions Trump Innocence"; co-presented three papers at the American Psychology-Law Society in Portland, Oregon; contributed a book chapter to the *APA Handbook of Forensic Psychology*, published in 2013; lectured at a number of institutions—including New York Police Department's Executive Development Program, the University of California at Irvine, Iowa State University, Temple University Law School, the New York State Bar Association, and the Massachusetts Continuing Legal Education program in Boston; published a commentary in the *Journal of Applied Research on Memory and Cognition* entitled "Paradigm shift in the study of human lie-detection;" and appeared on CBS 60 Minutes in a story entitled "Chicago: The False Confession Capital" (which aired on December 8, 2012) and in a PBS documentary film produced by Ken Burns entitled "The Central Park Five" (which aired on April 16, 2013). This past year, Kassin was appointed a consulting editor of the *Journal of Applied Research on Memory and Cognition*. He continued to serve as Consulting Editor for Law and Human Behavior, the Research Advisory Board of the Innocence Project, the Advisory Board member of the Social Science Research Network (SSRN), and reviewer for the National Science Foundation. He has also worked as a consultant and expert witness in both criminal and civil cases.

Last Fall, Professor **Kris Kirby** and Daniel Gerlanc '07 published bootES, a free, open source software package for generating bootstrap confidence intervals on effect sizes in the R statistical computing environment. This was followed by their publication of an article describing the benefits of this type of data analysis and use of the software in the journal Behavior Research Methods.

Professor Kirby served on the editorial boards of the *Journal of Behavioral Decision Making and Judgment and Decision Making,* and also served as an ad hoc reviewer for *Cognitive Science, Psychological Science,* and *Psychonomic Bulletin and Review*.

Assistant Professor **Nate Kornell** continues his research on cognition, education, and self-regulated learning. He became a consulting editor for four journals in the last year: *Archives of Scientific Psychology; Journal of Experimental Psychology: Learning, Memory, and Cognition; Memory & Cognition*; and *Psychonomic Bulletin & Review*. He continues to blog for *Psychology Today*. He published four journal articles this year. One was a review of research on the benefits of tests as learning events co-authored with Patricia Jacobs Klein '11 and Veronica Rabelo '11. Another paper examined the costs and benefits of taking a test and getting the answers wrong, and a third investigated why people learn categories (in this case of birds and butterflies) better when different categories are mixed together rather than being studied one at a time. The last article was a review of research on how students structure their own learning published in the high-profile journal *Annual Review of Psychology*.

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 developed a new upper-level seminar entitled "Child Psychopathology," and had the opportunity to learn a great deal about the recent revisions (and controversies) surrounding the publication of the American Psychiatric Association's newest diagnostic manual. In the fall, Professor Sandstrom presented a research talk as part of the inaugural International Video Conference on Peer Relations, entitled Measuring implicit processes: New applications for existing paradigms. In the spring, Professor Sandstrom chaired a symposium at the Biennial Meeting of the Society for Research in Child Development in Seattle, titled Power, Popularity, and Persuasion: Experimental Paradigms for Assessing Peer Conformity in Action. At this same meeting, Professor Sandstrom presented her own work, titled Fitting in to feel good: Can an experimental boost in self-esteem reduce pressure to conform? She also served as a panel discussant for a symposium about measuring implicit processes, as well as a symposium on the interplay of parental and peer relationships in early childhood. Over the past year, Professor Sandstrom has served as an ad hoc reviewer for *Journal of Research in Adolescence, Child Development*, and *Journal of Youth & Adolescence.*

Associate Professor **Noah Sandstrom** and thesis student Eric Dietsche '13 embarked on a new program of research exploring the mechanisms underlying neuronal damage and behavioral impairment following closed-head injury. This project has included several additional students including Jenna Adams '14, Ellen Cook '15, and Nitsan Goldstein '15. In related service, Sandstrom serves on a NESCAC Committee exploring medical issues in collegiate sports with a particular focus on concussion prevention and management. In October of 2012, Sandstrom attended the annual meeting of the Society for Neuroscience as well as the annual meeting of Faculty for Undergraduate Neuroscience at which he transitioned from President-Elect to President. In November, Professor Sandstrom was joined by a dozen Neuroscience concentrators for a neuroendocrine symposium at the University of Massachusetts. Sandstrom continues to Chair the Behavioral Neuroscience Fellowship study section at the National Institutes of Health and serves as a reviewer for several journals. New teaching activities include implementing a demonstration of a cockroach leg that dances to the beat of Carly Rae Jepsen's "Call Me Maybe" demonstrating electrical control of neuronal communication.

Assistant Professor **Catherine Stroud** is continuing work on her longitudinal research study 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. Effua Sosoo '13 and Charlotte Vinson '13 completed senior honor theses examining predictors of adolescent well-being and academic functioning. In addition, Professor Stroud and Emily Norkett '14 completed the one-year follow-up of a study investigating emotion regulation strategies in adolescents. Professor Stroud and Elizabeth Greiter '12 presented their work on effective strategies for coping with negative romantic events at the Biennial meeting of the Society for Research on Child Development in Seattle, WA. Professor Stroud also presented her work on daily links between negative mood and stress in couples at the Annual Meeting of the Association of Behavioral and Cognitive Therapies in Baltimore, Md. Professor Stroud and her colleagues co-authored a chapter on depression and interpersonal relationships, and contributed to a manuscript on the assessment of interpersonal problems. Professor Stroud became an advisory editor of the journal *Family Process* and co-founded a special interest group to promote research in clinical psychology at liberal arts colleges for the Association of Behavioral and Cognitive Therapies.

Professor **Safa Zaki's** research focuses on how the mind

and brain divide the perceptual world into categories. In her lab, she tests participants in categorization tasks, and compares their performance to the predictions of categorization models that make key assumptions about the involvement of various systems of the brain. This year, she started a new project with Alex Rich '13 in which they investigated a variety of sequential effects – that is, differences in performance based on the order in which participants observed category examples. This work is ongoing in the lab. She has also started a new project with collaborators at Dalhousie University to investigate categorization ability in children who have been diagnosed with an Autism Spectrum Disorder.

Professor Zaki published two papers this year. The first of these was published in the *Journal of Experimental Psychology: Learning, Memory, and Cognition* and the second was published in *Autism Research*. In addition to reviewing grant proposals for the National Science Foundation, Professor Zaki reviewed articles for several journals.

Professor **Betty Zimmerberg** continued her service as chair of the Psychology Department this year. In October, she attended the annual meeting of International Society for Developmental Psychobiology, where Sierra Germeyan '13 presented her preliminary thesis research. Zimmerberg also gave an invited talk in a Special Symposium: Connecting to the Humanities and Social Sciences, at the Society for Neuroscience annual

meeting in New Orleans in October. Her presentation on interdisciplinary teaching of neuroscience and art was joined by speakers on neuroeconomics, neuroethics and the neuroscience of music. She also wrote a short piece, "The Grid and Neuroscience" for the *Williams Magazine* on the relationship between Gestalt psychology and the conceptual works of Sol LeWitt. This year, Zimmerberg redesigned her tutorial to participate in the Gaudino Danger Curriculum, teaching a new behavioral epigenetics course entitled "Neurobiology of Danger". As part of the Danger Curriculum, Zimmerberg hosted Jan Haaken, the writer/director of a new documentary, Mindzone, for a premiere screening and discussion. This film followed the 113th Army Combat Stress Control unit in Afghanistan. Students in the "Danger" courses discussed the problems facing mental health professionals with two competing missions: maintaining the fighting forces and preventing psychiatric casualties.

Students in the Zimmerberg lab this year, using animal models to study the effects of prenatal antidepressant exposure and early child neglect, were Sierra Germeyan '13, Emily Levy '13, Manasi Iyer '14, Daniela Zarate '15, Lillian Audette '15 and Jackie Harris '16. Summer science student Sierra Germeyan '13 worked with Zimmerberg at the Marine Biology Labs in Woods Hole, MA. Other professional activities included serving on the Editorial Board of *Developmental Psychobiology* as well as reviewing for several journals.

Class of 1960 Scholars Program

To encourage students to explore careers in psychology, the Class of 1960 Scholars Program brings accomplished researchers from other colleges and universities to campus to give colloquia. In advance of the colloquia, the group of 1960 Scholars read and discuss the speakers' work with a faculty member and then join the speaker and faculty for dinner afterward. The 2012-13 Class of 1960 Scholars are listed below. This year marked the fifth year of the G. Stanley Hall Prize in Psychology, funded by a generous gift from the Chuzi family, parents of Sarah Chuzi '07, and given at graduation to a student who has demonstrated exceptional achievement in psychology. We were happy to award the prize this year to Sierra Germeyan '13 for her outstanding thesis and contributions to teaching and departmental life.

Class of 1960 Scholars in Psychology		
Julia Bender Stern '13	Sierra Germeyan '13	Emily Norkett '14
Katie Berenbaum '14	Yiqin Jiang '13	Alyssa Quann '14
Esther Cho '13	Claire Liu '14	Effua Sosoo '13
Chelsea Davies '13	Jackson Lu '13	Charlotte Vinson '13
Kaitlin Dinet '13	Fanny Mlawer '14	Lysa Vola '13
Jessica Fitts '13	Narah Moon '14	Emmanuel Whyte '13

PSYCHOLOGY DEPARTMENT COLLOQUIA

Lizabeth Roemer, University of Massachusetts Boston
> "Mindfulness and Acceptance-Based Behavioral Therapy for Anxiety: From Evidence-Based Treatment Development to Dissemination and Implementation"

Todd Rogers '01, Harvard Kennedy School of Government
> "Using Psychology to Increase Voter Turnout"

Jan Haaken, Portland State University
> "MIND ZONE: Therapists Behind The Front Lines" Film Screening with Q and A

Norman Spck, Children's Hospital Boston
> "Gender Non-Conforming Children and Transgender Youth: Lessons from GeMS"

Cheryl Kaiser, University of Washington
> "Blind to Injustice: Ironic Effects of Organizational Diversity Structures"

OFF-CAMPUS COLLOQUIA

Jennifer Randall Crosby
> "Targeted Social Referencing: Consequences for Perceivers and Targets"
> Poster presented at the annual conference of the Society for Personality and Social Psychology in New Orleans, LA, January 2013.

> "'Standing' Against Prejudice: How We View Those Who Respond to Bias"
> Poster presented at the annual conference of the Society for Personality and Social Psychology in New Orleans, LA, with Jordan Mickens '12, January 2013.

Susan Engel
> "Promoting Good Early Childhood Practices Around the World"
> Billund, Denmark, February 2013.

> "Ignorance and Curiosity"
> Helix Center/New York Psychoanalytic Society, New York, NY, April 2013.

Amie Ashley Hane
> "The Baby in the Bath Water: Associations Among Maternal Caregiving, Neonatal Somatic Discomfort, and Stress Reactivity During Bathing and Dressing"
> Paper presented as a poster at the biennial meeting of the Society for Research in Child Development, Seattle, WA with C. Barrios '12, A. Cardoos '12, L. Philbrook '09, & L. Holsti, April 2013.

> "Maternal Perceptions If Infant Difficult Temperament: Mother- Infant vs. Stranger-Infant Self- And Interactive Contingency"
> Paper presented as a poster at the biennial meeting of the Society for Research in Child Development, Seattle, WA with B. Beebe, N. Parashar, N. Banerjee, A. Margolis, M. Loeser, E. Bandes, C. Jaffe, A. Irwin, K. Buck, & S. Lee, April 2013.

> "Contextual Effects on Continuity and Discontinuity in Temperament Over Time"
> Paper presented in the symposium chaired by H. Henderson entitled "Risk and Protective Factors Underlying Behavioral Inhibition: Biological and Contextual Influences" at the biennial meeting of the Society for Research in Child Development, Seattle, WA with K. A.Degnan, H. A. Henderson, O. L. Walker, M. Ghera, & N. A. Fox, April, 2013.

Saul Kassin

"False Confessions"
Presented at the Annual Policy Meeting of the Innocence Network, New Orleans, May 2013.

"Why Confession Trumps Innocence"
Keynote speech at the Annual Meeting of the Eastern Psychological Association, New York, April 2013.

"An Empirical Study of Micro-Expression Lie Detection Training"
Paper presented at the Meeting of the American Psychology-Law Society, Portland, OR with S. Jordan, D. Wallace, & M. Hartwig, March 2013.

Do Confessions Change Juror Perceptions of Handwriting Evidence Over Time?"
Paper presented at the Meeting of the American Psychology-Law Society, Portland, OR, with J. Kukucka, March 2013.

"Nothing Good Happens After Midnight: The Effect of Sleep Deprivation and Chronotype On Confession Decisions"
Paper presented at the Meeting of the American Psychology-Law Society, Portland, OR with K. Scher & J. Miller, March 2013.

"Why Confessions Trump Innocence: The Case of Amanda Knox"
Keynote speech at the International Conference on Global Perspectives on Justice, Security, and Human Rights, John Jay College of Criminal Justice, New York, June 2012.

New York Police Department – Executive Development Program (NYC)

University of California at Irvine (Irvine, CA)

Iowa State University (Ames, IA)

Temple University Law School (Philadelphia)

Massachusetts Continuing Legal Education (Boston)

New York State Bar Association Continuing Legal Education (NYC)

Nate Kornell

"Extreme Overconfidence: Judging Future Remembering Based on the Present"
Poster presented at the 53rd annual meeting of the Psychonomic Society, Minneapolis, MN, November 2012.

"If It's Stored in My Memory I Will Surely Retrieve It: The Anatomy of a Metacognitive Belief"
Paper presented at the 7th biannual meeting of the International Association for Metacognition, November 2012.

Marlene Sandstrom

"Measuring Implicit Processes: New Applications for Existing Paradigms"
International video conference on peer relations, Concordia University, Montreal, Quebec, November 2012.

"Fitting in to Feel Good: Can an Experimental Boost in Self-Esteem Reduce Pressure to Conform?"
Paper presented at the Biennial Meeting of the Society for Research in Child Development, Seattle with Aaron Lim '12. Paper Symposium: Power, Popularity, and Persuasion: Experimental Paradigms for Assessing Peer Conformity in Action, April 2013.

"Implicit Cognitions and Adjustment in Children's Peer Relations"
Discussant at the Biennial Meeting of the Society for Research in Child Development, Seattle, April 2013.

"The Interplay of Parental and Peer Relationships in Early Childhood: Proximal and Distal Influences"
Discussant at the Biennial Meeting of the Society for Research in Child Development, Seattle, April 2013.

Noah Sandstrom
"Faculty for Undergraduate Neuroscience (FUN): Support for the Development of Undergraduate Students and Faculty in the Neurosciences"
Society for Neuroscience, New Orleans, LA with E. R. Reynolds & S. D. Dickinson, S. D., October 2012.

"The Current State of FUN (Faculty for Undergraduate Neuroscience)"
Society for Neuroscience Committee on Neuroscience Departments and Programs. Washington, D.C., March 2013.

Catherine B. Stroud
"Romantic Experiences and Depressive Symptoms in Adolescents: Evidence for Emotional Clarity as a Moderator"
Poster presented for the biennial meeting of the Society for Research on Child Development, Seattle, WA with Elizabeth A. Greiter '12, April 2013.

"Stress Generation Effects in the Daily Lives of Couples: Evidence for Relationship Satisfaction as a Moderator"
Poster presented at the Annual Meeting of the Association of Behavioral and Cognitive Therapies, National Harbor, MD with J. Davila, November 2012.

"Interpersonal Problems and Interpersonal Dysfunction: A Factor Extension of the Inventory of Interpersonal Problems—Circumplex Across Multiple Relationship Contexts and Measures"
Poster presented at the 2012 annual meeting for the Society of Research on Psychopathology, Ann Arbor, MI with S. Wilson, W. Revelle & C. E. Durbin, October 2012.

Betty Zimmerberg
"Behavioral Effects of Postnatal Fluoxetine Administration in Rats Selectively Bred for an Infantile Affective Trait"
International Society for Developmental Psychobiology, New Orleans, LA with Sierra Germeyan '13, Manasi Iyer '14, and Daniela Zarate '15, October 2012.

"Bridging Neuroscience and Art"
Society for Neuroscience, New Orleans, LA, October 2012.

POSTGRADUATE PLANS OF PSYCHOLOGY MAJORS

Aiden R. S. Alyxander	Unknown
Katherine A. Amano	Teaching intern at Emma Willard (teaching English, coaching, and RAing) while earning an M.A.T. at Union Graduate School of Education.
JiHye Baek	Unknown
Inan L. Barrett	Teaching in NY with Teach for America.
Julia R. Bender Stern	Working at Boston Children's Hospital next year as a Research Study Assistant in Gastroenterology and Nutrition.
Alexandra R. Berg	Unknown
Jennifer C. Borderud	Unknown
Robert J. Brackup	Unknown
Stephanie P. Browne	Working at J.P. Morgan in the Investment Bank.
Esther Cho	Unknown
William R. Craig	Unknown
Chelsea E. Davies	Working at Wediko Children's Services in New Hampshire.
Kaitlin E. Dinet	Teaching 7th grade science next year with Teach for America (Stamford, CT)
Casey L. Evans	Applying to clinical research jobs in Boston and hoping to apply to clinical psych grad programs in a couple of years.
Nathaniel H. Finan	Searching for a job in marketing/advertising in Boston.
Jessica J. Fitts	Working in Kate Stroud's lab on campus for the summer: hoping to travel for a year and then go on to graduate school.
Jennifer Garcia	Studying for the DAT this summer a well as applying to dental school for matriculation in August/September of 2014 while taking science classes at UCLA and looking for a part-time job/ volunteer.
Sierra C. Germeyan	Working as an IRTA fellow in the Clinical Epilepsy Section at the National Institutes of Health.
Jennifer P. Ginsberg	Applying to medical school for matriculation in summer 2014; during the gap time, performing at Disney World for a year.
Jennie R. L. Harding	Completing the Stanford Teacher Education Program in elementary education, one year program where she will receive her teaching credentials and masters degree.
Jenay E. Haskins	Unknown
Tanasia Hoffler	Unknown
Kimberly M. Holachek	Attending the Columbia University School of Social Work.
Katherine R. Holmes	Moving to Nashville, TN to pursue a career in the music business doing marketing or promotions.
Pacifique A. Irankunda	Working in New York next year for the Village Health Works organization and following that will pursue a career in international public health.

Yiqin Jiang	Associate Consultant at The Palladium Group.
Tania Karboff	Unknown
Jackson (Guannan) Lu	Pursuing a 5-year PhD in organizational behavior at Columbia Business School, NY.
Nicholas A. Marks	Attending grad school at NC State at the Institute of Advanced Analytics in an applied statistics program.
Kara L. McLaughlin	Clinical research assistant in the emergency room at Children's Hospital in Boston.
Ashley R. Meczywor	Hoping to work in either a clinical psychology research setting, in admissions/school counseling, or in mental health care.
Rebecca A. Nichols	Unknown
Katherine H. O'Leary	Unknown
Katherine M. Pettengill	Unknown
Brooke K. Pfister	Working as a tutor at a charter middle school as a member of the Match Corps in Boston for one year and is currently in the process of applying to medical school for the Fall of 2014.
Graham S. Righi	Unknown
Eric J. Robinson	Working in Electronic Digital Interchange for Epic Systems in Madison, WI.
Allison L. Rubin	Case Assistant at Seyfarth Shaw LLP in Boston.
Zachary B. Shapiro	Unknown
Aliza R. Shatzman	Working on Capitol Hill in Washington, DC.
Alexandria L. Sherman	Unknown
Daniel M. Silver	Doing the Match Teacher Residency next year at Match Community Day School, a Boston charter elementary school; plans to teach for four years in charter or public schools before applying to grad programs in either psychology or education.
Ayanna I. Smith	Unknown
Effua E. Sosoo	Lab manager at Binghamton University in the Mood Disorders Institute.
Hayley S. Swan	Unknown
Samantha G. Vilaboa	Unknown
Charlotte A. Vinson	Attending Teachers College at Columbia University, getting a Masters and Dual Certification in General and Special Elementary Education.
Elizabeth D. Visconti	Working at Tortoise Investment Management in White Plains, NY.
Lysa T. Vola	Unknown
Emmanuel J. Whyte	Awarded a Watson Fellowship, which will take him to Ghana and Japan next year to pursue an interesting project in his other major, Studio Art; following his return, will seek a two-year research position in psychology, study for the GREs, and apply to graduate school.
Caroline A. Wilson	Unknown
Christine Yeoun	Unknown

ABSTRACTS FROM STUDENT THESES

ASTRONOMY

Observation and Modeling of Solar Coronal Structures Using High-Resolution Eclipse Images and Space-Based Telescopes with Wide Field of View

Muzhou Lu

In part one, information regarding solar coronal structures and dynamics is extracted from modernized ground-based eclipse observations using high-resolution imaging techniques and computerized processing methods while enhanced space-based observations are used to create a multi-channel view of the corona. In part two, potential magnetic field models are constructed and compared with our observations.

Exploring a Theory of Dark Matter

Alice A. Sady

This thesis studies a particular theoretical framework for dark matter that adds three new particles to the Standard Model of particle physics. We examine how current experimental results constrain the model and how future results could confirm or further constrain the model.

BIOLOGY

The Agrobacterium T6SS is Activated by Host Responses and Induces Light-Dependent Host Defenses

Abigail Davies

Agrobacterium tumefaciens, a gram-negative soil bacterium, causes the well-characterized Crown Gall Disease on host plants. This bacterium is the only known organism capable of interkingdom gene transfer. The tumor-inducing Ti plasmid encodes tumor-inducing factors on the transferred DNA (T-DNA), which is delivered into the host cell via a Type IV Secretion System (T4SS) and incorporated into the host's chromosomal DNA for the production of plant growth hormones and nutritional resources for the bacterium. In addition to the T4SS, Agrobacteria also possess a functional Type VI Secretion System (T6SS), implicated in virulence in a variety of mammalian pathogens. T6SS proteins are encoded on the 14-gene imp operon and the divergently transcribed hcp operon. A T6SS mutant strain (#20) lacking the entire imp operon exhibits attenuated virulence.

We have obtained evidence that the Agrobacterium T6SS both triggers and dampens host defense responses. We hypothesize that Efr-mediated defenses common to both WT and T6SS-deletion mutant bacteria mask T6SS-triggered defenses in WT plants, but that in the efr mutant plant, the absence of a functional EF-Tu receptor allows for T6SS-elicited responses to become apparent.

The master Arabidopsis thaliana circadian regulator gene Circadian Clock Associated 1 (CCA1) has been shown to control resistance to a number of pathogens. At the same time, many plant defense genes seem to be regulated in a diurnal manner by changes in light rather than these endogenous rhythms. This thesis investigated whether Agrobacterium-induced expression of the Arabidopsis thaliana defense response genes FRK1 and WRKY29 was under circadian and/or light control.

Our results demonstrated time-of-day-dependent induction of host defense genes as well as bacterial virulence genes. Expression of A. thaliana defense genes FRK1 and WRKY29 suggested EFR-mediated responses were under circadian regulation, while T6SS-induced defenses seemed to be under light-mediated control. In addition, bacterial T6SS gene expression was induced in response to host defense gene levels, which a functional T6SS was in turn able to dampen slightly. These results suggest that the Agrobacterium T6SS is activated by host defense responses, resulting in the induction of further light-dependent A. thaliana defense gene expression.

Characterization of Von HippelLindau (VHL) in Helobdella sp. (Austin)

Laura Donnelly

The goal of the Savage lab is to identify early developmental regulators that function in annelid development. An unbiased screen was conducted to generate a list of candidate genes, of which I screened a subset. One of these, the Von Hippel-Lindau (VHL) gene product, yielded a novel and interesting expression pattern in the Helobdella embryo. VHL's canonical role is as the substrate recognition component of an ubiquitin ligase complex, but it has more recently been identified as acting in diverse capacities, such as regulating ciliogenesis. VHL acts as a microtubule stabilizer and is implicated in the establishment of polarity through its interaction with the PAR-aPKC complex. I analyzed the VHL sequence and characterized its expression pattern in leech embryogenesis using in situ hybridization. VHL is the first blastocoel marker identified in annelids. A second blastocoel was observed in the stage 5 embryo, a previously undocumented finding. The localization of VHL gene products to the blastocoel suggests that it is regulating decisions relating to asymmetry and cell fate specification.

Strain-Specific Specialization and Functional Evolution of the Light-Harvesting and Carbon Concentrating Complexes in Prochlorococcus

Katharine H. Dusenbury

The marine cyanobacterium Prochlorococcus dominates the euphotic zone in the tropical and subtropical open oceans. Recent work from our laboratory has suggested that the heterogeneity that exists in the Prochlorococcus photosynthetic apparatus must have an important role in enabling this lineage to thrive in the varied environments from the surface to depths of 200 m (Ting et al., 2009) In particular, many Prochlorococcus ecotypes have different copy numbers (ranging from one to eight) of the pcb gene encoding the prochlorophyte chlorophyll a/b binding (Pcb) protein (Ting, et al., 2009). Pcb proteins can form antenna rings around the photosystems to maximize light-harvesting efficiency. Due to this association, it has previously been suggested that the multiplication of the pcb gene in some Prochlorococcus strains is adaptive for growth at low light levels (Garczarek, et al., 2000). However, we found evidence that the association of the Pcb proteins with the photosystems in the various Prochlorococcus strains is actually highly specialized and that the presence of particular Pcb types may be more important for ecotype differentiation and adjusting to environmental conditions than the number of pcb genes a strain has. For instance, past work has demonstrated that PcbA subunits are typically associated with PSII in all studied Prochlorococcus strains. However, the only Pcb found to constitutively associate with PSI is the PcbG protein unique to SS120. In other strains, particularly MIT9313, PcbD has been found to form an antenna around PSI, but only under iron stress. Notably, the expression of these pcb genes, as well as the genes encoding the main components of the photosystem reaction centers, is not conserved across all Prochlorococcus strains. Together, these observations support our hypothesis that the Pcb proteins in Prochlorococcus have evolved conserved, but highly specialized functions. Furthermore, the diversification of Pcb proteins within the Prochlorococcus lineage likely played a critical role in the ability of this genus to adapt to different ecological niches and dominate the open oceans.

Along with having key differences in the copy number and expression of their photosynthetic apparatus genes, even closely related Prochlorococcus strains exhibit important differences in the evolution of their carbon concentrating microcompartment (or carboxysome) genes. In particular, we found that the gene encoding a carbonic anhydrase (CsoS3) present in the protein shell of the carboxysome has been evolving more rapidly in the MED4 strain than in other closely related strains. Interestingly, however, any evolutionary differences in the sequence and structure of Prochlorococcus carboxysome shell components (CsoS3, CsoS2, and CsoS1D) do not manifest themselves in significant strain-specific differences in the expression of these genes.

Through identifying specific differences in the structure, regulation, expression, and evolution of key genes/proteins involved in photosynthesis in Prochlorococcus, my work supports the overall hypothesis that Prochlorococcus isolates have evolved specialized photosynthetic strategies to best adapt to the numerous ecological niches in the open oceans. In particular, my results suggest that the specialization of the Pcb proteins, particularly PcbG and its closely related PcbD proteins, may have been integral in this process of strain-specific evolution and adaptation.

Exploring the Function of Phytosphingosine in Physcomitrella Patens

Michael Essman

This research project is the first to utilize RNA interference to examine sphingolipid function and metabolism in the moss Physcomitrella patens. Very little is known about sphingolipids in moss, although sphingolipids in higher plants have been the subject of many recent studies. We modified sphingolipid metabolism in Physcomitrella using RNAi to silence the sole sphinganine (d18:0) hydroxylase (SH) responsible for generating the most prevalent sphingolipid LCB, phytosphingosine (t18:0). Silencing the SH gene resulted in a dramatic shift in LCB profile, the predicted result of decreased hydroxylase activity. It also resulted in a profound decrease in growth. We suspected that the reduction in t18:0 availability was the cause for the dramatic reduction in growth in the SH RNAi phenotype, although the resulting accumulation of d18:0 could also be responsible. To test this, we examined whether growth could be rescued by adding t18:0 to the growth medium of SH-RNAi plants and observing whether growth increased relative to vehicle-treated SH-RNAi plants. Indeed, we found that there was a significant increase in growth after adding t18:0. Because exogenous t18:0 stimulated growth, we hypothesize that the observed reduction in growth was a result of a lack of t18:0, and not the accumulation of d18:0.

The Agrobacterium Type 6 Secretion System Modulates Hormone-Dependent Arabidopsis Defense Pathways

Elizabeth Hwang

Plant defenses rely upon hormone pathways for signaling and gene induction. Pathogens such as Agrobacterium tumefaciens may manipulate these pathways during the infection process. Our data suggest that host perception of the Agrobacterium Type 6 Secretion System triggers expression of these pathways. In addition, our results suggest a mechanism by which Agrobacterium may subvert host defense responses.

Are pgi and mpi Under Balancing Selection in Heliconius Butterflies?

Ryan Jenks

Heterozygote advantage, a type of balancing selection, has been studied in many different organisms, including humans. Here we tested for heterozygote advantage in two metabolic genes, mpi and pgi, in the tropical butterflies Heliconius petiverana and Heliconius rosina. The two genes were chosen based on previous evidence pointing to balancing selection. For pgi, balancing selection has been described in two high latitude butterflies, Colias and Melitaea cinxia. For mpi, a previous study in Heliconius found very high nucleotide variability and incongruence between gene trees and species trees. Taken together, these results could be indicative of balancing selection. We ran statistical tests on cDNA, to avoid the long introns, of both genes and created gene trees for each. None of the tests were statistically significant, and our gene trees were identical to the species tree. Interestingly, the Tajima's D value was negative for each individual gene, indicating a change acting across the entire genome (possibly population expansion), rather than natural selection acting on a particular gene. There was no evidence for balancing selection acting on either gene for our species. The types of habitats Heliconius butterflies live in could explain the lack of balancing selection. However, it could also be due to environmental factors. Melitaea cinxia butterflies show heterozygote advantage in low to moderate temperatures, but homozygotes for pgi have an advantage in higher temperatures. As Heliconius butterflies are from tropical environments, the higher temperatures could account for the lack of balancing selection found.

Regional Specificity in Dopaminergic Rescue of Endogenous Arousal

Yiqin Jiang

The driving force behind consciousness and behavior is arousal, which can be further separated into distinct endogenous and exogenous subcategories. The biological anime dopamine (DA) has been shown to play a role in human disorders of arousal. Furthermore, previous research has linked the Drosophilia gene, DopR1, to variability in arousal. DopR1 encodes for a receptor that is homologous to the human DA1 receptor. In the present study, a mutation of in DopR1, DopR[f02676] (DopR), is used. DopR is hypomorphic, and contains a UAS sequence, which when enhanced by

Gal4 produces a functional version of DopR. This genetic technique can be used to target the expression of DopR into specific neuroanatomical regions to examine their role in behavior. Selective expression of DopR into the ellipsoid body is seen to have effects on exogenous arousal; however, endogenous arousal and regional specificity is not yet well characterized. Here, I show that a complex pattern of neuroanatomical rescue into the mushroom bodies and fans-shaped body with DopR is sufficient to restore wild type circadian behaviors, while a subsection of these neuroanatomical regions are not. These findings suggest a complicated pattern of dopaminergic signaling between different neuroanatomical regions that holistically contribute to behavioral phenotypes.

Activating Dopaminergic Neuronal Circuits That Regulate Arousal in Drosophila Melanogaster

Brian Kirchner

Arousal is a state of alertness and wakefulness that underlies all behavior, as well as sensory perception and cognition. Endogenous arousal is that which drives the daily patterns of sleep and wake seen in most animals. A circadian clock in the central nervous system cycles autonomously, regulating the rhythm of this endogenous arousal. Acute environmental inputs can mediate levels of exogenous arousal, inducing behavioral changes on a more immediate timescale than those regulated by endogenous circadian arousal changes. Dopamine is involved in mediating these two manifestations of arousal in various neuroanatomical pathways via the action of dopamine receptors, including DopR, the human D1 receptor ortholog. In Drosophila melanogaster, it is unclear how much the two arousal systems overlap functionally in the neuroanatomy of the central nervous system. This was investigated by activating subsets of DopR-expressing neurons expressing the heat-activated Drosophila Transient! receptor potential A1 channel (TRPA1). By elevating the environmental temperature above the TrpA1 activation threshold in different neural pathways, we observed the effects of activating those pathways on sleep and locomotor activity in a circadian monitoring assay as well as on startle-induced visuolocomotor behavior in a fly stampede assay. Our results suggest that major neuropil structures including the mushroom bodies, the ellipsoid body, and the fan-shaped body can be subdivided into complexly interacting circuits that regulate endogenous arousal. The exogenous arousal pathways mediating visuolocomotor behavior are easily overwhelmed by ectopic activation of a variety of neural circuits. Our results also indicate that the level of activation within and the interaction between activated circuits are both critical factors in regulating arousal.

Construction of Chromosome Fragmentation Vectors of Localize Origins of Replication in Tetrahymena thermophila

Grace LaPier

Tetrahymena thermophila is a single-celled ciliate with two nuclei. The micronucleus, which has five pairs of chromosomes, is the germline nucleus and divides by mitosis. The macronucleus has about 45 copies each of approximately 181 chromosomes, as well as chromosome-containing ribosomal DNA, present at about 9,000 copies. The macronucleus is formed from a mitotic copy of the micronucleus during conjugation. The macronucleus divides amitotically.

DNA replication is initiated when the origin of replication complex (ORC) binds to DNA. Each macronuclear chromosome must contain an origin of replication, where the ORC would bind. However, few origins of replication have been identified in the macronucleus. Fragmentation of macronuclear chromosomes would allow for the location of origins of replication, as only fragments containing origins of replication would continue to replicate.

Chromosome 8254260 was selected for study. Chromosome fragmentation vectors must be constructed in order to break the chromosome in the desired locations for origin of replication localization. These vectors contain Tetrahymena DNA to serve as a site of homologous recombination, as well as chromosome breakage sequences to break Tetrahymena DNA and endogenously add telomeres. Three methods were used to attempt to construct vectors: overlap extension polymerase chain reaction; conventional restriction enzyme digestion and ligation; and polymerase chain reaction, restriction enzyme digestion and ligation. Once vectors are successfully produced, they can be transformed into Tetrahymena to help localize origins of replication on chromosome 8254260.

Regeneration of the Tracheosyringeal Nerve Following Transection: Central Reorganization and Effects on Song

Nicole Lou

Brain plasticity involves the concept of a brain adapting to its environment and allows for processes such as development, learning and repair of an injury. Zebra finch males learn and stabilize their songs during a critical period which ends at 90 days of age. However, injury to the tracheosyringeal nerve connecting the brain and the syrinx (the avian vocal organ) in mature birds induces a response that mediates new axon connections formed in repairing the nerve, indicating that mature zebra finches retain the ability to regenerate peripheral nerves. These newly formed projections were traced from the syrinx to nucleus nXIIts in the brain, which displayed a disrupted topographical map of syringeal muscles, despite a recovery of the template song. The number of new axon connections formed in the tracheosyringeal nerve had a negative relationship with subjects' age, while it was directly correlated with song recovery and song consistency. This experiment did not successfully trace the source of topographical disruption within nXIIts, but it did directly relate neural regeneration to behavioral recovery.

Huddling and Nest Building Do Not Completely Ameliorate the Cold Stress of Typical Housing in Mice

Rebecca Maher

Huddling and nest building are two methods of behavioral thermoregulation commonly utilized by mice under cold stress. Lab mice are typically housed at an ambient temperature (Ta) of 20°C, approximately 10°C below their thermoneutral zone of 30°C. We tested the hypothesis that the thermoregulatory benefits of huddling and nest building would lower heart rate (HR), blood pressure (BP) and metabolic rate (MR) of mice housed at 20°C to levels typical of mice housed at 30°C. Outbred mice were implanted with EKG/BP/core body temperature (Tb) telemeters, housed in metabolic cages and, using a repeated-measures crossover design, exposed to one of four conditions: 1) singly housed at 20°C, 2) group housed at 20°C, 3) singly housed with nesting material at 20°C, 4) singly housed at 30°C. There was a main effect of temperature in all measured parameters and no interactions due to group housing or nesting. In a second study, the same telemeter implanted mice were singly housed at 20°C before being assigned to either group housing or nesting at 20°C for a 10 day acclimation period. The mice were then singly housed at 30°C for one week. Again, there was a main effect of temperature in HR, BP, and daily food consumption, but no interaction due to group housing or nesting. In a final study, six groups of mice were allowed to acclimate to one of three conditions at either 20°C or 30°C: singly housed, group housed, or with nesting material. Group housing and nesting at 20°C significantly decreased plasma T3 levels and UCP1 expression in brown fat below that of singly housed mice at 20°C. These findings indicate that huddling and nest building lessen but do not completely ameliorate cold stress at 20°C.

The Role of Sex Hormones in Rapamycin-Induced Diabetes in Mice

Uttara Partap

While rapamycin is known to increase longevity in aging mice, it has also been shown to induce insulin resistance and glucose intolerance. We initially tested the hypothesis that long-term rapamycin dosage induces diabetes in mice. Outbred male and female mice were fed a rapamycin-containing diet for approximately 1 year, and analyzed for markers of diabetes. Only male mice were found to exhibit diabetic symptoms, including elevated fasting blood glucose (256±12 vs. control-fed: 87±5mg/dL) and detectable urine glucose (14,600±1,680mg/dL). Female mice remained euglycemic (91±3 vs. control-fed: 83±2mg/dL) with no detectable urine glucose. We then hypothesized that testosterone (T) was facilitating the progression of and 17β-estradiol (E2) was protecting against rapamycin-induced diabetes. A subset of males and females from the initial group was gonadectomized and monitored with weekly glucose tolerance tests for changes in diabetic status. Over 11 weeks post-castration, male mice showed a decreased rate of decline in glucose tolerance (ΔAUC=3114±2288 vs. sham: 9,094±5053mg.min/dL). Female mice progressively developed glucose intolerance (ΔAUC=8265±2329 vs. sham: -900±1153mg.min/dL) during the 10-week period post-ovariectomy . This was partially reversed by E2 administration over 4 weeks (ΔAUC=-7491±3542 vs. vehicle: -2141±1430mg.min/dL). Analysis of plasma samples indicated that glucose intolerance was not distinctly associated with fasting insulin

concentration: among rapamycin-fed mice, ovariectomized vehicle-implanted females, ovariectomized E2-implanted females, and sham-operated males showed comparable levels (1.0±0.09, 1.08±0.36, and 1.08±0.22ng/mL respectively). Western blots indicated no significant association between Akt phosphorylation and glucose intolerance. These results implicate T in the progression of and E2 in the protection against rapamycin-induced diabetes, through pathways distinct from regulation of insulin production and Akt signaling.

Chronic Rapamycin Treatment Confers Partially Reversible Diabetes Mellitus

Christine Schindler

Chronic rapamycin treatment, initially thought to promote longevity in mice, is now associated with impaired glucose homeostasis and insulin resistance. It was therefore hypothesized that chronic rapamycin treatment would cause reversible diabetes in mice. Outbred mice were treated with oral rapamycin for a period of one year and were assessed with glucose, insulin and pyruvate tolerance tests (GTT, ITT, PTT). Area under the curve analysis (AUC) of GTTs showed glucose intolerance in rapamycin treated males (AUC 10419±1839 vs. 2975±318 min-mg/dL) and rapamycin treated females (AUC 4744±867 vs. 2936±261). In a PTT, rapamycin treated males (AUC 7614 ±1044 vs. 3288 ± 575) showed pyruvate intolerance, suggesting excess gluconeogenesis. The ITT showed normal insulin sensitivity in both rapamycin treated males and females suggesting diabetes complications are a result of damaged islet cells, however an analysis of pathology showed no significant islet degradation. When rapamycin was removed from the diet, fasting blood glucose fell from 294±28 mg/dL to 135±11mg/dL (ad lib cohorts: 96±6 mg/dL) and had increased glucose tolerance (AUC 4877±742) in males. Females also exhibited increased glucose tolerance (AUC 2571±322) after removal of rapamycin treatment. These data suggest impairment of islet cell function in rapamycin treated mice that is partially reversible.

Investigating the Presence of Female Preference for Species-Typical Syntax in Male Zebra Finch Song

Rebecca Shoer

Zebra finch males sing in a syntactically linear manner. Although each male sings a unique combination of syllables, the pattern of singing is the same across the species. What might drive species typical syntax? One possibility is sexual selection. Female preferences may guide the development of zebra finch song. This project assessed the role of syntax linearity in female preference, and whether female presence during adolescence drives a male to develop a syntactically species-typical song. Females viewed a video presentation that was artificially generated. Short clips of a male singing were combined with either an atypical (variable) or typical (linear) syntax, assembled from prerecorded male syllables. Females' responses to the songs were video recorded, and their behavior was subsequently scored. All females showed a significant attention preference for either typical, atypical, or both syntax types, showing they attended to videos of males singing. However, there were no overall preferences for variable or linear syntax, although some individual females had significant preferences for one of the stimulus types.

In addition, four males were raised in isolation chambers without fathers, so that they did not have the opportunity to copy from a male tutor during song learning and development. Two males were raised with their sisters and two males were raised alone. Once the males' songs had crystallized, these songs were recorded and analyzed for syntax structure. Syntax structure was calculated as sequence stereotypy and stop variability. Males raised with their sisters had normal stereotypy and stop variability. Males without females did not have typical stereotypy and variability values. One male had significantly higher stereotypy and lower stop variability, indicating a highly stereotyped song with little variation. The other male had significantly lower stereotypy, with average stop variability.

Females appear to play an important role in the development of male song. Males raised with their naive sisters developed species-typical syntax. In contrast, males raised alone developed either more variable or more linear syntax than typical zebra finch song. However, the behavioral assay testing adult, experienced females did not reveal a consistent preference for typical, linear male syntax over all subjects. It may be that this behavioral assay was not sensitive to female preference, and that the small sample size limited the results. Nevertheless, the paradoxical nature of these results raise interesting questions about the interplay of male and female influences on song development.

Effects of Long Chain Base Modification on Growth and Metabolism in Physcomitrella Patens

Marissa Thiel

This thesis examined the effects of long chain base modification on growth and metabolism in Physcomitrella. We utilized RNAi to silence hydroxylase and a desaturase in Physcomitrella. In both of these transformants, a dramatic reduction in growth was observed. Comparison of cell length to total growth area showed that reduced cell size was strongly correlated with a reduction in the growth area of the plantlets. Transmission electron microscopy showed that both SH and DS transformants exhibit apparent plasmolysis. LCB profiling of the SH transformant showed a decrease in from the phytosphingosine (t18:0) and an increase in sphinganine (d18:0) variant, as was expected from silencing hydroxylase activity. Surprisingly, LCB profiling of the DS transformant showed an increase in desaturated LCBs. We hypothesize that this may be due to activity of another desaturase compensating for the silencing of the first desaturase. RT-PCR analysis was used to examine changes in the sphingolipid metabolic pathway. Most notably, we observed a change in expression consistent with a shift from glycosyl inositolphosphoceramide formation to glucosylceramide formation in the SH-RNAi and, to a lesser degree, DS-RNAi transformants.

Spatial and Temporal Population Genetic Structure in Disjunct Populations of the Arctic Plant Sagina nodosa, in Isle Royale, Michigan

Carrie Tribble

Sagina nodosa (knotted pearlwort) grows circumboreally in the sub-artic zone. Disjunct populations grow in the Isle Royale archipelago, Michigan. These populations occur at the southernmost edge of the species' range, making the population of interest in relation to thermal tolerance and climate change adaptation. The results of our analysis will add to our limited understanding of genetic responses to climate change. Given Isle Royale's protected status as a National Park, any changes in the population are likely due to measured shifts in weather patterns. We conduct microsatellite analyses of temporal and spatial separation in S. nodosa from Isle Royale. Here, we analyze a total of 179 individuals collected in two time periods: 1997-2000 and 2011, as well as from 4 distinct islands in each time period. We find evidence of strong hierarchical structure between islands and high inbreeding within island. We believe that S. nodosa pollination and seed dispersal methods prevent significant gene flow from occurring across the water channels between islands. We additionally report strong evidence of genetic change over the past decade, indicating that climate induced environmental stress may be affecting populations of S. nodosa in Isle Royale.

Demonstrating Chromosome Fragmentation and Telomere Addition in Tetrahymena thermophila

Emily Whicker

The ciliate, Tetrahymena thermophila, exhibits nuclear dimorphism. The germline micronucleus contains five pairs of chromosomes, and divides mitotically during asexual reproduction. The somatic macronucleus, derived from a copy of the micronucleus during conjugation, contains ~45 copies of 180 chromosomes and ~9000 copies of the rDNA chromosome. The macronucleus divides amitotically during asexual reproduction, which can lead to an unequal distribution of chromosomes to the daughter nuclei. However, cell lethality across generations due to chromosome loss is not observed, and thus, the presence of a copy number control mechanism that preserves the correct copy number of each macronuclear chromosome is indicated.

Artificial fragmentation of the macronuclear chromosomes using plasmid vectors containing a Chromosome Breakage Sequence (Cbs) should allow for the detection of a copy number control region. The vector inserts into the genome by homologous crossing over, and fragmentation occurs due to Cbs processing and telomere addition to the fragmented ends of the chromosome. Previous students have obtained and characterized transformants, although telomere addition to the fragmented ends of the chromosome has not been conclusively shown.

In this thesis, PCR analysis demonstrated telomere addition to the fragmented end of the recovered chromosome in nine different transformants, and Southern hybridizations to further show telomere addition initiated. Furthermore, the construction of additional fragmentation vectors was attempted.

Hspb7 Expression in Both the Embryo and Yolk Syncytial Layer Contributes to Zebrafish Valvulogenesis

Jonathan Wosen

Congenital heart defects occur in 1-2% of the roughly 4,000,000 annual live births in the United States; understanding the causes of these defects is critical to their prevention. Unlike other organs, the heart begins functioning before fully completing development, making it sensitive to feedback from contractility and hemodynamic forces exerted by shear stress or hydrostatic forces of flowing blood. Zebrafish are a useful model for the human heart at three weeks of development, a critical period at which heart morphogenesis begins.

Previous research has identified a role for small heat shock protein (sHsp) hspb7 in heart development. Morpholino knockdown of hspb7 during the 1-4 cell stage randomizes heart laterality (Lahvic, 2010). Moreover, hspb7 morphants suffer from reduced ventricle size, over-proliferation of valve tissue, and failed or reduced migration of cardiac progenitor cells (Springel, 2012). Interestingly, the migration defect is also observed when hspb7 morpholino is injected 3-4 hours post-fertilization (hpf). At this stage, morpholino is restricted to the extra-embryonic yolk syncytial layer. This observation raises two questions 1. What is the identity of the migration-promoting YSL signal? and 2. What effects does this signal exert on later events in heart development?

Work on the first question remains ongoing, but to address the second question, we tested whether valve formation is cell autonomous (i.e. independent) of hspb7-regulated signals in the yolk syncytial layer (YSL)—however, the evidence presented here suggests that both YSL and embryonic hspb7 contribute to valve formation. In addition, we also tested hspb7 cDNA for alternative splice isoforms as part of an ongoing effort to understand the failure of previous attempts to rescue the phenotype of hspb7 injection. Our data provide no evidence for hspb7 splice isoforms in zebrafish based on sequencing of 3' cDNA ends.

CHEMISTRY

Synthesis and Characterization of Mannose-Functionalized Polymeric Micelles

Lauren Abougi

Self-assembling glycopolymers have garnered increased attention from the scientific community as an effective solution to the complications presented by current therapeutics. Using glycopolymers to encapsulate highly toxic drugs, targeted delivery can be achieved by exploiting the enhanced permeation and retention (EPR) effect and by functionalizing polymers with sugar moieties specific to receptors present on tumorassociated cell lines. With this combination of passive and active targeting in mind, amphiphilic diblock copolymer poly(2-(α-D-mannosyloxy)ethyl methacrylate)-copoly(tert-butyl acrylate), or pMannHEMA-co-ptBA, was synthesized in seven different molecular weight and diblock compositions using reversible addition fragmentation chain transfer (RAFT) polymerization.

These glycopolymers exhibited low critical micelle concentrations, ranging from 0.08 mg/mL to 0.93 mg/mL in ddH$_2$O. By dynamic light scattering and transmission electron microscopy, the micelles were shown to be spherical in shape and between 70 and 100 nm in diameter. The binding behavior of the copolymer with concanavalin A (ConA) was also examined by measuring the turbidity change rate. Each of the copolymers displayed increased absorbance in the presence of ConA, indicating receptor recognition. Consequently, this work provides a general synthetic route to self-assembling glycopolymers. Due to this self-assembling nature and receptor recognition abilities, glycopolymers such as these are distinguished as potentially clinically relevant molecules in the future of drug delivery.

Manipulation of the Electronic and Optical Properties of Phenylenevinylene-Based Oligomers Through the Incorporation of Polycyclic Aromatic Hydrocarbons

Christopher Corbett

The Earth's increasing energy demands combined with the diminishing reserves of fossil fuels motivates the exploration of renewable and cleaner energy sources. Solar energy has the potential to meet the Earth's growing energy

needs, but current solid state devices are costly, require time to produce, and have less than ideal efficiencies. Organic electronic devices, and specifically organic solar cells are of great interest in designing the next generation electronic devices to replace current solid state devices. Organic solar cells have the potential to be lighter, cheaper, easier to produce, and more efficient than current silicon-based devices. Work in the Park Lab, which previously focused on designing these devices, has focused on the active materials that are necessary for charge excitation and transport, and are ultimately responsible for the production of current. Our goal is to alter the structure and properties of the electron donor component of the active layer through the incorporation of polycyclic aromatic molecules into the parent oligomer. Several variations of the parent trimer were produced that incorporated these highly conjugated arenes. The increase in conjugation due to the addition of these compounds has significant effects on the absorption and emission properties of our oligomers.

Construction of Biological and Chemical Systems for Novel Antibiotic Drug Discovery

Bryn Falahee

Antibiotics were arguably one of the most important discoveries of the 20th century. With the invention of antibiotics, the average lifespan of the human population substantially increased. However, many microbes have developed resistance to antibiotics currently used in the clinic. If new antibiotics are not developed, diseases and infections that were once considered easy to treat may become incurable. To develop novel antibiotics, we will target histidine kinase CckA. This kinase mediates an essential signaling pathway in Caulobacter crescentus. Additionally, histidine kinases are highly conserved in the bacterial genome, making CckA a good target.

Using disulfide exchange screening, we synthesized small drug fragments to use in fragment based drug discovery. Here, we provide a successful synthetic approach for building disulfide drug fragments. We also present the optimization of the protein system that will be used to test the drug fragments. An unnatural cysteine residue was designed and incorporated into CckA so that the protein can be used for disulfide exchange screening. Two cysteine mutants were expressed and purified, T498C and V488C. We also compared kinetics of the mutated CckA constructs to the wild type protein to verify that the mutations did not dramatically alter the active site of the protein. Preliminary inhibition data of AMP-PNP was obtained for the V488C mutant. Additionally, the T498 and wild type proteins were tested on LCMS to verify that the proteins could be visualized for tethering analysis. Moving forward, protein expression and purification should be optimized and kinetics data should be verified. The work accomplished thus far prepares the lab to move forward with initial disulfide exchange screening.

Role of Proteases and a Protease Inhibitor in Streptomyces coelicolor Development

Emily Gao

Streptomyces coelicolor is the model organism for the Streptomyces genus of gram-positive, soil dwelling bacteria with a complex multicellular life cycle intimately coordinated with its production of secondary metabolites such as antibiotics. The NY415 bald mutant is a developmental mutant of the species incapable of forming an aerial mycelium and thus provides a prime opportunity to study the molecular pathways and interactions that give rise to the organism's complex life cycle. The NY415 bald mutant has a higher extracellular protease activity and produces much less Streptomyces trypsin-like inhibitor (STI) than the wild type strain. Previously, it was found that exogenous addition of wild type culture supernatant to NY415 bald colonies was capable of recovering normal development. This suggests that some species secreted by the wild type is crucial and missing in NY415 culture supernantant and provides further incentive to monitor the protein differences between the mutant and wild type. Overexpression of SCO0732 was found to delay and possibly reduce sporulation, suggesting that lower levels of SCO0732 expression are needed for normal sporulation. Mutation of SCO0762, the gene for Streptomyces trypsin-like inhibitor (STI), also led to delays in and disruption of the sporulation process. Analysis of the protease activity of the SCO0762 mutant and the SCO0732 overexpression strain suggested that both strains have increased protease activity in comparison to the wild type. An assay was developed to quantify protease inhibitor activity, and tested using the protease inhibitor leupeptin. Finally, it was found that exogenous addition of concentrated wild type culture supernatant to NY415 cells could not consistently cause a recovery of normal development in this bald mutant, suggesting that the species responsible for this recovery is only effective at the proper concentration.

Manipulation of the Electronic and Optical Properties of Polycyclic Aromatic Hydrocarbons Through the Incorporation of Electron-Withdrawing Functionality

Alejandro Gimenez

As we envision newer, more modern, and greener devices to address our current energy concerns, there are limitations with relying on current solid state materials, as they are costly, heavy, and exhibit less than ideal efficiencies. Organic electronic devices, which have the potential to be cheaper, lighter, and more efficient, may be better suited for the applications of the future. These devices are fundamentally based on polycyclic aromatic hydrocarbons, which exhibit interesting optical and electronic properties that can be fine-tuned. In the Park Lab, we have explored various conjugated systems, which could serve as potential electron donor or acceptor materials in the active layer of solar cells. In particular, we introduced a set of electron-withdrawing substituents to various arenes in the hope of tuning their electronic structure. We probed the effects of various substituents on the absorption and emission properties of anthracene, pyrene, and perylene, and found that the electronic structure of these various arenes can be tuned systematically.

Copper(I) and Copper(II) Complexes with Tetradentate Pyridine-amine Ligands as Atom Transfer Radical Polymerization Catalysts

Sarah Guillot

Atom transfer radical polymerization (ATRP) is a versatile, metal-mediated method of producing polymers with controlled composition and molecular weights. The redox couple of the metal tunes control by modulating the equilibrium between the growing, active radical state and the capped, dormant state of polymer chains. Ligand structure has been shown previously to strongly impact the catalysts' ability to control the polymerization. Polydentate ligands of amine and pyridine donor moieties have produced some of the most active ATRP catalysts. In this work, copper bromide complexes of neutral tetradentate pyridine-amine ligands with additional amine, ether or thioether donor atoms were synthesized and utilized in the ATRP of styrene. We explored how differences in ligand design affected the efficiency of the ATRP of styrene. All complexes were active ATRP catalysts with fast polymerization rates and good molecular weight control. Redox potentials ranged from -0.1 to -0.3 V (vs. SCE). As expected, the variation in donor atoms impacted the degree of control and rates of polymerizations. Diverse structural motifs in the solid state and NMR evidence of ligand fluxionality in solution relate to differences in polymerization rates and control, and affirm ligand design as an effective tool to tune the rate and degree of control in ATRP.

Characterization of a Novel Carrier Protein Phosphodiesterase, SCO6672, in Streptomyces coelicolor A3(2)

Sora Kim

The *Streptomyces* are a genus of filamentous, Gram-positive soil bacteria that are known to produce a wide array of secondary metabolites, many of which have therapeutic significance as antibiotics. Many of these antibiotic molecules are nonribosomal peptide or polyketide compounds. Essential to biosynthesis of these antibiotic molecules is the post-translational attachment of the 4'-phosphopanthetheine (Ppant) group onto the carrier protein(s) catalyzed by phosphopantetheinyl transferases (PPTases) to generate holo-carrier protein(s). The SCO6673 PPTase is one of three PPTases encoded in the *S. coelicolor* A3(2) genome, the model organism for the genus, and this enzyme has been shown to be required for calcium-dependent antibiotic (CDA) biosynthesis.

The *SCO6672* gene is adjacent to and upstream of *SCO6673* and encodes a protein with a putative metallophosphoesterase domain that shares homology to calcineurin-like phosphoesterases. SCO6672 was previously shown to catalyze hydrolysis of the Ppant group from a PCP domain of the CDA synthetase *in vitro*, and this is hypothesized to serve as a post-translational mechanism of control of antibiotic biosynthesis by regulating the availability of holo-carrier proteins. These preliminary observations of SCO6672 phosphodiesterase activity were confirmed with a general phosphodiesterase substrate, bis-pNPP, and two more PCP domains of the CDA synthetase as assayed through MALDI-TOF mass spectrometry and conformationally-sensitive polyacrylamide gel electrophoresis.

The physiological function of SCO6672 *in vivo* was investigated by studying the effect of complementation on antibiotic production and morphological differentiation of a D*SCO6672-6673*::*apr* mutant. We found that undecylprodigiosin (RED) production in complemented strains was restored to levels comparable to the wild-type strain, and that overexpression of SCO6672 led to underproduction of RED; effects of complementation and overexpression on CDA production or morphological differentiation were inconclusive. These results suggest that the physiological role of SCO6672 in *S. coelicolor* A3(2) is complex, and that it may influence multiple aspects of antibiotic biosynthesis.

Amino Acid Based Thermoresponsive Micelles

Alexander Lou

Micelles assembled from amphiphilic copolymers have garnered interest for their potential application to targeted drug delivery. We have synthesized several polymers of the form poly(N-acryloyl-(amino acid)-N-isopropylamine)-block-poly(acrylic acid) using methionine, alanine, valine, isoleucine, and phenylalanine. Benzyl containing monomers, whether the benzyl moiety was an end group or in the side chain, were the least polymerizable. Their self-assembly and thermoresponsive behaviors were probed by dynamic light scattering (DLS) and circular dichroism (CD). The copolymers exhibited stable CD spectra, independent of assembly state or temperature. DLS revealed methionine-based micelles of 15 and 33 nm in radius, and phenylalanine-based micelles having a critical micelle temperature (CMT) of 45 - 50˚C. Self-assembly and potential for tunable thermoresponsive behavior makes these polymers promising as drug delivery systems.

Targeting LexA Cleavage to Prevent the Development of Antibiotic Resistance: In vivo Characterization of LexA Cleavage Inhibitors

Lovemore Makusha

The phenomenon of antibiotic resistance has resulted in the need for new strategies to combat bacterial infections. Bacteria quickly develop resistance, rendering current antibiotics ineffective soon after discovery. In this context, the SOS system, an inducible DNA repair mechanism whose activation has been implicated in the development of drug resistance, has emerged as an intriguing drug target. Herein, we report of the systematic discovery of compounds that inhibit LexA cleavage, a key step in the activation of the mutagenic SOS response. Through a high-throughput assay previously developed in our lab, together with in vitro protein assays, we discovered ten compounds that inhibit Escherichia coli LexA cleavage. We developed an in vivo reporter assay using a Bacillus subtilis strain containing the lacZ gene under the transcriptional control of an SOS promoter and showed that all five of the compounds we tested mitigated the induction of the SOS response, presumably through inhibition of LexA cleavage. Moreover, the concentration dependence of in vivo inhibition correlated well with in vitro results in the distantly related E. coli species. Together, our results indicate the feasibility of targeting LexA cleavage to abrogate the production of resistance-conferring mutations in the bacterial genome.

Deterministic and Stochastic Analysis of a 2-gene Minimal Oscillator

Steve Mendoza

We analyze a 2 gene minimal oscillator with differential and stochastic techniques. We find conditions that maximize the amount of oscillations. In particular, we find that oscillations in the stochastic regime are optimized by larger particle numbers and higher cooperativity constants. We also try to generalize our results to a circadian rhythms model in Drosophila. Doing this, we find that our results are qualitatively similar to those found in the paper. We argue that our model could serve as a template for other oscillatory genetic circuits in nature.

Advancements Toward the Total Synthesis of Jerangolid D

Mika Nakashige

Efforts towards the total asymmetric synthesis of jerangolid D are elucidated in this document. Jerangolid D is a polyketide natural product isolated from the Sorangium cellulosum bacterium and is known to exhibit antifungal

properties. Jerangolid D contains two rings: a cis–dihydropyran and an α,β-unsaturated δ-lactone. These two rings are joined by a doubly allylic remote stereogenic center. Ambruticin, another antifungal secondary metabolite, shares several structural components. The synthesis of the cis–dihydropyran highlights the reductive carbon-Ferrier rearrangement reaction that was optimized during the course of this research. From here, we strategically intercepted Jacobsen's synthesis of ambruticin and take advantage an asymmetric hydroformylation to set the remote stereogenic center. The remaining steps were adapted from methods for kavalactone syntheses developed in this lab to create the α,β-unsaturated δ–lactone and ultimately yield jerangolid D.

Identification and Characterization of Bacterial SOS Response Inhibitors

Asvelt J. Nduwumwami

The development of bacterial resistance to current frontline antibiotics is becoming increasingly problematic in the treatment of bacterial infections. Recent evidence suggests that the bacterial SOS response plays an active role in tolerance to current therapeutic agents and is involved in pathways that lead to full-fledged antibiotic resistance. The SOS response is widespread among bacteria and its regulation is conserved. This SOS system is therefore an attractive target for development of antimicrobials. To validate the SOS response as a novel target in combating antibiotic resistance, we have screened 3520 small bioactive molecules for their ability to inhibit LexA cleavage, the prerequisite for the induction of the SOS response. We identified a total of eight compounds that inhibited LexA cleavage in addition to two previously found in the Lovett Laboratory. Seven of those compounds inhibited only RecA-mediated LexA cleavage in Escherichia coli and three of them inhibited both RecA–mediated cleavage and RecA-independent LexA autodigestion at pH 10.

Synthesis and Characterization of Substituted Acenes For Use as Electron Donors and Acceptors in Organic Solar Cells

Erica Wu

Electronic devices fashioned out of organic compounds may offer numerous benefits compared to their solid-state, silicon-based counterparts; they have the potential to be cheaper, lighter, more flexible, and more efficient. In particular, organic solar cells are increasingly being researched in response to growing global energy consumption. The Park Lab is interested in exploring various conjugated systems for use in the active layer of organic solar cells, and this year, we worked on developing a synthetic library of various substituted acenes, linearly fused polycyclic aromatic hydrocarbons. Pentacene-based reaction chemistry was explored, as pentacene's small bandgap and high charge mobility confers interesting optical and electronic properties for use in organic electronic devices. Pentacene-based compounds were synthesized and characterized in this project, and the addition of electron-withdrawing substituents was found to significantly impact the absorption and emission properties of pentacene, as well as lead to increased rates of photooxidation.

Synthesis of Disulfide Fragments for Site-directed Ligand Discovery with CckA

Peter Young

One promising method for discovering new, effective drugs is to find new cellular machinery to target. Histidine kinases (HKs), which mediate two-component signaling pathways (TCSs) in bacteria, may represent a viable new target for pharmacological inhibition. CckA, an essential HK in Caulobacter crescentus, is an excellent platform of discovery for TCS inhibitors. With site-directed ligand discovery (or "tethering")—a fragment-based technique—small, weakly binding disulfide drug compounds can be covalently trapped in the enzyme active site by cysteine-capture, where they can be detected by whole-protein mass spectrometry. This technique allows the energy landscape of the active site to be probed and characterized so that a powerful CckA inhibitor can be constructed from scratch.

With this in mind, a CckA mutant with a cysteine within 5 Å of the ATP binding site, His_6-$CckA_{190-562}$-V488C, was engineered as a covalent handle for site-directed ligand discovery with CckA and identified by MALDI time of flight whole-protein mass spectrometry. It was found that the two-step, one-pot synthesis of disulfide fragments for screening

with cys-CckA is best conducted with (1-Cyano-2-ethoxy-2-oxoethylidenaminooxy)dimethylamino-morpholino-carbenium hexafluorophosphate instead of 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide) due to an unidentified impurity. A disulfide fragment library of nine compounds was synthesized and identified by ^{1}H-NMR and LC/MS. Using cysteine-capture, these nine fragments can be screened for even weak binding activity in the CckA active site. Eventually, this technique could lead to the discovery of a novel, effective drug that functions by inhibition of histidine kinase mediated TCSs.

Towards the Total Synthesis of Enigmazole A: Model Studies Toward a C_1-C_{12} Fragment

Menghan Zhao

Enigmazole is a phosphorylated 18-membered macrolide natural product isolated from the sponge Cinachyrella enigmatica. The molecule exhibits potent cytotoxic activity, although its mechanism of action is unclear. Enigmazole A also possesses unique architectural elements, with eight stereogenic centers and a 2,4-disubstituted oxazole moiety, and has thus become an alluring synthetic target. The original synthetic plan for the molecule envisioned the use of Evans β-ketoimide aldol chemistry to rapidly and efficiently construct the C_1–C_4 dipropionate unit, while also selectively installing three of the eight stereogenic centers. However, the method furnishes a superfluous hydroxyl at the C_3 position, and removal of this hydroxyl group has proven to be a formidable challenge. Herein we report on two distinct synthetic strategies: 1) continued efforts toward removal of the C_3 hydroxyl through radical deoxygenation and 2) efforts toward construction of the C_1–C_{12} fragment without the presence of a C_3 hydroxyl, either through a rapid lactone synthesis developed in our lab or a Myers diastereoselective alkylation.

COMPUTER SCIENCE

Measuring the Effects of Energy Intermittency in Distributed Systems

Thomas J. Gaidus

Sorting benchmarks have been developed for researchers to study and compare the performance of different hardware/software configurations using a set of predefined metrics. While these metrics and benchmarks do measure many useful characteristics of the data centers, their use cases are not realistic for what production data centers performing actual sorting operations may face. GreenSort is a new sorting benchmark that accounts for the fact that many data centers are moving towards powering themselves with renewable energy-sources that often provide an intermittent supply. When power is no longer assumed to be constant and plentiful, the cluster must perform different scheduling operations to keep the energy demand always below the supply. In the GreenSort benchmark, the systems performance, while being forced to stay under the power curve, is compared to its unencumbered sorting performance to determine the systems effectiveness in dealing with the intermittency. The more efficient a system is in dealing with the new, changing power supply, the more competitive that machine is in the GreenSort benchmark competition.

This thesis describes the details and parameters of the GreenSort benchmark, and provides a sample sorting implementation, called NapSort, to act as a reference for future competitors. The performance of NapSort using four power-saving algorithms is evaluated in the context of GreenSort to highlight the intended use of the benchmark.

Home Occupancy Detection and Prediction via Energy Disaggregation

Jennifer M. Gossels

Excessive energy use is a serious problem. Although the topic is well-publicized and most people agree that "something needs to be done," few homeowners are willing to do this "something" by making lasting changes to their behavior. Thus, any effective solution to reduce energy consumption must require minimal homeowner involvement. We would like to design automated energy-saving systems that can, for example, turn off the television and lower the heat set point when the homeowner is away. However, such systems rely on occupancy detection and prediction information. Hence, before we can implement these technologies, we need to develop techniques for detecting and predicting home occupancy. We present a four-step process to detect and then predict home occupancy using only the home's aggregate power data. Because overall power data are readily available, our work will allow homeowners who cannot be bothered to install

complex sensor systems to take advantage of energy-saving mechanisms that depend on occupancy information. Using circuit-level data from one home, we begin by identifying 30 sets of appliances that commonly run together. We then train a classifier to assign unseen instances into one of these 30 classes without any circuit-level information. Third, we complete the detection stage of our project by mapping occupancy to each of the 30 classes based on their characteristic appliances. Finally, we use these occupancy detection data as inputs for an occupancy prediction algorithm. In the best case, we predict occupancy with 97.53% accuracy.

Implementing Online GreedyFuture

Donny Huang

In this thesis, we provide a practical implementation of the theoretical algorithm online GreedyFuture, and test its empirical performance.

Prototype Support Vector Machines: Supervised Classification in Complex Datasets

April T. Shen

Real-world machine learning datasets may be highly complex. Data of a single class may be distributed irregularly throughout the feature space and measures of distance as a proxy for similarity can be unreliable. Classification learning algorithms for such datasets typically require model selection, which in practice is often an ad-hoc and time-consuming process that depends on assumptions about the structure of data. To avoid this, I introduce the ensemble of prototype support vector machines (PSVMs). This algorithm trains an ensemble of linear SVMs that are tuned to different regions of the feature space and thus are able to separate the space arbitrarily, reducing the need to decide what model to use for each dataset. I also present experimental results demonstrating the efficacy of PSVMs in both noiseless and noisy datasets.

ShrinkWrap: Efficient Dynamic Race Detection for Array-Intensive Programs

James R. Wilcox

We explore a new technique for efficient dynamic race detection on programs using arrays intensively. Standard techniques lead to redundant operations and redundant representations in many common cases. For these common cases, we design dynamic compression methods that eliminate this redundancy. Finally, we implement our techniques in a prototype tool called ShrinkWrap, which is built as an extension to a state-of-the-art precise dynamic race detector. We evaluate the performance and precision of ShrinkWrap on a suite of benchmark programs. We show that our prototype can improve performance dramatically when the target program accesses arrays in a pattern we recognize. The vast majority of the accesses that must be checked by the underlying race detector can be eliminated on almost half of our benchmark programs. However, we also find that our prototype is not always as time efficient as one might expect given the number of accesses eliminated.

GEOSCIENCES

Evolution and Distribution of Permeability in a Complete Section of Upper Oceanic Crust: IODP Hole 1256D

Miranda L Bona

Permeability is the principal hydrologic parameter controlling fluid flow in the Earth's crust, yet measuring oceanic crust permeability has proven to be a challenge due to limited access and sampling. To better understand the evolution and distribution of permeability in the upper oceanic crust, we examine permeability of basalt and gabbro core samples recovered from the Integrated Ocean Drilling Program (IODP) Hole 1256D. We present a new method for determining core-scale permeability, which we call "maximum original permeability", a two-dimensional value based on the size and shape of micro-fractures analyzed in thin section. We also determine dry core-sample permeability and seawater-saturated core-sample permeability at confined pressures in the laboratory. The maximum original permeability of

these samples ranges from 10^{-18} to 10^{-14} m², dry laboratory permeability from 10^{-16} to 10^{-12} m², and saturated laboratory permeability from $<10^{-22}$ to 10^{-18} m². At Hole 1256D, permeability decreases with depth, and the 15 million year old crust preserves multiple generations of hydrothermal mineral precipitates that seal all open pore space. These fractures, which control or once controlled permeability, also vary in orientation with depth, consistent with models of crustal accretion: sub-horizontal fractures are found in the lava flows and gabbroic intrusions; sub-vertical fractures in the dikes. The distribution and evolution of permeability aids our understanding of hydrothermal circulation, the evolution of oceanic crust, the regulation of ocean chemistry, and the distribution of chemosynthetic sub-seafloor microbial communities.

Geochemical Response of Two Adjacent Alpine Basins in Green Lakes Valley, Colorado, in a Low-Snow Year

Claudia R. Corona

Stream and groundwater geochemistry reflects processes in the uppermost part of the earth's crust, where rock materials interact with the biosphere, atmosphere, and hydrosphere within the Critical Zone. This study examines the geochemistry of Saddle and Martinelli streams, which flow from two snowmelt-dominated, alpine catchments within the Boulder Creek basin, Front Range, Colorado.

Varying hydrologic inputs and biogeochemical reactions influence spatial variations of basin solute concentrations. The concept of a "representative elementary area" (REA) suggests that the variability of geochemical response to precipitation within a watershed is large when the basins are small. Recent literature suggests basin areas of 0.10-15.0km², represent the threshold where solute concentrations become fairly constant. Careful sampling of small (0.25 km²) headwater catchments, which encompass zero order ephemeral and intermittent streams, can be used to test whether the REA concept is valid.

Hydrologic, chemical, and spatial data were collected at a site and synoptically upstream and compared to long-term hydrologic, chemical, and meteorological datasets for Saddle and Martinelli basins. My work emphasizes 2012, a summer of low snowmelt and abundant rainfall, and incorporates data from 2010 and 2011. Basin discharge measurements show 2010 was an average water year, 2011 was a wet water year, and 2012 was a low flow year.

Analysis of major ions (Ca^{2+}, Mg^{2+}, Na^+ and K^+, Cl^-, SO_4^{2-}, HCO_3^- and NO_3^-) and dissolved SiO_2 in 126 water samples shows near neutral pH, and low solute concentrations; Ca^{2+} is the dominant cation and HCO_3^- is the dominant anion. Calculations of total solute flux for the Saddle and Martinelli basins show that cations are derived mainly from weathering and anions are controlled by precipitation and biologic activity. Precipitation accounts for <20% of stream export of K^+, Mg^{2+}, and Na^+ and 99% of the silica derives from weathering. Precipitation accounts for all of the NO_3^-, 71% of the SO_4^{2-} and 24% of the Ca^{2+} that leaves the basin. As a result of uptake by biologic activity, almost no NO_3^- leaves the basin. Downstream changes of ion concentration reflect the combined effects of increasing drainage area, longer contact times and groundwater flow. Martinelli and Saddle basin geochemistry does not show a decrease in variability with increasing drainage area, suggesting that REA concept may not apply to small, snowmelt-dominated catchments.

Geochemistry and Geothermometry of Mid Miocene to Pliocene Alkalic Rocks of the Powder River Volcanic Field

Johnny R. Hinojosa

The Neogene Powder River Volcanic Field (PRVF) is surrounded by the regionally dominant Columbia River Basalt Group (CRBG) but contrasts strongly with it compositionally, containing alkaline (highly sodic) rock types ranging from mafic to intermediate composition. The goals of this work are to constrain PRVF magma chamber temperatures based on Fe-Ti geothermometry calculations (Andersen and Lindsley, 1988 and Ghiroso and Evans, 2008) and to relate the sodium-rich lavas to possible contamination by underlying country rocks through geochemistry. Whole-rock and trace element chemistry was done by XRF and ICP-MS, respectively, while precise mineral chemistry was obtained using an electron microprobe. Geothermometry calculations yielded an approximate temperature range of 650° – 750° C for selected samples of basaltic trachyandesite, which provides a minimum temperature for magma chamber conditions. The temperature range represents the conditions where magnetite and ilmenite exsolved from solid solution.

It also allows an estimate of the depth where this occurred, between 17 – 19 km based on an elevated 40˚ C/km geo-thermal gradient appropriate to an extensional tectonic setting. Samples containing elevated Na_2O are more precisely classified as mugearite (trachybasalt) and benmoreite (trachyandesite). Based on elevated Na_2O, Sr, and Ba and light rare earth element enrichment, it is likely that a mafic parental magma related to the Yellowstone Hotspot interacted with more siliceous and sodic overlying rock such as the leucotonalite and trondjhemite from the Wallowa batholith. A future study might focus on a broader range of sampling from the PRVF and units of the Wallowa batholith in order to confirm geochemical relationships.

Using Geophysical Techniques in the Critical Zone to Determine the Presence of Permafrost

Gabriel M. Lewis

Global warming during the 20th and 21st centuries has increased air temperatures in alpine areas of the southern Rocky Mountains sufficiently to melt large areas of previously frozen ground, referred to as permafrost. Previous studies used geomorphological, hydrological, and GIS techniques to infer the distribution of frozen ground and ice lenses on Niwot Ridge and in adjacent Green Lakes Valley, Colorado Front Range. Predictions of permafrost occurrence have not previously been verified in the field by subsurface geophysical measurements, although permafrost, ice lenses, and temperature profiles beneath active gelifluction lobes were documented in several studies during the 1970s along Niwot Ridge. Electric Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) are geophysical techniques that have been utilized worldwide to study the evolution of alpine permafrost and ice lenses. Combining these geo-physical methods maximizes the accuracy of each method while reducing their inherent ambiguities and limitations. Green Lakes and 4th of July Valleys offer ideal locations to verify the existence of ice masses within rock glaciers, where models predict they exist.

This study reports: (1) interpreted results of 16 ERT and 2 GPR lines totaling 815 m that were collected to test per-mafrost predictions in alpine zones; (2) soil temperature profiles and morphology in several pits excavated to sap-rolite along ERT lines; (3) energy modeling of water temperatures for Como Creek, a small alpine creek on Niwot Ridge, compared with measured temperatures for nearby Martinelli Stream; and (4) computer modeling of subsurface temperatures from surface temperatures on Niwot Ridge, Colorado, according to a model calibrated using data from Hopkins Memorial Forest, Williamstown, MA.

Analysis of seven ERT lines from elevations of 3500 to 3900 m on Niwot Ridge demonstrates that my study area lacks permanent ice lenses (resistivity of approximately 200-1000 kΩm) beneath a surface layer of coarse, blocky debris (resistivity of ~ 20 kΩm). Gelifluction lobes, as well as nearby snow field areas, may contain seasonal ice lenses that are misinterpreted as permafrost features, but ice often melts completely by late summer. Soil and water temperatures reveal that the subsurface is too warm to permit the development of permafrost, and heat-flow models confirm this hy-pothesis. Inactive periglacial deposits within the Boulder Creek Watershed support evidence of a climate through the late Pleistocene that produced and supported permafrost and permanent ice lenses. During the last glacial maximum, temperature and precipitation values supported gelifluction and permafrost at elevations as low as Gordon Gulch. Better understanding of the present distribution of permafrost and active periglacial features helps predict changes to alpine landscapes as permafrost disappears and has implications for quantity of runoff in the near future.

A Comparative Study of Snowmelt-Driven Water Budgets in Adjacent Alpine Basins, Niwot Ridge, Colorado Front Range

Ian M. Nesbitt

The Critical Zone, which extends from the top of the weathered bedrock to the tops of the tallest vegetation in alpine and subalpine headwater areas delivers fresh water to urban corridors near mountainous areas of North America. Snowmelt runoff from alpine basins typically accounts for over 80% of annual flow, but water budgets are not well quantified nor well understood in detail. Redistribution of snow by wind, the difficulty of estimating water losses from sublimation and evapotranspiration, and groundwater gains and losses from outside the basin make streamflow and water budget measurements challenging. I investigated two adjacent 0.25 km² catchments, Martinelli and Saddle streams, both at ~3500 m, on Niwot Ridge in the Colorado Front Range. Mean annual runoff is ~230 mm (25% of mean annual precipitation) at Saddle basin and ~310 mm (30% of mean annual precipitation) at Martinelli basin, based on

12 and 28 years of gaging records, respectively.

Saddle stream is not fed by a late-lying snowpack, but records indicate that ablation-season discharge is still closely related to snowmelt in the basin. Martinelli basin shelters a ~6 m thick snowpatch in 8 ha of the basin, even in a low snow year. During much of the ablation season, snowpack mass density (ρ) is 0.5 g cm^{-3} and ablation rates are ~100 mm day^{-1}. Since vegetation is shallow-rooted or nonexistent in Martinelli, evapotranspiration (ET) is probably not a major factor. Saddle basin is more heavily vegetated, but only the lower reaches are wooded; ET is likely < 260 mm annually. Specific runoff measured at the gage during 2012 was ~270 mm at Martinelli and ~35 mm at the Saddle gage. By monitoring snowpack area changes and longitudinal discharge, we were able to demonstrate that at least 30% of annual precipitation in Martinelli basin and 10% in Saddle basin bypasses the gage as subsurface flow. Short-term yield calculations indicate that approximately 2.5% of precipitation discharges from the basin as measurable surface water within a five-day period; the rest recharges groundwater or becomes immeasurable subsurface flow. For comparison, a nearby 2.3 km^2 glaciated basin, Green Lake 4, discharges 50% of the water that falls on it within the same five-day period. Measured water yields from small, unglaciated alpine catchments thus should be viewed with caution.

Climate-Growth Relationship Divergence in the Hopkins Forest, Williamstown, Massachusetts

Sarah E. Rowe

This study analyzes climate and tree growth data from the Hopkins Forest, Williamstown, Massachusetts, to determine what climatic conditions are most favorable for tree growth. Before 1980, red oak growth is positively correlated with wet summers before the growth year and dry springs in the growth year; beech growth is positively correlated with high winter precipitation and dry springs. Sugar maple is positively correlated with wet winters and summers in the growth year, and red maple growth is positively correlated with dry winters, summers, and springs in the growth year. However, after 1980, these relationships change direction; for example, red maple growth after 1980 is positively correlated with dry summers and uncorrelated with the other seasons. This is consistent with evidence of the divergence problem, or breakdown in growth-climate relationships, witnessed globally in the past fifty years. I investigate several hypotheses to explain the divergence problem and find that phase-shift explanations are the most likely to account for this change.

MATHEMATICS & STATISTICS

Regression With Missing Data: An Investigation of the Case with Uniform Predictors and Missingness Related to the Response Variable

Jack T. Ervasti

Missing data is a very important problem in many fields, including the social, behavioral and medicinal sciences. As a result, a number of techniques for analyzing data sets with missing values have been developed and refined in the last few decades. There has also been a significant amount of research done on the bias introduced with different types of missing data when these techniques are performed.

In this paper, I investigate how various types of missingness affect the bias of regression parameters under imputation and complete case analysis. Using simulated data sets, I examine cases with normally and uniformly distributed predictor variables and different types of simulated missingness. I find that uniformly distributed predictors cause bias under different circumstances than normally distributed predictors when missing values are imputed. In particular, I find that if the predictors are uniformly distributed, regression parameters are biased when missingness is related to the response variable and are approximately unbiased when missingness is related to missing values. These results indicate a lack of investigation into missing data with uniformly distributed variables and missingness that is conditional on the response variable. Based on these findings I perform an experiment to gain a deeper understanding of the relationship between types of missingness and the bias of regression parameters in the case with uniform predictor variables.

A Trajectory Smoothing and Clustering Method for the Identification of Potent shRNAs

Alexander H. Greaves-Tunnell

RNA interference (RNAi) is a potent and specific mechanism of gene silencing with extensive applications to research, biotechnology, and medicine. Recently, there has been considerable interest in short hairpin RNAs (shRNAs) as triggers for "programmable" RNAi, due in part to the fact that they enable stable and heritable gene silencing. However, the experimental identification of potent shRNAs is costly and inefficient, and prediction of potent shRNAs for novel targets remains a major challenge. In this paper, we introduce a smoothing and clustering method for data collected from the Sensor assay, the first massively parallel biological procedure for the identification of potent shRNAs. This method is based on a novel treatment of the data as fundamentally longitudinal in nature. We identify a set of roughly 300 top performing shRNAs for the given targets, and conduct preliminary validation based on three sequence and thermodynamic features of known potent shRNAs.S

Benford's Law and Stick Fragmentation

Joy Jing

Many datasets and real-life functions exhibit a leading digit bias, where the first digit base 10 of a number equals 1 not 11% of the time as we would expect if all digits were equally likely, but closer to 30% of the time. This phenomenon is known as Benford's Law, and has applications ranging from the detection of tax fraud to analyzing the Fibonacci sequence. It is especially applicable in today's world of 'Big Data' and can be used for fraud detection to test data integrity, as most people are unaware of the phenomenon.

The cardinal goal is often determining which datasets follow Benford's Law. We know that the decomposition of a finite stick based on a reiterative cutting pattern determined by a 'nice' probability density function will tend toward Benford's Law. We extend these previous results to show that this is also true when the cuts are determined by a finite set of nice probability density functions. We further conjecture that when we apply the same exact cut at every level, as long as that cut is not equal to 0.5, the distribution of lengths will still follow Benford's Law.

Perimeter-Minimizing Tilings by Convex and Non-Convex Pentagons

Zane K. Martin

We study the presumably unnecessary convexity hypothesis in the theorem of Chung et al. on perimeter-minimizing planar tilings by convex pentagons. We prove that the theorem holds without the convexity hypothesis in certain special cases, and we offer direction for further research.

Clustering Time Dependent PITCHf/x Data

Christopher P. Picardo

In this paper I extend the powerful model based clustering framework to data that incorporates an entire time period, specifically single seasons from the PITCHf/x database. Traditional clustering methods are reviewed and described in detail in order to motivate the introduction of model based clustering. In order to apply model based clustering to the time indexed data, a cluster consistency algorithm is proposed that treats the cluster selection problem as equivalent a model selection problem from the supervised learning literature. Finally, the cluster consistency procedure is applied to the PITCHf/x dataset to select the appropriate number of clusters for several pitchers over an entire season. The PITCHf/x season data for two starting pitchers is then analyzed using the cluster movements for the entire season.

Generalizing Nondeterminism for Algebraic Computation Machines

Scott Sanderson

In this thesis we present an introduction to the BSS Machine model, which serves as a generalization of the Turing Machine model of computation. Motivated by the classical equivalence of nondeterministic computation and

deterministic verifiability, we develop an extension to the BSS Machine model that preserves important structural features of nondeterministic Turing Machines. We use our machines to develop a new family of relativized complexity classes, and we prove some containment relations between these and the BSS Machine generalizations of P and NP.

The Forest Through the Trees in Multilabel Classification

Benjamin Bradbury Seiler

Traditional machine learning classification algorithms are not suited for statistical classification problems in which an instance can simultaneously belong to more than one class. Such multilabel classification problems have prompted significant research in recent years including a concerted effort to bridge the gap between established classification techniques and this nonstandard framework. Based on such works as recently as Tsoumakas and Katakis [2007] and Vogrincic and Bosnic [2011], the vast majority of novel multilabel classification algorithms are compared to baseline problem transformation techniques using only support vector machines or linear models. In this study, we broaden the pool of potential base learners for problem transformation techniques and discover significant evidence to suggest the superiority of partition tree based methods in many cases, thereby, raising the bar for baseline competitiveness.

Formal Fibers of Height-n Primes and Completions of Complete Intersection Domains

Philip D. Tosteson

Of interest in commutative algebra is the relationship between a Noetherian local ring and its completion. This thesis investigates the relationship between a complete Noetherian local ring (T,M), and Notherian local subrings R of T that have I as their completion. In particular, given an ideal I of T and a countable collection of prime ideals C of T, we ask whether there exists a subring R, with completion T, such that (I intersect R) is prime, and the formal fiber of R at (I intersect R) has maximal elements precisely C. This question quickly relates to the construction of complete intersection domains whose completions are complete intersection rings and which have specified generic formal fiber. We study this question in several specific special cases, and further discuss progress and a method of attack on a more general case.

NEUROSCIENCE

Effects of Neonatal Fluoxetine Exposure on Behavior Across Development in Rats Selectively Bred for an Infantile Affective Trait

Sierra Germeyan

Infants born to depressed mothers are at higher risk for insecure attachment and behavioral problems. Thus, current medical practice is to continue psychotropic medication of pregnant women with depression despite concerns about its behavioral teratology. There are few animal studies focused on long-term behavioral effects of prenatal antidepressant exposure; in addition, studies have not looked at individual differences in baseline affective state as a source of response variability. In this study, fluoxetine, a common SSRI, was administered to rat pups from postnatal day 2 to 7 to model exposure to antidepressants in the human third trimester. Five behavioral measures were conducted from the neonatal to adult age periods in Low and High lines selectively bred for their rate of ultrasonic vocalizations after brief maternal separation. Neonatal fluoxetine administration decreased distress calls to a greater extent in High line rats than Lows, however this reduction in anxiety behavior was not found in juveniles or adults. Fluoxetine impaired coordination in neonates and increased activity in juveniles; these results suggest a drug-related developmental delay in motor systems. Neonatal fluoxetine effects persisted into adulthood, as seen in a measure of social interaction. These results suggest not only that there are long-term behavioral consequences of SSRI use during late pregnancy, but that baseline affect may be an important indicator of sensitivity to these adverse effects.

Investigating the Effects of Early Deprivation on Prosocial Behavior

Emily Levy

The Early Deprivation (ED) animal model of human child neglect is useful for examining the consequences of early life stress on subsequent behaviors across the lifespan. In this model, neonatal rat pups are isolated from the dam and littermates for 3 hours daily for the first week of life. While ED has been shown to cause cognitive and learning deficits, the effects of ED on prosocial behavior, measured by releasing a trapped cagemate, have not been studied. In the present study, ED and control rats were tested as juveniles for emergence and open field activity and as adults for social recognition and prosocial behavior. As juveniles, ED males showed a feminization effect, matching the elevated activity levels and lower emergence latencies of control and ED females. As adults, the sex effect was reversed: females showed a weaker tendency to free their cagemate and a longer latency to do so than males. ED females seemed especially prosocially impaired, and observed social behavior with the cagemate supports this conclusion. These results in the context of the current literature suggest that further honing of the methods studying prosocial behavior is required. The present study, however, provides useful insight into the life-long effects of early life stressors in rodents and their parallels to human ontogeny.

PHYSICS

Experimental Characterization of Algorithms for Holographic Optical Trapping

Alyssa C. Barlis

We have experimentally characterized three algorithms for holographic optical trapping applications. Previous computational results based on a 10x10 square lattice of optical traps suggest a significant difference in algorithm performance. Our preliminary results, while inconclusive, show differences in mean trap stiffness for holograms calculated using each of the three algorithms. Modifications and improvements to the experimental setup are discussed, along with suggestions for future work.

b-philic Particles at the Large Hadron Collider

Dylan P. Gilbert

We estimate the ability of the Large Hadron Collider, the world's most advanced proton collider, to see fundamental particles that interact most strongly with a peculiar particle called the bottom quark.

Observation of Kinetic Processes in Weakly Segregated Diblock Copolymer Films

Mir Henglin

I present an examination the ordering processes of striped diblock copolymer films. It is commonly assumed that all systems which share a common smectic symmetry create order with identical dynamics. Past research performed on strongly segregated diblocks has attempted to characterize such behavior and examine the different ordering processes of such copolymer films.

Measurement of the 7S1/2 Hyperfine Splitting and Isotope Shift in 205Tl and 203Tl

David A. Kealhofer

We report a preliminary measurement of the 205Tl 7P1/2 hyperfine splitting using a twostep excitation in a hot atomic vapor. We find a significant (20 MHz) discrepancy from a previous published value for this splitting. This result is proof that in the main the experimental apparatus works as expected and measurements of the 203Tl 7P1/2 hyperfine splitting and isotope shift should follow soon. Two laser beams, 378 nm and 1301 nm, are overlapped in a heated vapor cell containing both isotopes of thallium . The 378 nm laser frequency is locked with a controlled feedback loop, and can excite 203Tl, 205Tl, or both isotopes into the intermediate 7S1/2 state. The 1301 nm laser frequency is swept across the 7P1/2 hyperfine levels, and this Doppler-free spectrum is detected with a photodiode and lock-in amplifier.

We calibrate the frequency scale with a 500 MHz Fabry-Pérot interferometer and a pair of electro-optic modulators.

Entanglement and Bosonic Character of Pairs of Distinguishable Fermions

Christina P. Knapp

All elementary particles can be characterized as bosons or fermions. I use theoretical physics to investigate when two fermions act like a boson. In particular, I look at the connection between bosonic behavior and the quantum mechanical property of entanglement.

A Precise Measurement of the Stark Shift in the Indium 5P1/2 --> 6S1/2 410 nm Transition

Nathan A. Schine

This thesis presents a new high precision measurement of the Stark shift in an indium atomic beam, detailing the unusual measurement method of frequency modulation spectroscopy as well as experimental apparatus and data analysis techniques. This measurement results in a value for the polarizability difference between the 6S1/2 and 5P1/2 states of indium and furthermore provides a model-dependent measurement of the lifetimes of the 6P1/2 and 6P3/2 states.

Entangled State Synthesis and Control of Resonators

Roshan Sharma

We investigate and study the optimality of algorithms to generate quantum states in a single resonator coupled to a qubit and two resonators coupled via a qubit.

Quantum Fourier Transform and Quantum Schur Transform with Qudits

Qiao Zhang

The thesis explores the potential advantages of implementing quantum algorithms using qudits (quantum digits) over qubits (quantum bits).

PSYCHOLOGY

Maternal Relationship Representations and Preschoolers' Physiological Responding to Relational Disruption

Julia Bender Stern

Previous research has established the importance of physiological regulation in response to stress as a predictor of child outcomes, but no prior study has examined the effect of maternal relationship representations on child physiological regulation. Thirty-seven preschool-aged children (M = 42.47 months) and their mothers attended a laboratory visit and completed the Play/No-Play Paradigm (PNPP), a novel loss of contingency paradigm based on the traditional Still-Face Paradigm, and heart rate and vagal tone were collected from the children at baseline and throughout the paradigm. Each mother also completed a questionnaire measure of dyadic adjustment and gave a Five-Minute Speech Sample about her child from which Maternal Expressed Emotion was coded. Maternal Expressed Negativity was significantly associated with suppressed vagal tone in children in the first no-play episode and the final free play episode of the PNPP. The number of positive comments a mother expressed about her child was positively associated with self-reported dyadic satisfaction. Maternal Positive Relationship Representations, as a composite of Maternal Expressed Positivity and dyadic satisfaction, predicted augmented vagal tone in children in the second no-play episode and the final free play episode of the PNPP. The results illuminate the importance of early interventions to foster positive maternal relationship representations, thereby improving the child's ability to physiologically regulate their response to relationship stress, which may reduce health and behavioral risks associated with dysregulated stress responding

"Looking" for Intention and Harm in Judgments of Discrimination

Esther Cho

Two studies examined the effects of stereotype threat and individual differences in concerns with being prejudiced on visual attention to, and assessments of, a potentially racist behavior. In Study 1 (N= 70), participants looked at a minority individual for a shorter duration during an interracial interaction when the manipulation brought attention to prejudice compared to when it did not. In both Study 1 and Study 2 (N = 167), participants who were high in internal motivation to avoid prejudice (IMS: Plant & Devine, 1998) were more interested in information about harm to targets of discrimination, while individuals who were low in IMS were more interested in the intent of the perpetrator. These studies suggest that individual prejudice concerns and situational influences may affect both visual attention and valuation of intent and harm information in judgments of discrimination.

Taxonomies and Expectancies about Mental Disorders and Treatment in Burundi: A Bottom-up Approach to Global Mental Health

Pacifique Irankunda

This research is part of an effort to develop culturally sensitive, effective mental health services in a developing central African country, Burundi, with little existing infrastructure for mental health research or service delivery. Best practices in global mental health stress the importance of understanding local beliefs and values and using existing community resources in developing mental health services, a "bottom-up" approach. As a first step, this research seeks to validate the names, idioms, and symptoms that Burundians use to describe mental illnesses, as identified in an earlier pilot study (n=761), as well as their beliefs about causes and treatments. Individual interviews were conducted (for people who couldn't read or write) and questionnaires were handed out (for people who could read and write) in a rural village with people awaiting appointments at the Village Health Work Clinic (www.villagehealthworks.org). We presented one group of participants (n= 542) with the names of the primary mental illnesses identified by the pilot interviews, and asked about what they consider to be the symptoms and causes of each. We presented a second group of participants (n=150) with the symptom descriptions (also from pilot interviews) of each, and asked about the names and causes associated with each. A separate study (n=198) examined people's expectancies about four types of treatments: medication, spiritual healing (priests), traditional healing, and a standard Western empirically supported treatment (CBT for depression, exposure therapy for PTSD, family psychoeducation for psychosis). As in study I, these expectancies were assessed in the context of the three disorders: akabonge, guhahamuka, and ibisigo. Individual interviews were conducted (for people who couldn't read or write) and questionnaires handed out (for people who could read and write) in the same rural village with people awaiting appointments at the same clinic. We described the disorder, followed by descriptions of the treatments, and standard efficacy expectations questions after each treatment description. In study I, findings generally confirmed the stability of the three types of problems identified by the pilot study: akabonge, guhahamuka, and ibisigo, with symptoms corresponding roughly to depression, PTSD, and psychosis. Diverse beliefs about causes and treatments were identified, some concordant with western approaches and some less so. In study II, findings indicated higher expectancies for good outcomes with empirically supported treatment (and spiritual healing for psychosis), and suggested interactions between the types of treatments and the type of distress. Implications for the development of educational and therapeutic interventions, and plans for future research that can inform mental health treatment development are discussed.

Sequential Effects on Attention Allocation during Categorization

Alexander Rich

During categorization, humans exhibit a variety of sequential effects – that is, differences in performance based on the order in which they observed category exemplars. In the current study, we propose that some sequential effects may be caused by comparisons between temporally juxtaposed exemplars which influence attention allocation. In Experiment 1, we tested this theory with a categorization task in which we manipulated presentation order during learning such that exemplar comparisons were predicted to draw attention to a target dimension. Our results supported our theory that exemplar comparisons affect attention allocation. In Experiment 2, we investigated whether the comparisons we

hypothesized could account for the interleaving effect observed in several recent studies (e.g., Kornell & Bjork, 2008), by drawing attention to dimensions of difference between interleaved exemplars. We did not observe a significant interleaving effect in Experiment 2, and thus were unable to determine the role of attention in the effect. However, we found a negative correlation between subjects' level of learning and the strength of their exhibited interleaving effect, suggesting that future studies with varying levels of learning may produce stronger findings.

Is Curiosity Contagious? Effects of Peer Interaction on Children's Curiosity

Daniel Silver

The curiosity levels of 83 fourth graders were assessed using a new behavioral measure, the fish task. Next, students were paired according to curiosity level (low-curiosity with either high- or low-curiosity, middle-curiosity with middle-curiosity), asked to engage in a battery of tasks designed to elicit exploratory tendencies, and then reassessed. Curiosity levels remained constant for those initially high and moderate in curiosity, but students low in baseline curiosity experienced a significant increase following completion of the exploratory tasks. A moderate-curiosity group that completed the exploratory tasks without a partner experienced no increase in curiosity, suggesting that interaction between the low-curiosity students and their peers was crucial to the increase in curiosity experienced by the low-curiosity students. While further research is needed to confirm this finding, it fits into a growing body of literature suggesting that school-aged children tend to express curiosity more readily with the help of their peers than they would otherwise (e.g., Hackmann & Engel, 2002).

Predictors of Stress Generation Among Adolescent Girls: Coping, Rumination, and Personality

Effua E. Sosoo

Research has evidenced support for the stress generation phenomenon, which asserts that individuals contribute to the occurrence of stress in their lives, resulting in depressive symptoms. However, few studies have examined characteristics of individuals that render them more likely to generate interpersonal stress. To fill this gap, the present study examined normal and abnormal personality traits and coping strategies as predictors of episodic and chronic stress generation among a sample of early adolescent girls. Participants were 99 maternal caregivers and their daughters aged 133-180 months. Findings indicated that several normal and abnormal personality traits and coping strategies were associated with chronic interpersonal stress generation, which in turn, were associated with depressive symptoms. Little evidence found that normal and abnormal personality traits and coping strategies led to episodic interpersonal stress generation. Clinical implications and future directions of research were discussed.

Family Stress and Adolescent Academic Functioning: The Role of Coping Strategies

Charlotte Vinson

Abundant evidence supports the spillover model, which asserts that the emotions and behavioral patterns that typify one part of the family system will bleed into other family subsystems. In spite of this, there are significant gaps in the spillover literature. This study aimed to address those gaps by (a) examining whether family-related stress spills over into adolescent academic functioning; and (b) exploring adolescents' coping strategies as mediators and moderators of family-academic spillover. Participants were 99 female caregivers (M = 44.36 years old) and 99 adolescent girls (M = 149.20 months old). Through the use of objective stress interviews assessing mothers' and adolescents' reports of family and academic functioning, results indicated greater family-related stress was associated with poorer academic functioning, supporting the spillover model. In addition, four coping strategies emerged as moderators of family-academic spillover, such that spillover only occurred for adolescents who less frequently used effective (primary engagement) coping strategies and more frequently used ineffective coping strategies (disengagement, involuntary engagement, and rumination). Moreover, family-related stress was associated with more use of involuntary engagement, which in turn, was associated with poorer academic functioning. Finally, greater use of secondary engagement, disengagement, and involuntary engagement coping strategies were also associated with more adaptive academic functioning. Suggestions for clinical implications were discussed and future directions for further research were explored

You Can't Handle the (Inconvenient) Truth: Environmental Information Avoidance

Elizabeth Visconti

Four studies investigate the role of information avoidance in the environmental domain, particularly in relation to global warming. Information avoidance is a tendency for individuals to distance themselves from information that may have negative consequences. These studies seek to find evidence of environmental information avoidance. Study one predicts that people do engage in environmental information avoidance for both emotional and non-emotional reasons. Study two predicts that individuals will seek information more often when the self-prediction method is used, and less often when information is presented as uncontrollable. Study three and four predict that greater behavioral obligations that are attached to information will cause participants to avoid information more often than when behavioral obligations are less severe, or when the obligations are not mandatory. Additionally, the concept of self-prediction is used in attempt to encourage individuals to seek information. Evidence was found supporting the hypothesis that if learning information leads to, or could possibly lead to, a significant behavioral obligation, more people will avoid learning the information than if there are no behavioral obligations attached to learning the information. No evidence was found supporting the hypothesis that the more controllable the consequences of learning information are, the more people will not avoid the information. No evidence was also found supporting the idea that asking a person to predict whether or not they would learn their carbon footprint if given the choice would cause them to make that choice later on.

Peer Attachment Styles & Adjustment: Negotiating Relationships Online and Offline

Emmanuel Whyte

Although transitioning from high school to college could be considered a positive step in a young person's life, this period is often marked by considerable stress. Considering the importance of interpersonal stressors (Hammen, 2005), and that adjusting to college requires that first year students establish new social support networks, we are interested in how these students create and negotiate new peer relationships. Our study examines attachment theory as one factor in how students navigate their new social landscapes. Further, we wanted to explore how peer relationships were negotiated in the online and offline realms and whether social capital and social capital behaviors are related in systematic ways to attachment styles and social, personal/emotional, and institutional adjustment to college. First-year students completed online questionnaires at the beginning, middle, and end of their first semesters in college (ns ranged from 77-134 over the waves). Attachment style, indexes of adjustment, social capital, and behaviors that seek to build social were measured in a survey taken online at each wave. The results revealed securely attached individuals had better overall adjustment, and that offline social capital behaviors were better than online social capital behaviors as predictors of social and institutional, but not personal/emotional, adjustment, Additional hypotheses were addressed and the findings discussed as well as the limitations of the study and implications for future research.

ABSTRACTS FROM FACULTY PUBLICATIONS AND PRESENTATIONS

ASTRONOMY

A Comparison of Observed Abundances in Five Well-Studied Planetary Nebulae

Jolene Tanner, *Karen B. Kwitter*, and Bruce Balick

We compare nebular abundances of He, N, O, and Ne derived from five bright well-studied planetary nebulae by various authors using disparate telescopes, apertures, and analysis methods. Our results show the independent observations yield abundances that generally agree to better than 50%.

Planetary Nebulae in M31 as Tracers of the History of the Disk of M31

Bruce Balick, Romano Corradi, *Karen B. Kwitter,* and Richard B.C. Henry

Luminous PNe have been mapped at radii Rgal well beyond the disk radius (R25) and the HI warp of M31 and beyond 50 kpc. Theory suggests that luminous PNe are the descendants of stars more massive than about 2 Msun, which raises questions of their formation at these distances where most stars are ancient. We have measured the abundances of He, N, O, Ne and other light alphas from the optical spectra of the sample. O/H is uniformly solar and its gradient is surprisingly shallow. The locations of the central stars on an H-R diagram confirm that they have indeed evolved from stars of about 2 Msun. This rules out their origin from dwarf galaxies that may have been assimilated as the outer disk of M31 formed. Instead, the results support the suggestion of Bernard et a.l (2012) that the ISM from which the central stars formed was tidally extracted from an M31-M33 encounter in which a burst of star formation occurred ~2 GY ago.

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

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 to 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) 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] high excitation, e.g., during flares or above large sunspots. The height of the chromosphere was measured spectro-photometrically, using spectral lines from light elements and compared with the equivalent height of the lower chromosphere measured using spectral lines from heavy elements.

Solar Eclipses Observed from Antarticia

Jay M. Pasachoff

Williams College - Hopkins Observatory and California Institute of Technology

Aspects of the solar corona are still best observed during totality of solar eclipses, and other high-resolution observations of coronal active regions can be observed with radio telescopes by differentiation of occultation observations, as we did with the Jansky Very Large Array for the annular solar eclipse of 2012 May 20 in the US. Totality crossing Antarctica included the eclipse of 2003 November 23, and will next occur on 2021 December 4; annularity crossing Antarctica included the eclipse of 2008 February 7, and will next occur on 2014 April 29. Partial phases as high as 87% coverage were visible and were imaged in Antarctica on 2011 November 25, and in addition to partial phases of the total and annular eclipses listed above, partial phases were visible in Antarctica on 2001 July 2011, 2002 December 4,

2004 April 19, 2006 September 22, 2007 September 11, and 2009 January 26, and will be visible on 2015 September 13, 2016, September 1, 2017 February 26, 2018 February 15, and 2020 December 14. On behalf of the Working Group on Solar Eclipses of the IAU, the poster showed the solar eclipses visible from Antarctica and this article shows a subset (see www.eclipses.info for the full set). A variety of investigations of the Sun and of the response of the terrestrial atmosphere and ionosphere to the abrupt solar cutoff can be carried out at the future eclipses, making the Antarctic observations scientifically useful.

SOT Observations of the Transit of Venus

Tarbell, Ted, Alphonse C. Sterling, Toshifumi Shimizu, *Jay M. Pasachoff*, Kevin Reardon, Glenn Schneider, Tom Berger, Yukio Katsukawa, Yoshinori Suematsu, Leon Golub, Paolo Tanga, Thomas Widemann, Shinsuke Imada, Atsushi Yamazaki, and Miho Kanao

Hinode 6 Meeting, St. Andrews, 2012

Hinode observations of the 2012 June 5/6 transit of Venus were planned in collaboration with   many international scientists under the umbrella of HOP 209, with primary contacts Sterling and Shimizu. Despite the unfavorable timing with respect to orbital sunrise and sunset, SOT obtained very high resolution images around second and third contacts in multiple wavelength bands. TRACE observations of the 2004 transitof Venus showed Venus's atmosphere unexpectedly clearly during the ingress between rst and second contactsand the egress between third and fourth contacts. Accordingly, many observations of the 2012 transit were directed at studies of the Cytherean atmosphere, both from a point of increased understanding of Venus's mesosphere in collaboration with Venus Express scientists and of understanding better the detailed working of transits as analogues of extrasolar planet detections. The SOT observations, with 0.054 and 0.108 arcsec pixels, are the highest resolution images ever obtained at a planetary transit, and they clearly show the circum-Venusian "aureole" in which light from the photosphere is refracted by the o-disk portion of the Venusian atmosphere. Calibrated measurements of the aureole intensity as a function of wavelength, time and azimuth are shown. Aureole observations potentially allow us to determine the atmospheric scale height and its atmospheric distribution with the asymmetric distribution of the luminosity along the arc. Examples of other imaging by Hinode XRT & EIS, SDO, and from ground-based sites at Haleakala, Big Bear, Kitt Peak, and Sacramento Peak may be shown for comparison.CHEMISTRY PUBLICATIONS

Variability in Be Stars in NGC 659 and NGC 663
S. P. Souza, A.B. Davis, '14, and Y.G. Teich

Presented at 221st meeting of the American Astronomical Society in Long Beach, CA January 2013 BAAS. 45, PM354.22

Since summer 2010 we have been monitoring variations in Hα emission in early- type (primarily Be) stars in ~30 young open clusters and associations, using narrowband filter photometry. We include B-type stars that may not be classical Be stars, but at some time have showed Hα in emission. Such stars are often irregular variables, and systematic spectroscopic monitoring has been restricted to the brightest such objects. Our basic observing and processing methods are described in Souza et al. (2011). While imaging sacrifices the more detailed information offered by spectroscopy, it permits us to observe a larger sample of stars with greater temporal coverage.

We report results from the first 2+ observing seasons (2010 – 2012) for 10 stars in the young open clusters NGC 659 and NGC 663. NGC 659 contains at least five Be stars. NGC 663, with at least 22 Be stars, has been much studied. Be stars that did not vary significantly in our data, or that are heavily overlapped by other stars on our images, are not reported on here. Observations of these clusters are ongoing, and a more detailed report is in preparation.

Two New Cool Variables in the Field of NGC 659
S. P. Souza

J. Amer. Assoc. Var. Star Obs., in press (2013)

From data taken in the course of a program to monitor variations in Hα emission by hot, massive stars, we report the incidental finding that the very red stars USNO-B1.0 1508-0065037 [R.A. (J2000) = 01 44 37.56; Dec. (J2000) = +60 49

53.5] and 1507-0066512 [R.A. (J2000) = 01 44 26.90; Dec. (J2000) = +60 44 35.3] are irregular variables with brightness ranges to date of 0.2mag and 0.8mag, respectively.

BIOLOGY

A Guide to Clark Art Institute Interpretive Trails
In collaboration with the Michael Singer Studio, Wilmington, VT, *Hank Art* researched, wrote, and provided photographs.

Integrating Genomics Research Throughout the Undergraduate Curriculum: A Collection of Inquiry-Based Genomics Lab Modules
Lois M. Banta, Erica J. Crespi, Ross H. Nehm, Jodi A. Schwarz, Susan Singer, Cathryn A. Manduca, Eliot C. Bush, Elizabeth Collins, Cara M. Constance, *Derek Dean*, David Esteban, Sean Fox, John McDaris, Carol Ann Paul, Ginny Quinan, Kathleen M. Raley-Susman, Marc L. Smith, Christopher S. Wallace, Ginger S. Withers and Lynn Caporale

Cell Biology Education-Life Science Education 11:203-208 (2012).

We wish to let *CBE—Life Sciences Education* readers know about a portal to a set of curricular lab modules designed to integrate genomics and bioinformatics into commonly taught courses at all levels of the undergraduate curriculum. Through a multi-year, collaborative process, we developed, implemented, and peer-reviewed inquiry-based, integrated instructional units (I3Us) adaptable to a range of teaching settings, with a focus on both model and nonmodel systems. Each of the products is built on vetted design principles: 1) they have clear pedagogical objectives; 2) they are integrated with lessons taught in the lecture; 3) they are designed to integrate the learning of science content with learning about the process of science; and 4) they require student reflection and discussion (Figure 1; National Research Council [NRC], 2005). Eleven I3Us were designed and implemented as multi-week modules within the context of an existing biology course (e.g., microbiology, comparative anatomy, introduction to neurobiology), and three I3Us were incorporated into interdisciplinary biology/computer science classes. Our collection of genomics instructional units, together with extensive supporting material for each module, is accessible on a dedicated website (http://serc.carleton.edu/genomics/activities.html) that also provides links to bioinformatics tools and online assessment and pedagogical resources for teaching genomics.

Packera insulae-regalis (Asteraceae, Senecioneae), A New Species Endemic to Isle Royale, Michigan, U.S.A
Kowal, R.R., E.J. Judziewicz, and *J. Edwards.*

2011. *Britonnia* 63(3): 343–354.

Packera insulae-regalis (Asteraceae, Senecioneae) is a new species that is only known from one population occurring near the summit of Mount Franklin on Isle Royale, Michigan, U.S.A. It resembles both *P. paupercula* and *P. indecora* but is hexaploid, whereas the former has diploid and tetraploid populations and the latter is octoploid around the western Great Lakes. Whereas most species of *Packera* are self-incompatible (as is *P. paupercula*) and a few are self-compatible (as is *P. indecora*), *P. insulae-regalis* is unique in the genus in being partially self-compatible, as far as is known. Its origin postglacially by hybridization between these two species is hypothesized.

High-Throughput Microsatellite Marker Development for the Distylous Herb *Primula mistassinica* (Primulaceae)
Matheny H '12., Edwards J. & *Maroja L.S.*
(in print). Applications in Plant Sciences.

Plant Sphingolipids: Function Follows Form
Jonathan E Markham, *Daniel V. Lynch*, Jonathan A. Napier, Teresa M. Dunn, and Edgar B. Cahoon

Current Opinion in Plant Biology. 2013, 16:350-357 (in press)

Plant sphingolipids are structurally diverse molecules that are important as membrane components and bioactive molecules. An appreciation of the relationship between structural diversity and functional significance of plant sphingolipids is emerging through characterization of Arabidopsis mutants coupled with advanced analytical methods. It is increasingly apparent that modifications such as hydroxylation and desaturation of the sphingolipid nonpolar long-chain bases and fatty acids influence their metabolic routing to particular complex sphingolipid classes and their functions in signaling pathways and other cellular processes, such as membrane protein targeting. Here, we review recent reports investigating some of the more prevalent sphingolipid structural modifications and their functional importance in plants.

Commentary: Evidence that sphingolipid signaling is involved in responding to low temperature
D.V.Lynch

Partial Complementarity of the Mimetic Yellow Bar Phenotype in *Heliconius* Butterflies
Maroja L.S., Alshuler R '11., McMillan O. & Jiggins C.

Heliconius butterflies are an excellent system for understanding the genetic basis of phenotypic change. Here we document surprising diversity in the genetic control of a common phenotype. Two disjunct *H. erato* populations have each recruited the Cr and/or Sd loci that control similar yellow hindwing patterns, but the alleles involved partially complement one another indicating either multiple origins for the patterning alleles or developmental drift in genetic control of similar patterns. We show that in these *H. erato* populations cr and sd are epistatically interacting and that the parental origin of alleles can explain phenotypes of backcross individuals. In contrast, mimetic H. melpomene populations with identical phenotypes (*H. m. rosina* and *H. m. amaryllis*) do not show genetic complementation (F(1) s and F(2)s are phenotypically identical to parentals). Finally, we report hybrid female inviability in *H. m. melpomene* × *H. m. rosina* crosses (previously only female infertility had been reported) and presence of standing genetic variation for alternative color alleles at the Yb locus in true breeding H. melpomene melpomene populations (expressed when in a different genomic background) that could be an important source of variation for the evolution of novel phenotypes or a result of developmental drift. Although recent work has emphasized the simple genetic control of wing pattern in *Heliconius*, we show there is underlying complexity in the allelic variation and epistatic interactions between major patterning loci.

Insights into bilaterian evolution from three spiralian genomes
Simakov O, Marletaz F, Cho SJ, Edsinger-Gonzales E, Havlak P, Hellsten U, Kuo DH, Larsson T, Lv J, Arendt D, *Savage R*, Osoegawa K, de Jong P, Grimwood J, Chapman JA, Shapiro H, Aerts A, Otillar RP, Terry AY, Boore JL, Grigoriev IV, Lindberg DR, Seaver EC, Weisblat DA, Putnam NH, Rokhsar DS.

Current genomic perspectives on animal diversity neglect two prominent phyla, the molluscs and annelids, that together account for nearly one-third of known marine species and are important both ecologically and as experimental systems in classical embryology. Here we describe the draft genomes of the owl limpet (Lottia gigantea), a marine polychaete (Capitella teleta) and a freshwater leech (Helobdella robusta), and compare them with other animal genomes to investigate the origin and diversification of bilaterians from a genomic perspective. We find that the genome organization, gene structure and functional content of these species are more similar to those of some invertebrate deuterostome genomes (for example, amphioxus and sea urchin) than those of other protostomes that have been sequenced to date (flies, nematodes and flatworms). The conservation of these genomic features enables us to expand the inventory of genes present in the last common bilaterian ancestor, establish the tripartite diversification of bilaterians using multiple genomic characteristics and identify ancient conserved long- and short-range genetic linkages across metazoans. Superimposed on this broadly conserved pan-bilaterian background we find examples of lineage-specific genome evolution, including varying rates of rearrangement, intron gain and loss, expansions and contractions of gene

families, and the evolution of clade-specific genes that produce the unique content of each genome.

Induction of torpor: Mimicking natural metabolic suppression for biomedical applications

Hjalmar R. Bouma, Esther M. Verhaag, Jessica P. Otis, Gerhard Heldmaier, *Steven J. Swoap*, Arjen M. Strijkstra, Robert H. Henning, and Hannah V. Carey

Mammalian hibernation consists of periods of depressed metabolism and reduced body temperature called "torpor" that are interspersed by normothermic arousal periods. Numerous cellular processes are halted during torpor, including transcription, translation, and ion homeostasis. Hibernators are able to survive long periods of low blood flow and body temperature followed by rewarming and reperfusion without overt signs of organ injury, which makes these animals excellent models for application of natural protective mechanisms to human medicine. This review examines efforts to induce torpor-like states in non-hibernating species using pharmacological compounds. Elucidating the underlying mechanisms of natural and pharmacologically induced torpor will speed the development of new clinical approaches to treat a variety of trauma and stress states in humans. J. Cell. Physiol. 227: 1285–1290, 2012. © 2011 Wiley Periodicals, Inc.

Oral bezafibrate induces daily torpor and FGF21 in mice in a PPAR alpha dependent manner
Lisa P. Chu '10, Steven J. Swoap

Fibroblast growth factor 21 (FGF21) is a hormone released from the liver that mediates many of the physiological responses of fasting, such as lipolysis and ketogenesis. FGF21 is induced by the nuclear receptor PPARα when bound to its endogenous agonist, free fatty acid, or to the synthetic agonist, bezafibrate. To determine whether PPARα agonists mediate the metabolic suppression and accompanying fall in body temperature (Tb) in a bout of torpor that occurs in mice in response to fasting, C57Bl/6J mice (wildtype) and PPARα −/− mice were implanted with temperature telemeters and fed either a control (CON) diet or one containing a PPARα agonist, bezafibrate (BEZA), for 2 weeks, followed by a fast. Wildtype mice on the BEZA diet had a striking phenotype: most entered spontaneous torpor bouts without caloric restriction towards the end of the 2 weeks. This is the first demonstration that an additive to food could induce spontaneous bouts of daily torpor. However, PPARα −/− did not express this phenotype. Moreover, wildtype mice on the BEZA diet had twice the length of torpor bouts in response to a fast as did wildtype mice on the CON diet. PPARα −/− mice did enter bouts of fasting-induced torpor, but these were unaffected by the BEZA diet. The BEZA diet induced the level of FGF21 in the blood to fasting levels only in wildtype mice. Collectively, these findings suggest that a BEZA diet mimics the fasted state in both induction of FGF21 and in thermoregulation and does so in a pathway dependent on PPARα.

Central adenosine receptor signaling is necessary for daily torpor in mice
Benjamin W. Iliff '10, Steven J. Swoap

When calorically restricted at cool ambient temperatures, mice conserve energy by entering torpor, during which metabolic rate (MR), body temperature (Tb), heart rate (HR), and locomotor activity (LMA) decrease. Treatment with exogenous adenosine produces a similar hypometabolic state. In this study, we conducted a series of experiments using the nonspecific adenosine receptor antagonists aminophylline and 8-sulfophenyltheophylline (8-SPT) to test the hypothesis that adenosine signaling is necessary for torpor in fasted mice. In the first experiment, mice were subcutaneously infused with aminophylline while Tb, HR, and LMA were continuously monitored using implanted radiotelemeters. During a 23-h fast, saline-treated mice were torpid for 518 ± 43 min, whereas aminophylline-treated mice were torpid for significantly less time (54 ± 20 min). In a second experiment, aminophylline was infused subcutaneously into torpid mice to test the role of adenosine in the maintenance of torpor. Aminophylline reversed the hypometabolism, hypothermia, bradycardia, and hypoactivity of torpor, whereas saline did not. In the third and fourth experiments, the polar adenosine antagonist 8-SPT, which

does not cross the blood-brain barrier, was infused either subcutaneously or intracerebroventricularly to test the hypothesis that both peripheral and central adenosine receptor signaling are necessary for the maintenance of torpor. Intracerebroventricular, but not subcutaneous, infusion of 8-SPT causes a return to euthermia. These findings support the hypothesis that adenosine is necessary for torpor in mice and further suggest that whereas peripheral adenosine signaling is not necessary for the maintenance of torpor, antagonism of central adenosine is sufficient to disrupt torpor.

Adenosine, AMP, and Daily Torpor
Swoap, Steven J., B.W. Iliff '10, and S. Le

Published in: *Living in a seasonal world: thermoregulatory and metabolic adaptations* – 2012.

Thermoregulation: An Orphan Receptor Finds Its Way in the Cold
Steven J. Swoap

Current Biology. Volume 22, Issue 1, 10 January 2012, Pages R17–R18

The hypometabolic state of torpor is a widely utilized and well-orchestrated response to food shortage. A new study shows that the melatonin-related orphan receptor GPR50 plays an important function in metabolic regulation for entry into torpor.

Three Decades of Cultural Evolution in Savannah Sparrow Songs
Heather Williams, Iris I. Levin, D. Ryan Norris, Amy E.M. Newman, and Nathaniel T. Wheelwright.

Animal Behaviour. 85:213-223.

Cultural evolution can result in changes in the prevalence not only of different learned song types within bird populations but also of different segments within the song. Between 1980 and 2011, we examined changes within different segments of the single songs of male Savannah sparrows, *Passerculus sandwichiensis*, in an island population. Introductory notes did not change. The buzz segment showed similar stability; although a rare low-frequency variant appeared and then disappeared, the buzz segments from 1980 and 2011 were essentially identical. The middle segment, made up of discrete notes assembled into several types, was variable. However, the form of the middle segment did not affect fitness and may serve to denote individual identity. The terminal trill decreased steadily in frequency and duration over three decades. Longer trills were associated with lower reproductive success, suggesting that trill duration was under sexual selection. The notes sung between introductory notes were also associated with reproductive success. A high cluster sung in 1980–1982 disappeared altogether by 2011, and was gradually replaced by click trains, which were associated with greater reproductive success. During the final decade of the study, more clicks were added to click trains. Longer click trains, which may require vocal virtuosity and so indicate male quality, were also associated with greater reproductive success. Both trill duration and the number of clicks increased in variance during the three-decade span of the study. We suggest that such increases in variance might be a signature of directional cultural selection. Within the Savannah sparrow's relatively short and simple learned song, cultural evolution appears to be mediated by different mechanisms for different song segments, perhaps because the segments convey different information.

How the early voltage clamp studies of José del Castillo inform "modern" neuroscience
Zottoli, S.J.

Neuroscientist. 2012 Oct;18(5):415-21. Epub 2012 May 31.

The description of ionic currents that flow across the membrane of the squid giant axon during an action potential sparked an interest in determining whether there were similar currents in vertebrates. The preparation of choice was the node of Ranvier in single myelinated fibers in frog. José del Castillo spent 3 years on the United States mainland from 1956 to 1959. During that time, he collaborated with Jerome Y. Lettvin and John W. Moore. I discuss how these individuals met one another and some of their scientific discoveries using the voltage clamp to study squid giant axons and frog nodes. Much of this work was conducted at the Marine Biological Laboratory in Woods Hole, MA, and

I attempt to convey a sense of the unique scientific "melting pot" that existed at the Marine Biological Laboratory and the broader effect that del Castillo had on "modern" neuroscience.

CHEMISTRY

Are rare, long waiting times responsible for the slowdown of glass dynamics upon cooling?
Ji Won Ahn '12, Bryn Falahee '13, Chiara Del Piccolo '14, Michael Vogul, and *Dieter Bingemann*

Journal of Chemical Physics, 138, 12A527, 2013.

The dramatic slowdown of the structural relaxation at the glass transition is one of the most puzzling features of glass dynamics. Single molecule orientational correlation times show this strong Vogel-Fulcher-Tammann temperature dependence typical for glasses. Through statistical analysis of single molecule trajectories, we can identify individual glass rearrangement events in the vicinity of a probe molecule in the glass former poly(vinyl acetate) from 8 K below to 6 K above the glass transition temperature. We find that changes in the distribution of waiting times between individual glass rearrangement events are much less dramatic with temperature, the main difference being a small, but decisive number of increasingly long waiting times at lower temperatures. We notice similar individual, local relaxation events in molecular dynamics trajectories for a variety of glassy systems further from the glass transition, leading to waiting time distributions with similar features as those observed in the single molecule experiments. We show that these rare long waiting times are responsible for the dramatic increase in correlation time upon cooling.

Statistical Identification of Structural Rearrangement Events in Molecular Dynamics Trajectories
Dieter Bingemann

Computer Physics Communications, 184, 757-764, 2013.

We describe a statistical analysis method to detect simultaneous break points of the mean in multiple observables with Gaussian fluctuations as often observed in single molecule experiments and molecular dynamics trajectories. The maximum likelihood method finds the most likely break point in a given sequence of normally distributed multivariate observations using Hotteling's T2statistic. In stochastic simulations we determine the threshold F-values for the acceptance of a break point in three dimensions and test the sensitivity and accuracy of the method. We present an algorithm that systematically identifies the most likely break points in a trajectory in a self-consistent manner. We test the method and algorithm with trajectories from molecular dynamics simulations on a prototypical atomistic glass former.

Syntheses and Structures of Closely Related Copper(I) Complexes of Tridentate (2-pyridylmethyl)imine and (2-pyridylmethyl)amine Ligands and Their Use in Mediating Atom Transfer Radical Polymerizations
Sara Turner '11, Zachary D. Remillard '12, Desire T. Gijima '10, Emily Gao '13, R. D. Pike, and *Christopher Goh*

Inorganic Chemistry, 51, 10762-10773, 2012.

A series of five copper(I) bromide complexes of tridentate (N,N,L) pyridine-imine and pyridine-amine ligands with a third amine, ether, or thioether neutral donor was synthesized and utilized in the atom transfer radical polymerization of styrene. The ligand design illustrated a systematic approach to the development of copper complexes for use in ATRP. Variations in the nature of the ligand impacted the solid state structures of the complexes. A mononuclear [CuBr(L)] complex was observed for L = pyridine-amine-amine, whereas complexes of L = pyridine-imine-amine and -thioether formed dinuclear [CuBr(L)](2) structures with a central 10-membered ring. A doubly-bromide-bridged dimer was revealed for the [CuBr(L)] complex of L = pyridine-imine-ether and a polymeric species for [CuBr(L)], where L = pyridine-imine-amine and the imine-amine spacer was extended from two to three carbon atoms. In the application of these complexes to the ATRP of styrene, the redox potentials of the complexes were found to be one indicator of ATRP efficiency. Of the series presented, two complexes in particular provided fast polymerization rates and good to excellent molecular weight control. In both of these complexes, the ligand contained all nitrogen-based donor moieties.

New Excavations at the Site of Contrebandiers Cave, Morocco

Harold L. Dibble, Vera Aldeias, Esteban Alvarez-Fernández, Bonnie A.B. Blackwell, Emily Hallett-Desquez, Zenobia Jacobs, Paul Goldberg, Sam C. Lin, André Morala, Michael C. Meyer, Deborah I. Olszewski, Kaye Reed, Denné Reed, Zeljko Rezek, Daniel Richter, Richard G. Roberts, Dennis Sandgathe, Utsav Schurmans, *Anne R. Skinner*, Teresa E. Steele, and Mohamed el-Hajraoui

New excavations at Contrebandiers Cave, Morocco, began in 2007 and continued through 2010. This site, origi-nally excavated by Roche in the 1950s, contained deposits with Aterian, Iberomaurusian, and Neolithic materials, although the laǎer were completely removed during Roche's excavations. This report presents an overview of the recent excava-tions, the stratigraphic sequence of the site, absolute dates based on OSL, TL, and ESR, and detailed data on the lithic (Iberomaurusian, Aterian, and Mousterian) and faunal assemblages, the laǎer of which includes large mammals, mi-crovertebrates, and marine shells.

The Sopeña Rockshelter, a New Site in Asturias (Spain) Bearing Evidence on the Middle and Early Upper Paleolithic in Northern Iberia

Ana C. Pinto-Llona, Geoffrey Clark, Panaglotis Karkanas, Bonnie Blackwell, *Anne R. Skinner,* Peter Andrews, Kaye Reed, Alexandra Miller, Rosaria Macias-Rosado, and Jarno Vakiparta

Iberia has become a major focus of modern human origins research because the early dates for the Aurignacian in some sites in northern Spain seem to preclude an "Aurignacian invasion" from east to west. Neanderthals associated with Mousterian industries occur late in time. The occurrence of Neanderthal-modern hybrids dated to around 24 ka, and the possibility of in situ transition between the Middle and Upper Paleolithic along the north Spanish coast, also raise important questions. To approach these questions requires excavations with modern methods of sites containing relevant archaeological records, in situ stratigraphic deposits, and reliable dating. Here we offer a preliminary report on the Sopeña site, a rockshelter containing well stratified late Middle and Early Upper Palaeolithic deposits. We describe the sedimentology for the archaeological layers, dates obtained so far, and lithic and faunal materials including the micromammal taphonomy from a deep test pit along the east wall.

On the Industrial Attributions of the Aterian and Mousterian of the Maghreb

Harold L. Dibble, Vera Aldeias, Zenobia Jacobs, Deborah I. Olszewski, Zeljko Rezek, Sam C. Lin, Esteban Alvarez-Fernández, Carolyn C. Barshay-Szmidt, Emily Hallett-Desguez, Denné Reed, Kaye Reed, Daniel Richter, Teresa E. Steele, *Anne Skinner,* Bonnie Blackwell, Ekaterina Doronicheva, Mohamed El-Hajraoui

North Africa is quickly emerging as one of the more important regions yielding information on the origins of mod-ern Homo sapiens. Associated with significant fossil hominin remains are two stone tool industries, the Aterian and Mousterian, which have been differentiated, respectively, primarily on the basis of the presence and absence of tanged, or stemmed, stone tools. Largely because of historical reasons, these two industries have been attributed to the western Eurasian Middle Paleolithic rather than the African Middle Stone Age. In this paper, drawing on our recent excavation of Contrebandiers Cave and other published data, we show that, aside from the presence or absence of tanged pieces, there are no other distinctions between these two industries in terms of either lithic attributes or chronology. Together, these results demonstrate that these two 'industries' are instead variants of the same entity. Moreover, several additional characteristics of these assemblages, such as distinctive stone implements and the manufacture and use of bone tools and possible shell ornaments, suggest a closer affinity to other Late Pleistocene African Middle Stone Age industries rather than to the Middle Paleolithic of western Eurasia.

Challenges in constraining pluvial events and hominin activity: Examples of ESR dating molluscs from the Western Desert, Egypt

B.A.B. Blackwell, *A.R. Skinner,* F. Mashriqi, A.E. Deely, R.A. Long, J.J.J. Gong, M.R. Kleindienst, J.R. Smith,

Receiving <0.1 mm/y of precipitation, Egypt's hyperarid Western Desert, today lacks naturally occurring surface water. Artesian spring deposits, tufa deposited by springs and carbonate-rich silty lacustrine sediment attest that oases in the Western Desert had surface water during the Pleistocene. Paleolithic artefacts, fossil ungulate teeth, and snails occurring within the Pleistocene deposits and dotting the surface record times when higher rainfall and/or groundwater tables during pluvial events allowed surface water to exist in wetlands, small ponds and lakes, enabling hominin habitation. Archaeological finds ranging from Early to Later Stone Age (ESA–LSA) occur in gravel lags, within sedimentary deposits, and on the older geomorphic surfaces. Near Kharga, large tufa deposits ranging from a few hectares to more than 10 km2 in area, such as Matana and Medauwara, dot the edge of the Libyan Plateau. Molluscs were dated using standard ESR protocols. To test for reworked fossils, multiple samples from a single sample were dated independently. In some units at Medauwara, multiple gastropod populations from different times have been preserved, while others appear to only preserve a single population. To see the effects of the cosmic dose rate on ESR ages, ages were calculated using zero cosmic dose rate, the full modern cosmic dose rate, and time-averaged cosmic and sedimentary dose rates. For gastropods from Matana, no significant difference in ESR ages resulted from different cosmic dose rate assumptions. Therefore, at Matana 2, the shells dated at 27.7 ± 1.9 assuming time-averaged external dose rates, while at Matana 3, they averaged 65.1 ± 4.1 ka, suggesting that water was present for hominin use at times during OIS 2 and 4.

COMPUTER SCIENCE DEPARTMENT

Smart*: An Open Data Set and Tools for Enabling Research in Sustainable Homes

Sean Barker '09, Aditya Mishra, David Irwin, Emmanuel Cecchet, Prashant Shenoy, and *Jeannie Albrecht*

The goal of the Smart* project is to optimize home energy consumption. As part of the project, we have designed and deployed a "live" system that continuously gathers a wide variety of environmental and operational data in three real homes. In contrast to prior work, our focus has been on sensing depth, i.e., collecting as much data as possible from each home, rather than breadth, i.e., collecting data from as many homes as possible. Our data captures many important aspects of the home environment, including aver- age household electricity usage every second, as well as usage at every circuit and nearly every plug load, electricity generation data from on-site solar panels and wind turbines, outdoor weather data, temperature and humidity data in indoor rooms, and, finally, data for a range of important binary events, e.g., at wall switches, the HVAC system, doors, and from motion sensors. We also have electricity usage data every minute from 400 anonymous homes. This data corpus has served as the foundation for much of our recent research. In this paper, we describe our data sets as well as basic software tools we have developed to facilitate their collection. We are releasing both the data and tools publicly to the research com- munity to foster future research on designing sustainable homes.

Measurement and Analysis of Child Pornography Trafficking on P2P Networks

Ryan Hurley, Swagatika Prusty, Hamed Soroush, Robert J. Walls, *Jeannie Albrecht*, Emmanuel Cecchet, Brian Neil Levine, Marc Liberatore, Brian Lynn, and Janis Wolak

Peer-to-peer networks are the most popular mechanism for the criminal acquisition and distribution of child pornography (CP).

In this paper, we examine observations of peers sharing known CP on the eMule and Gnutella networks, which were collected by law enforcement using forensic tools that we developed. We characterize a year's worth of network activity and evaluate different strategies for prioritizing investigators' limited resources. The highest impact research in criminal forensics works within, and is evaluated under, the constraints and goals of investigations. We follow that principle,

rather than presenting a set of isolated, exploratory characterizations of users. First, we focus on strategies for reducing the number of CP files available on the network by removing a minimal number of peers. We present a metric for peer removal that is more effective than simply selecting peers with the largest libraries or the most days online. Second, we characterize six aggressive peer subgroups, including: peers using Tor, peers that bridge multiple p2p networks, and the top 10% of peers contributing to file availability. We find that these subgroups are more active in their trafficking, having more known CP and more uptime, than the average peer. Finally, while in theory Tor presents a challenge to investigators, we observe that in practice offenders use Tor inconsistently. Over 90% of regular Tor users send traffic from a non-Tor IP at least once after first using Tor.

Cooperative Types for Controlling Thread Interference in Java
Jaeheon Yi, Tim Disney, *Stephen N. Freund*, and Cormac Flanagan

International Symposium on Software Testing and Analysis, July 2012.

Multithreaded programs are notoriously prone to unintended interference between concurrent threads. To address this problem, we argue that yield annotations in the source code should document all thread interference, and we present a type system for verifying the absence of undocumented interference in Java programs. Under this type system, well-typed programs behave as if context switches occur only at yield annotations. Thus, well-typed programs can be understood using intuitive sequential reasoning, except where yield annotations remind the programmer to account for thread interference. Experimental results show that yield annotations describe thread interference more precisely than prior techniques based on method-level atomicity specifications. In particular, yield annotations reduce the number of interference points one must reason about by an order of magnitude. The type system is also more precise than prior methods targeting race freedom, and yield annotations highlight all known concurrency defects in our benchmarks.

The Knapsack Problem with Neighbour Constraints
Glencora Boradaille, *Brent Heeringa*, and Gordon Wilfong

Journal of Discrete Algorithms, Volume 16, October 2012, Pages 224–235

We study a constrained version of the knapsack problem in which dependencies between items are given by the adjacencies of a graph. In the 1-neighbour knapsack problem, an item can be selected only if at least one of its neighbours is also selected. In the all-neighbours knapsack problem, an item can be selected only if all its neighbours are also selected. We give approximation algorithms and hardness results when the vertices have both uniform and arbitrary weight and profit functions, and when the dependency graph is directed and undirected.

Point-set Embeddability of 2-Colored Trees
F. Frati, M. Glisse, *W. Lenhart*, G. Liotta, T. Mchedlidze, and R. Islam Nishat

Twentieth International Symposium on Graph Drawing, Redmond, Washington, September 2012.

In this paper we study bichromatic point-set embeddings of 2-colored trees on 2-colored point sets, i.e., point-set embeddings of trees (whose vertices are colored red and blue) on point sets (whose points are colored red and blue) such that each red (blue) vertex is mapped to a red (resp. blue) point. We prove that deciding whether a given 2-colored tree admits a bichromatic point-set embedding on a given convex point set is an NP-complete problem; we also show that the same problem is linear-time solvable if the convex point set does not contain two consecutive points with the same color. Furthermore, we prove a 3n/2 − O(1) lower bound and a 2n upper bound (a 7n/6 − O(log n) lower bound and a 4n/3 upper bound) on the minimum size of a universal point set for straight-line bichromatic embeddings of 2-colored trees (resp. 2-colored binary trees). Finally, we show that universal convex point sets with n points exist for 1-bend bichromatic point-set embeddings of 2-colored trees.

On Representing Graphs by Touching Cuboids
D. Bremner, W. Evans, F. Frati, L. Heyer, S. Kobourov, *W. Lenhart*, G. Liotta, D. Rappaport, and S. Whitesides

Twentieth International Symposium on Graph Drawing, Redmond, Washington, September 2012.

We consider contact representations of graphs where vertices are represented by cuboids, i.e. interior-disjoint axis-aligned boxes in 3D space. Edges are represented by a proper contact between the cuboids representing their end- vertices. Two cuboids make a proper contact if they intersect and their intersection is a non-zero area rectangle contained in the boundary of both. We study representations where all cuboids are unit cubes, where they are cubes of different sizes, and where they are axis-aligned 3D boxes. We prove that it is NP-complete to decide whether a graph admits a proper contact representation by unit cubes. We also describe algorithms that compute proper contact representations of varying size cubes for relevant graph families. Finally, we give two new simple proofs of a theorem by Thomassen stating that all planar graphs have a proper contact representation by touching cuboids.

On Point-sets that Support Planar Graphs
V. Dujmovic, W. Evans, S. Lazard, *W. Lenhart,* G. Liotta, D. Rappaport, and S. Wismath

Computational Geometry: Theory and Applications, Vol. 46, Issue 1, January 2013.

A universal point-set supports a crossing-free drawing of any planar graph. For a planar graph with n vertices, if bends on edges of the drawing are permitted, universal point-sets of size n are known, but only if the bend points are in arbitrary positions. If the locations of the bend points must also be specified as part of the point set, we prove that any planar graph with n vertices can be drawn on a universal set Sn of $O(n^2/\log n)$ points with at most one bend per edge and with the vertices and the bend points in S. If two bends per edge are allowed, we show that $O(n\log n)$ points are sufficient, and if three bends per edge are allowed, $O(n)$ points are sufficient. When no bends on edges are permitted, no universal point-set of size $o(n^2)$ is known for the class of planar graphs. We show that a set of n points in balanced biconvex position supports the class of maximum-degree-3 series-parallel lattices.

Toward Practical Real-Time Photon Mapping: Efficient GPU Density Estimation
Mara '12, Luebke, and *McGuire*

March, ACM SIGGRAPH Symposium on Interactive 3D Graphics and Games, 2013-02-20.

We describe the design space for real-time photon density estimation, the key step of rendering global illumination (GI) via photon mapping. We then detail and analyze efficient GPU implementations of four best-of-breed algorithms. All produce reasonable results on NVIDIA GeForce 670 at 1920x1080 for complex scenes with multiple-bounce diffuse effects, caustics, and glossy reflection in real-time. Across the designs we conclude that tiled, deferred photon gathering in a compute shader gives the best combination of performance and quality.

GPU Ray Tracing
Parker, Friedrich, Luebke, Morley, Bigler, Hoberock, McAllister, Robison, Dietrich, Humphreys, *McGuire*, and Stich

Communications of the ACM, Vol 56, No 5, May 2013.

The NVIDIA® OptiX™ ray tracing engine is a programmable system designed for NVIDIA GPUs and other highly parallel architectures. The OptiX engine builds on the key observation that most ray tracing algorithms can be implemented using a small set of programmable operations. Consequently, the core of OptiX is a domain-specific just-in-time compiler that generates custom ray tracing kernels by combining user-supplied programs for ray generation, material shading, object intersection, and scene traversal. This enables the implementation of a highly diverse set of ray tracing-based algorithms and applications, including interactive rendering, offline rendering, collision detection systems, artificial intelligence queries, and scientific simulations such as sound propagation. OptiX achieves high performance through a compact object model and application of several ray tracing-specific compiler optimizations. For ease of use it exposes a single-ray programming model with full support for recursion and a dynamic dispatch mechanism similar to virtual function calls.

GEOSCIENCES

Scale Microfossils from the Mid-Neoproterozoic Fifteenmile Group, Yokon Territory

Phoebe A. Cohen and Andrew H. Knoll

ABSTRACT—Microscopic phosphatic scales are found in limestones and cherts from the 812–717 million year old Fifteenmile Group of the Yukon Territory. These enigmatic microfossils, which to date have not been identified in any other locality, display a diversity of intricate morphologies. Here we describe six new genera containing 17 new species of scale microfossils obtained from macerated limestone. We also revise existing taxa described originally from chert thin sections and now additionally freed from limestone by acid dissolution. New taxa described here are: Archaeoxybaphon serratacapacis n. sp., Archeoxybaphon serratapusilla n. sp., Paleoscutula inornata n. gen. n. sp., Paleoscutula serrata n. gen. n. sp., Paleoscutula convocationis n. gen n. sp., Hexacatillus allmonii n. gen. n. sp., Hexacatillus retetantillus n. sp., Quadrireticulum allisoniae n. gen. n. sp., Quadrireticulum palmaspinosum n. gen. n. sp., Circidentatus pistricis n. gen. n. sp., Circidentatus variodentatus n. gen. n. sp., Ospercapatera awramikii n. gen. n. sp., Circitorquis soccus n. gen. n. sp., Paleohexadictyon alexandrae n. sp., Paleomegasquama arctoa n. sp., Petasisquama petasus n. sp., and Thorakidictyon circireticulum n. gen. n. sp. Taxa described or amended here are Characodictyon skolopium Allison and Hilgert, 1986, Paleohexadictyon myriotrematum Allison and Hilgert, 1986, Archeoxybaphon polykeramoides (Allison and Hilgert, 1986) emend., Paleohexadictyon litosum (Allison and Hilgert, 1986) emend., and Thorakidictyon myriocanthum (Allison and Hilgert, 1986) n. comb. Many eukaryotic clades include species with surficial scales but none provides a close morphological analog to the Fifteenmile scales. Nonetheless, comparative and functional morphology suggest that the diversification of heavily armored and morphologically complex cell-coverings records a changing ecological landscape in Neoproterozoic seas.

Lithologic Controls on Lavaka Occurrence in Madagascar

Voarintsoa, N.R., Cox, R., Madison, R.M.O, and Rakotondrazafy, A.F.M.

The characteristic gullies of central Madagascar—lavakas—vary greatly in abundance over short distances, but existing understanding does not explain why some hillsides should have high concentrations of lavakas when nearby slopes have fewer. We present a GIS analysis of lavaka abundance in relation to bedrock geology and topography, covering two areas in the central highlands: the region near Ambatondrazaka and that around Tsaratanana. Both regions have similar average lavaka density (6 lavakas/km2 in Ambatondrazaka, and 5 lavakas/km2 in Tsaratanana, but local lavaka concentrations vary widely. Individual one-km2 squares can host up to 50 lavakas/km2 in Tsaratanana and up to 150 lavakas/km2 in Ambatondrazaka. We find no predictive relationship between bedrock type and lavaka abundance. There is, however, a relationship between lavakas and slope such that lavakas increase in abundance as slopes get steeper, up to an optimum steepness, beyond which they become less numerous. The optimum steepness for lavaka development is about 10-15° in Tsaratanana and 25-30° in Ambatondrazaka. Lavakas also seem to favour slopes where the gradient is changing locally, with an optimum change in grade somewhere in the range 2-5°. Our results provide quantitative constraints on lavaka distribution that can be tested in other areas.

Boulder Ridges on the Aran Islands (Ireland) are Built and Moved by Storm Waves

Cox, R., Zentner, D.B. '09, Kirchner, B.J. '13, and Cook, M.S.

Boulder ridges on the Atlantic coasts of the Aran Islands are linear or arcuate deposits of cobbles, boulders, and mega-gravel that have accumulated and migrated during the last two millennia, and are still active at the present time. Diverse sources provide the evidence for ridge activity. 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. These advancing

ridges contain boulders with masses up to 78 tonnes at 11 m above high water, 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 ≈10.5 tonnes) even in years without exceptionally large storms. Thus there is abundant evidence for ridge activity since the 1839 mapping; and as there have been no tsunami in the northeastern Atlantic in that time period, we conclude that the Aran Islands boulder ridges are built and moved by storm waves.

Using the Accumulation of CBD-Extractable Iron and Clay Content to Estimate Soil Age on Stable Surfaces and Nearby Slopes, Front Range, Colorado

Dethier, David P., Birkeland, Peter W., and *McCarthy, James A. '11*

In many transport-limited environments, morphology, pedogenic iron and clay content provide a basis for estimating the exposure age of soils and associated landforms. We measured citrate-buffered dithionite (CBD)-extractable Fe (Fed) and clay concentration in fresh rock, saprolite, morainal and colluvial materials, and soil horizons from stable surfaces and hillslopes in the Colorado Front Range. Fresh igneous and highgrade metamorphic rocks contain ~1% Fed and 1 to 5% clay. As bedrock and surficial deposits age, Fed and clay accumulate from weathering and dustfall. Late Holocene regolith at warm, dry sites contains small amounts of Fed and clay, but relatively moist soils developed on early Holocene cirque deposits contain as much as 1.5% Fed and 8% clay. Concentrations and total profile accumulation of Fed and clay increase with age in soils developed on stable surfaces of glacial deposits as old as ~130 kyr. On stable sites, Fed and clay accumulation from weathering and dust is ~0.02 g cm−2 kyr−1 and ~0.2 g cm−2 kyr−1, respectively. We used the Fed and clay inventory in soil profiles at dated, stable Front Range surfaces to calculate accumulation functions, which allowed us to estimate soil age at hillslope sites. Heterogeneous parent material, particularly on hillslopes, and climate-related effects add to variability in measured relations. Mobile regolith in Gordon Gulch, one of the Boulder Creek Critical Zone Observatory (CZO) catchments, yields profile ages from about 0.5 to 5Å~104 yr, comparable to values measured using other techniques. Calculated profile ages are older on a north- vs. south-facing slope and increase from the drainage divide to the footslope. Ages calculated for stabilized colluvium and well-developed buried profiles at nearby hillslope sites (Lefthand, Ward and Rollinsville) suggest that these soils have stabilized over periods >105 yr. In the absence of radiometric ages, the accumulation of Fed and clay in soils on stable sites and hillslopes provides a useful, local chronofunction for 103 to ~3Å~105 yr. Local footslope thickening of mobile regolith, buried soils, and areas of Fed- and clay rich stabilized colluvium suggest that steady-state models of hillslope regolith must be modified to account for observed soil properties.

Changing Mountain Permafrost from the 1970s to Today – Comparing Two Examples from Niwot Ridge, Colorado Front Range, USA

Leopold, Matthias, Völkel, Jörg, *Dethier, David*, and Williams, M. W.

Melting mountain permafrost is reported from alpine areas around the world as a direct consequence of rising air temperatures over the past decades. However, alpine sites that offer sufficient older data to compare with recent conditions are rare. The study site Niwot Ridge, situated at ~ 3600 m a.s.l. in the Front Range of the Rocky Mountains, Colorado, USA, offers permafrost distribution data from the early 1970s. We used four different approaches to evaluate and compare the old data with recent conditions and to discuss consequences in how the old data should be considered.

(i) Air photographs and survey stakes were used to compare modern surface conditions of a solifluction lobe with those in the past. Despite high resolution of the air photographs (0.3 m), the error of position after geo-rectification was higher (± 1.0 m) than average displacementrates of gelifluction lobes (10 mm * a−1), rendering this approach unsuitable. Replication of a 1963 –1967 study of soil movement from 2006 – 2009 yielded average movement rates of 11.4 mm * a−1 compared to 9.4 mm * a−1 in the 1960s.

(ii) Temperature profiles of a three-year survey (2007– 2009) to depths of 7 m were compared with data from the 1970s

from the same site. Modern temperature profiles document a complex annual curve that includes several weeks of unfrozen conditions; this finding is in contrast with the permafrost conditions reported from the 1970s.

(iii) Electric resistivity profiles on a gelifluction lobe, surveyed in different seasons during the year, show the freezing front down to 2 m depth during the early winter, the melting process during spring conditions and the complete melt of all ice lenses during the summer months. Geophysical results corroborate data from nearby temperature loggers and were used to extend the survey to other areas on Niwot Ridge.

(iv) A simple 1 D-heat flow model was driven by the annual temperature variations of 1972 and

2008, resulting in several weeks of unfrozen conditions at various depths but with temperatures close to freezing during the 1970s.

Our study documents that at present, on south facing slopes, permafrost neither exists at 2 m depth on wet sites nor at 4 m depth on dry sites as suggested during the 1970s. Our modeling approach further suggests that, except on wet gelifluction lobes, it is likely that permafrost was not present at 3600 m during 1970, if so, permafrost degradation on south facing slopes on Niwot Ridge was not driven by recent climate change. However, north-facing slopes do cover permafrost, and certainly did in the 1970s, they are most probably affected by climate warming as already documented by a changing hydro-chemical signal in nearby streams.

Subsurface Architecture of the Boulder Creek Critical Zone Observatory from Electrical Resistivity Tomography

Leopold, Matthias, Völkel, Jörg, Huber, Juliane, and *Dethier, David*

Earth Surf. Process. Landforms DOI: 10.1002/esp.3420. 2013

The architecture of the critical zone includes the distribution, thickness, and contacts of various types of slope deposits and weathering products such as saprolite and weathered bedrock resting on solid bedrock. A quantitative analysis of architecture is necessary for many model-driven approaches used by pedologic, geomorphic, hydrologic or biologic studies. We have used electrical resistivity tomography, a well-established geophysical technique causing minimum surficial disturbance, to portray the subsurface electrical resistivity differences at three study sites (Green Lakes Valley; Gordon Gulch; Betasso) at the Boulder Creek Critical Zone Observatory (BcCZO). Possible limitations of the technique are discussed. Interpretation of the specific resistivity values using natural outcrops, pits, roadcuts and drilling data as ground truth information allows us to image the critical zone architecture of each site. Green Lakes Valley (3700 MASL), a glacially eroded alpine basin, shows a rather simple, split configuration with coarse

blockfields and sediments, partly containing permafrost above bedrock. The critical zone in Gordon Gulch (2650 MASL), a montane basin with rolling hills, and Betasso (1925 MASL), a lower montane basin with v-shaped valleys, is more variable due to a complex Quaternary geomorphic history. Boundaries between overlying stratified slope deposits and saprolite were identified at mean depths of 3.0_2.2m and 4.1_3.6m in the respective sites. The boundary between saprolite and weathered bedrock is deeper in Betasso at 5.8_3.7 m, compared with 4.3_3.0m in Gordon Gulch. In general, the data are consistent with results from seismic studies, but electrical resistivity tomography documents a 0.5–1.5m shallower critical zone above the weathered bedrock on average. Additionally, we document high lateral variability, which results from the weathering and sedimentation history and seems to be a consistent aspect of critical zone architecture within the BcCZO.

Using Geophysical Techniques in the Critical Zone to Determine the Presence of Permafrost

Lewis, Gabriel '13, Leopold, Matthias, and *Dethier, David*

Geological Society of America Abstracts with Programs, 44 (7), 460, 2012

Electric Resistivity Tomography (ERT) and Ground Penetrating Radar (GPR) are geophysical techniques utilized worldwide to study the evolution of alpine permafrost and ice lenses. Combining these techniques maximizes the accuracy of each method while reducing their inherent ambiguities and limitations. The alpine Green Lakes and 4th of July Valleys within the Colorado Front Range offer ideal locations to verify the existence of ice masses within rock

glaciers, where they are predicted by many models. On nearby Niwot Ridge, geomorphological, hydrological, and GIS techniques have been used to calculate probabilities of permafrost at depth, but predictions have not previously been verified in the field. Permafrost and ice lenses beneath active solifluction lobes were also documented in several studies during the 1970's along Niwot Ridge. This study examines: (1) the results of 15 ERT lines totaling 765 meters within the Critical Zone, sited to test permafrost predictions in alpine zones; (2) soil temperature profiles and morphology in several pits excavated to saprolite along ERT lines; and (3) measurements of the 4th of July Rock Glacier's retreat during the past century including its implications for nearby permafrost. Analysis of seven ERT lines from elevations of 3500 to 3900 meters on Niwot Ridge demonstrates that these locations lack permanent ice lenses (resistivity of approximately 200-1000 kΩm) beneath a surface layer of coarse, blocky debris (resistivity of ~ 20 kΩm). Solifluction lobes, as well as nearby snow field areas may retain semi-permanent ice lenses that were considered permafrost features, but ice often melts out completely by late summer. The rock glaciers have experienced decades of retreat due to high-elevation warming and decreases in moisture supply (i.e. droughts during the winters of 2002-2003 and 2011-2012), resulting in partial melting of subsurface ice and deposition of a layer of rocks previously supported by ice. Better understanding of the present distribution of permafrost and active periglacial features may help predict changes to alpine landscapes as permafrost disappears as well as implications for the quantity of runoff from these areas in the future.

Physical and chemical properties of a strongly developed buried soil, exposed laterally for 100 m in Betasso Gulch (a Boulder Creek Critical Zone Observatory catchment), illustrate the potential and pitfalls in using paleosols on hillslopes to infer past environmental conditions. The buried soil consists of a >100 cm thick A/Bt/BC profile that developed in granitic colluvium on a 10 degree, forested footslope. Luminescence dating suggests that a 3-m thickness of underlying colluvium accumulated between 18 and 12 ka; younger slope deposits buried the soil by about 6 ka. Organic matter in the buried A gave radiocarbon ages between 8550 and 8995 cal. BP. Hillslopes generally are stable in the dry modern environment and the younger deposits support thin, sandy A/Bw sequences. In contrast, both the A and Bt horizons of the buried soil contain 28 to 35 percent clay, most of it smectite, and substantial amounts of pedogenic Fe, properties consistent with an extended period of soil formation and/or changed climate. However, the 14C and luminescence ages allow <6 kyr of pedogenesis on the hillslope. NMR spectroscopy also demonstrates that black color of the buried A horizon reflects large amounts of aromatic components (fine charcoal), rather than pedogenic accumulation of organic matter. Thick, smectite-rich soil profiles developed in granitic saprolite crop out along upper slopes and ridgecrests at Betasso. Field and laboratory data suggest that the properties of the Betasso paleosol are consistent with upslope erosion of saprolitic soils, downslope redeposition of older soil material, and considerable eolian input. Soils developed on hillslopes in deeply weathered environments may thus contain only indirect information about time of formation and paleoclimate.

Inferring Age and Paleoclimate from a Hillslope Paleosol-- a Cautionary Tale from the Front Range, Colorado

Dethier, David P., Leopold, Matthias, Völkel, Jörg, Blum, Alex E., Huber, Juliane, and Steffens, Markus

Physical and chemical properties of a strongly developed buried soil, exposed laterally for 100 m in Betasso Gulch (a Boulder Creek Critical Zone Observatory catchment), illustrate the potential and pitfalls in using paleosols on hillslopes to infer past environmental conditions. The buried soil consists of a >100 cm thick A/Bt/BC profile that developed in granitic colluvium on a 10 degree, forested footslope. Luminescence dating suggests that a 3-m thickness of underlying colluvium accumulated between 18 and 12 ka; younger slope deposits buried the soil by about 6 ka. Organic matter in the buried A gave radiocarbon ages between 8550 and 8995 cal. BP. Hillslopes generally are stable in the dry modern environment and the younger deposits support thin, sandy A/Bw sequences. In contrast, both the A and Bt horizons of the buried soil contain 28 to 35 percent clay, most of it smectite, and substantial amounts of pedogenic Fe, properties consistent with an extended period of soil formation and/or changed climate. However, the 14C and luminescence ages allow <6 kyr of pedogenesis on the hillslope. NMR spectroscopy also demonstrates that black color of the buried A horizon reflects large amounts of aromatic components (fine charcoal), rather than pedogenic accumulation of organic matter. Thick, smectite-rich soil profiles developed in granitic saprolite crop out along upper slopes and ridgecrests at Betasso. Field and laboratory data suggest that the properties of the Betasso paleosol are consistent with upslope erosion of saprolitic soils, downslope redeposition of older soil material, and considerable eolian input. Soils developed on hillslopes in deeply weathered environments may thus contain only indirect information about time of

formation and paleoclimate.

A Comparative Study of Snowmelt-Driven Water Budgets in Adjacent Alpine Basins, Niwot Ridge, Colorado Front Range

Nesbitt, Ian M. '13, and *Dethier, David P.*

The critical zone in alpine and subalpine headwaters areas delivers drinking water to urban corridors near mountainous areas of North America. Snowmelt runoff from alpine areas typically accounts for over 80% of annual flow, but water budgets are not well quantified nor well understood in detail. Redistribution of snow by wind, the difficulty of estimating water losses from sublimation and evapotranspiration, and groundwater gains and losses associated with unconsolidated subsurface material make streamflow and water budget measurements challenging. We investigate two adjacent catchments, Martinelli and Saddle, both about 0.25km2 at ~3500m, on Niwot Ridge in the Colorado Front Range. Nearby Long-Term Ecological Research (LTER) monitoring stations indicate mean annual precipitation is between 1210 and 950mm. Mean annual runoff is ~310mm at Martinelli and ~230mm at Saddle, based on 12 and 28 years of gaging records, respectively.

Saddle basin is not fed by an extensive seasonal snowpack, but records indicate ablation-season discharge is still closely related to snowmelt in the basin. Martinelli shelters a ~6m thick snowpatch in 8 ha of the basin, even in a low snow year. During much of the ablation season, snowpack mass density (ρ) is 0.5g cm-3 and ablation rates are ~100mm day-1. Since vegetation is shallow-rooted or nonexistent in Martinelli, evapotranspiration (ET) may not be a major factor. Saddle is more heavily vegetated, but only the lower reaches are wooded; ET may be as much as 260mm. Runoff during 2012 was ~270mm yr14C at Martinelli and ~35mm at Saddle. By monitoring snowpack area changes and longitudinal discharge, we were able to demonstrate that at low flow at least 30% of snowmelt discharge at Martinelli and over 50% at Saddle becomes subsurface flow and is unrecorded by the gages. We believe similar hydrologic budgeting can be applied to a wide range of small alpine catchments with similar "losing stream" characteristics.

Detailed Volcanostratigraphy of an Accreted Seamount: Implications for Intra-plate Seamount Formation

Susan R. Schnur and *Lisa A. Gilbert*

Seamounts are a ubiquitous feature of the seafloor but relatively little is known about their internal structure. A seamount preserved in the Franciscan mélange of California suggests a sequence of formation common to all seamounts. Field mapping, geophysical measurements, and geochemical analyses are combined to interpret three stages of seamount growth consistent with the formation of other intraplate seamounts such as the Hawaiian volcanoes and the island of La Palma. A seamount begins to form as a pile of closely packed pillows with a high density and low porosity. Small pillow mound volcanoes common at mid-ocean ridges are seamounts that do not grow beyond this initial stage of formation. The second stage of seamount formation is marked by the first occurrence of breccia. As the seamount grows and becomes topographically more complex, slope varies and fractured material may begin to accumulate. Magma supply may also become spatially diffuse as the seamount grows and new supply pathways develop through the edifice. The second stage thus exhibits variability in both flow morphologies and geophysical properties. The final cap stage is composed of thin flows of various morphologies. These sequences reflect the shoaling of the seamount and a greater variability in extrusion rate resulting from waning magma supply and increased mass wasting. Understanding the growth and structure of seamounts has important implications for intra- plate volcanism and for models of hydrothermal circulation in the oceanic crust.

Not Just "Rocks for Jocks": Who Are Introductory Geology Students and Why Are They Here?

Lisa A. Gilbert, Jennifer Stempien, David McConnell, David Budd, Katrien van der Hoeven Kraft, Ann Bykerk-Kauffman, Megan Jones, Catharine Knight, Ronald Matheney, Dexter Perkins, and Karl Wirth

Do students really enroll in Introductory Geology because they think it is "rocks for jocks"? In this study, we examine the widely held assumption that students view geology as a qualitative and remedial option for fulfilling a general education requirement. We present the first quantitative characterization of a large number of Introductory Geology students, their demographic characteristics and motivations at the start of the course, and their reasons for enrolling. More than 1,000 undergraduate students from seven institutions across the U.S. participated in this study, providing demographic information and responses to the Motivated Strategies for Learning Questionnaire. Students taking Introductory Geology either to fulfill a general education requirement (72% of the survey population) or because they thought it would be easy (19%) had relatively low motivation. The youngest students (18 or 19 years, 62% of the survey population) and those who had not declared a major or were planning a non-science major (79%) also had relatively low motivation. In contrast, students taking the course for a major or minor (26%), because of prior interest in geology (31%), or because of interest in the interactions between humans and the environment (15%) had relatively high motivation. The differences in motivation we identify have important implications for Introductory Geology instructors, particularly those teaching large-enrollment courses, and validate the need for understanding student characteristics when designing course goals and selecting instructional strategies.

Evolution of Permeability in the Upper Oceanic Crust Formed From Super-Fast Spreading: IODP Hole 1256D

Miranda L. Bona '13, Lisa A. Gilbert, and *Reinhard A. Wobus*

Permeability is the principal hydrologic parameter responsible for controlling fluid flow through conduits in the Earth's crust, yet determining permeability has proven to be a challenge. For a detailed examination of the core-scale permeability of basalts and gabbros recovered from the Integrated Ocean Drilling Program (IODP) Hole 1256D, we calculated maximum original permeability, a two-dimensional permeability value based on the size and shape of micro-fractures measured in thin section. Core-scale maximum original permeability ranges from 10^{-14} to 10^{-18} m^2, which is several orders of magnitude higher than measurements made in the laboratory under pressure and saturated with seawater. However, these calculated maximum original permeability values are within the same range as laboratory measurements of dry core samples measured at ambient pressures. The maximum original permeability values are thus more reminiscent of permeability of the upper oceanic crust prior to hydrothermal mineral precipitation. All micro-fractures observed in thin section were filled with one or more generations of mineral precipitates, such as smectite, sulfides, quartz, and chlorite. Some open pore space remained in vesicles located higher in the section, but porosity and permeability both decrease with depth, particularly as the previously water-filled spaces are filled with smectite. Maximum original permeability values inform our understanding of the permeability of the upper oceanic crust and space available for diverse and complex microbial life within the subseafloor.

Dike Intrusion Controls on Permeability and Hydrothermal Circulation of Oceanic Crust at IODP Hole 1256D

Lisa A. Gilbert, Paola Tartarotti, Emanuele Fontana, *Miranda L. Bona '13, Daniel Gross '12 , Grace LaPier '12*, and *Connor Dempsey '13*

We examine the hydrothermal structure of the lava-dike transition zone in oceanic crust of Integrated Ocean Drilling Program (IODP) Hole 1256D using detailed sample measurements of permeability, porosity, metamorphic minerals, and structures. The transition zone consists of basaltic sheet and massive flows, a cataclastic unit, and hyaloclastic breccias. Structural investigations show that this transition occurs through a larger depth interval than that previously defined, extending 254 m upward from the top of the Sheeted Dike Complex (811.4 to 1065.7 meters below seafloor

(mbsf)). Through the transition zone, models predict a general decrease in permeability, based on a corresponding decrease in porosity with depth. Laboratory measurements of physical properties show porosity decreases drastically, as does permeability. Thin sections reveal no open pore space, and all structures are filled: veins (mm- to cm-thick), sets of parallel veins, vein networks, Riedel-deformation bands, cataclasites (<mm), incipient breccia, and hyaloclastic breccia hosting sulfide mineralizations. Smectite, mixed chlorite-smectite, Fe-oxyhydroxide, quartz, chalcedony, and calcite are the main secondary minerals; hyaloclastic breccia hosts sulfides (mainly pyrite) and is cemented by chalcedony, quartz, calcite, anhydrite, and minor amphibole. The dip angle of planar structures (including cataclasites) show an average downdip increase, thus such sub-vertical structures may represent original cooling fractures and/or might be related to the regional tectonics (i.e., extensional tectonics of the rift zone) or to the local tensional stress field created at the top of the dikes as a direct consequence of dike intrusion. Since this transition zone is located near the boundary between the Low Temperature Alteration Zone (above) and the Hydrothermal Alteration Zone (below), we postulate that fracturing and hydrothermal alteration in the investigated crustal interval likely occurred during dike intrusion. Consequently, the lower part of the lavas (below 811.4 mbsf or 561 meters sub-basement) seems to mark a boundary layer between different stress fields, permeability regimes, and metamorphic imprints.

What Darwin Did Not See: Pleistocene Fossil Assemblages on a High-Energy Coast at Ponta das Bicudas, Santiago, Cape Verde Islands

Baarli, B.G., Santos, A., Mayoral, E.J., Ledesma-Vázquez, J., *Johnson, M.E.*, Silva, C.M. da, and Cachão, M.

Geological Magazine, 150, 183-189, 2013

Two distinct Pleistocene assemblages from SE Santiago Island are comparable to modern analogues elsewhere in the Cape Verde Islands. A low diversity Siderastrea radians assemblage lived atop basalt knobs surrounded by sand on a slope below a cliff. A Millepora alcicornis-Megabalanus azoricus assemblage occupied the cliff. The latter was a typical rocky-shore assemblage from a high-energy setting below the tidal zone. Bioerosion structures in basalt by Circolites kotoncensis and Gastrochaenolites isp. also occur there. Despite extensive studies on local limestone deposits in 1832 and 1836, lack of exposure prevented Darwin from seeing these fossils.

Coastal Dunes with High Content of Rhodolith (Coralline Red Algae) Bioclasts: Pleistocene Formations on Maio and São Nicollau in the Cape Verde Archipelago

Johnson, M.E., Baarli, B. G., Silva, C.M. da, Cachão, M., Ramalho, R.S., Ledesma-Vázquez, J., Mayoral, E.J., and Santos, A.

Aeolian Research, 8, 1-9, 2013

Rhodoliths are spherical growths (coralline red algae) that contribute bioclasts to coastal dunes in the Gulf of California (Mexico) and the Canary Islands (North Atlantic). Pleistocene dunes on Maio and São Nicolau islands in the Cape Verde archipelago were studied to quantify rhodolith contribution relative to other sources. Near Pilão Cão on Maio, a transverse dune at Lomba Greija covers 0.3 km2, exposing stoss slopes that dip 8º - 10º NE and leeward slip faces that dip 28º -32º SW and SE. Point counts on thin-section samples show that basalt and other non-carbonate materials account for 5%, on average, whereas fine matrix and voided space (dissolved grains) account for 67%. Among remaining identifiable bioclasts (coralline red algae, mollusks, corals, foraminifera, and echinoderms), rhodolith grains with an average diameter of 0.5 mm account for 74%. Near Carriçal at Covoadinha de Chacina on the SE coast of São Nicolau, the stoss slope dips 8º SE for 70 - 80 m on narrow longitudinal dunes. Point counts on a thin-section sample taken 2.5 m above basement rock, reveal that basalt and other non-carbonate materials account for 10%, on average, whereas fine matrix and voided spaces account for 60%. Among identifiable bioclasts from the remainder (coralline red algae, mollusks, echinoderms, and bryozoa), rhodolith grains ranging in size from 0.5 - 1 mm account for 96%. Potential enrichment from coralline red algae may be overlooked in coastal dunes, because content normally is described as dominated by mollusk shells, the tests from abundant foraminifera, and/or ooids.

Ichnology in Oceanic Islands; Case Studies from the Cape Verde Archipelago

Mayoral, E., Ledesma-Vázquez, J., *Baarli, B.G.*, Santos, A., Ramalho, R., Cachão, M., da Silva, C.M., *Johnson, M.E.*

Palaeogeography, Palaeoclimatology, Palaeoecology, 381-382, 47-66, 2013

Miocene and Pleistocene marine deposits in the Cape Verde Archipelago are represented by a series of thin, transgressive sandy-bioclastic limestones that typically occur between subaerial and/or submarine volcanic flows. This position within volcanic flows makes them an ideal palaeobathymetric case study, because the submarine/subaerial passage zone above them provides a reliable and independent indicator of palaeodepth. In terms of palaeoichnology, the older Miocene sediments are characterized by the Thalassinoides ichnoassociation, whereas Pleistocene sediments are characterized by the Macaronichnus-Dactyloidites ichnoassociation. The fair-weather suite of the proximal Cruziana ichnosubfacies is represented by the ichnotaxa Dactyloidites, Bichordites, Cardioichnus, Phycodes, Teichichnus, aff. Taenidium, Palaeophycus and Thalassinoides in addition to the Thalassinoides ichnoassociation. The Macaronichnus-Dactyloidites ichnoassociation is more complex, including representatives of both the proximal Cruziana and Skolithos ichnofacies. Only representatives of the Skolithos ichnofacies (Skolithos, Macaronichnus, Conichnus and Ophiomorpha) are represented in the post-storm suite. So far, bioerosive structures were found on the Miocene/Pleistocene unconformity surface of Maio Island, and on basaltic palaeocliffs at Ponta das Bicudas, on Santiago Island. They are represented by the ichnoassemblage Gastrochaenolites torpedo-Entobia isp. corresponding to the Entobia ichnofacies. Bathymetric calibration deduced from the position of the following passage zone between submarine and sub-aerial lava flow allows for confirmation of the proximal Cruziana ichnosubfacies and Skolithos ichnofacies at a palaeodepth between 12 to 18 m depth.

Coral-Stromatoporoid Faunas from the Shores of a Late Silurian Island, Inner Mongolia, North China
Rong, J., *Johnson, M.E.*, Deng, Z., Dong, D., Xue, Y., *Baarli, B.G.*, and Wang, G.

Previous research on a small continental island called Bater Island from south-central Inner Mongolia focused on palaeogeographic relationships in the context of the North China Block and the prevailing pattern of atmospheric and oceanic circulation interpreted from Ludlovian (Upper Silurian) strata surrounding an Ordovician diorite inlier. Preliminary information first available regarding the palaeontology of a rare rocky-shore environments preserved on this ancient island is revised and expanded based on a study of the dominant coral and stromatoporoid sponge fossils. The Silurian rocky-shores of Bater Island contain a fauna of tabulate corals (including 7 genera, Mesoculipora, Thamnopora, Striatopora, Cladopora, Taxopora, Planocoenites and Okopites) and stromatoporoid sponges (Clathrodictyon and Actinostromella) which are herein described and illustrated for the first time. Compared to other rocky-shore faunas from North America, the diversity of the tabulate corals from the more sheltered, leeward side of Bater Island is high (AFR19) and no tabulates have been discovered on the windward, rough-water side of the island, where only stromatoporoids were found. Bater Island also remains the only known locality worldwide to feature stromatoporoids in a rocky-shore setting.

Disparate Paths in the Geologic Evolution of the Northern and Southern Appalachians; a Case for Inherited Contrasting Lithospheric Substrates
Hibbard, James, and *Karabinos, Paul*

Modern understanding of the tectonic evolution of the Appalachians allows for recognition of most of the first-order lithotectonic elements and events of the orogen. Comparison of these features and events along the length of the orogen indicates that the northern and southern segments of the Appalachians display distinct first-order differences.

Contrasts between these segments of the orogen existed from the outset of the Appalachian cycle. Mesoproterozoic basement rock types south of Pennsylvania are different than those to the north and basement rocks in each area display distinct Nd and Pb isotopic signatures. A subsequent phase of c. 770-680 Ma, Cryogenian rifting is recorded in the southern Appalachians, but is missing in the northern part of the orogen. During the Paleozoic, the accretion of peri-Gondwanan terranes was partitioned, with Carolinia and Suwanee confined to the southern Appalachians and Ganderia, Avalonia, and Meguma limited to the northern Appalachians. Consequential to this partitioning, associated magmatism and some attendant tectonism is asymmetrically distributed between the two segments of the orogen. The terminal Appalachian collisional event, the Carboniferous Alleghanian orogeny, is distinctly different in the two

segments of the orogen; there is an asymmetry with respect to the volume of magmatic rocks in the northern and southern Appalachians and their Carboniferous tectonic styles contrast sharply. Lastly, there is a modern first-order topographic change in the foreland of the orogen; the southern foreland is characterized by a continuous elevated plateau, whereas north of the New York promontory, foreland topography is more varied.

All of these varied first-order changes occur in the vicinity of the New York promontory, suggesting that it represents an enduring, fundamental boundary in the orogen. The nature and duration of differences between the two segments of the Appalachians indicate that this boundary was not an extrinsic ephemeral feature, such as a plate triple junction or hot spot. Rather, we suggest that an intrinsic difference in the Laurentian lithospheric substrate present from the outset of the Appalachian cycle, as reflected by contrasts in the Mesoproterozoic basement in each segment, could be the root cause of these significant contrasts.

High Strain and Decoupled Deformation in the Mantle of Gneiss domes
Karabinos, Paul

Geological Society of America Abstracts with Programs, 44, 70, 2012

Two N-S trending sets of mantled gneiss domes are first-order features of the northern Appalachians. The western belt contains thirteen domes that expose either 1 Ga Laurentian basement rocks or approximately 475 Ma rocks of the Shelburne Falls arc in the cores. The eastern belt contains twenty-one gneiss domes cored by either 600 Ma crust of Ganderian affinity or approximately 450 Ma rocks of the Bronson Hill arc. The domes in both belts are surrounded by rocks of Silurian and Devonian age, which were deposited or erupted in two N-S trending basins, and deformed during the Devonian Acadian orogeny. The Chester dome in southeastern Vermont is 60 km long, elongated parallel to N-S striking Acadian structures, and only 15 km wide. Core gneisses in the dome preserve E-W oriented Grenvillian fabrics and structures. In contrast, Neoproterozoic to Ordovician units that mantle the Chester dome contain strong N-S striking Acadian fabrics that are parallel to foliation in the surrounding Silurian and Devonian rocks. The mantling units are dramatically thinner than elsewhere in southern Vermont, and they are commonly absent. A strong spatial correlation between the attenuated and excised mantling units and highly strained mylonitic rocks suggests the presence of a ductile, normal-sense shear zone, which commonly extends into the uppermost part of the Mesoproterozoic gneisses. Garnet-bearing rocks from the core and mantle of the dome record 2 to 3 kb of decompression during metamorphism, whereas rocks above the high-strain zone were metamorphosed during nearly isobaric conditions. Strain markers, kinematic indicators, reconstructed P-T paths, and stratigraphic omission suggest that extension occurred during northward and upward extrusion of rigid lower to middle crustal wedges of Proterozoic and Ordovician quartz-feldspar-rich gneisses relative to a thick tectonic cover of the surrounding Silurian and Devonian rocks, which were transported westward in large-scale nappes prior to and synchronous with doming at approximately 380 Ma. High strain focused in the mantling units served to decouple the westward transport of nappes from structurally lower northward extrusion of rigid core gneisses in the domes and to accommodate the dramatic contrast in strain between rocks in the dome cores and surrounding units.

SketchUp Models
Karabinos, Paul, and Hennesy, Ronan

Geological Society of America Abstracts with Programs, 44, 236, 2012

This is a contribution to the Pardee Keynote Symposium entitled "Digital Geology Speed Dating." At Table 6 we discuss Interactive 3D models, illustrating how geologic structures and concepts can be created with Trimble SketchUp. The free version of this program allows for importing USGS DEM and DDF format files, which can be used to portray topographic surfaces that can be draped with geological maps, and coupled with accurately located cross-sections. SketchUp can also help produce models illustrating how planes and more complex surfaces structures intersect topography. SketchUp models can show in detail how to solve the three-point problem and how down-plunge projections work. Interactive block diagrams illustrating contact and crosscutting relationships can help students in introductory and structural geology courses grasp fundamental concepts in geology.

Cross-sections and models produced with SketchUp can be geolocated and exported to Google Earth as Collada files to give the 3-D models greater geographic context. Accurately located cross-sections can be elevated above the ground

surface. SketchUp models in Google Earth can be attributed with added user-interaction using the Keyhole Markup Language (KML) TimeSpan element and the Google Earth Time Slider. It is also possible to make the ground surface transparent to reveal sections in the subsurface and integrate them with geologic maps. 3-D models of real folds and faults created with SketchUp can be precisely located in Google Earth to give virtual field trips greater authenticity. The free version of SketchUp presents educators with a valuable teaching resource with which to engage students in tasks that encourage the visualization and consideration of 3-D geometries.

The professional version of SketchUp offers the ability to create dynamic components, which are available for everyone to use in the free version. Dynamic components add another level of interactivity to SketchUp models. For example, models illustrating how the stereographic projection works can incorporate dynamic components so that the user can specify any values of strike and dip or trend and plunge to explore how planes and lines will plot on the stereonet.

Evidence for the Dashwoods Terrain in the New England Appalachians
Karabinos, Paul

The Appalachian passive margin of Laurentia was tectonically stable from Early Cambrian to Early Ordovician, when collision with the Notre Dame-Shelburne Falls arc initiated westward thrusting of continental margin rocks at ca. 470-460 Ma. However, Early Ordovician magmatism and deformation in the Laurentian Dashwoods terrain in Newfoundland was coeval with passive margin sedimentation. Waldron and van Staal (2001) explained this paradox by suggesting that Dashwoods was a peri-Laurentian microcontinent separated from Laurentia by a narrow sea during Neoproterozoic rifting. Subduction under Dashwoods began in Cambrian time, but tectonism was confined to Dashwoods, and did not destabilize the passive margin to the west.

Based on inheritance in zircon, Karabinos et al. (1998) suggested that Shelburne Falls arc magmas mixed with Laurentian crust, and they showed an east-dipping subduction zone under a Laurentian-derived ribbon continent. However, direct evidence for an analogous peri-Laurentian terrain in the New England Appalachians is obscure due to younger Paleozoic deformation. The Moretown Formation, which extends from northern VT to southern MA, may have formed on the margin of Dashwoods, and be roughly equivalent to the Fleur de Lys Supergroup in Newfoundland. Lithologically diverse, the Moretown Fm. was interpreted as a Middle Ordovician fore-arc deposit in early plate tectonic models. Yet it is predominantly quartz-rich clastic metasediment, including quartzite and quartz-pebble conglomerate. It was intruded by mafic and felsic magmas of diverse geochemistry and age, including the 479 ± 8 Ma Hallockville Pond Gneiss in Massachusetts (Karabinos and Williamson, 1994), and 484 ± 4 and 496 ± 8 Ma tonalites in southern Vermont (Ratcliffe et al., 1997). Furthermore, detrital zircons from the Moretown Fm. indicate a Grenvillian source. Thus, the Moretown Fm. was intruded by arc-derived magmas in the Cambrian, derived from Grenvillian crust, and is distinct from coeval sediments on the Laurentian margin to the west. The oldest intrusive rocks in the Moretown Fm. probably predate the Shelburne Falls arc and likely formed in an older subduction zone under a micro-continent. An older subduction history may also explain enigmatic Cambrian Ar-hornblende cooling ages in northern Vermont (Laird et al., 1993).

Visualizing Structure Contours with SketchUp: From Strike and Dip to Cross-Section Construction
Karabinos, Paul

The use of structure contours to interpret maps and cross-sections is an example of a fundamental geologic concept rooted in 3D visualization. Students typically learn how to solve specific structure contour problems using 2D projections, but many fail to link the solution to the underlying 3D geometry. 3D models can help students visualize structure contours, and Trimble SketchUp is a particularly useful application for making them because it is relatively easy to learn and free.

I created a sequence of models that shows how to use structure contours to 1) test if a contact is planar, 2) determine the strike and dip of planar beds, 3) find the true thickness of stratigraphic units, 4) solve the 3-point problem, 5)

determine the depth of a target unit, 6) estimate displacement across faults, and 7) create cross-sections. I also made a dynamic component (which required SketchUp Pro to make but can be used by anyone with the free version) that can be used to quickly generate structure contours for a planar surface with arbitrary strike and dip. The user can also specify the interval and elevation range of the structure contours, and the exact position of the surface. I wrote a tutorial that describes how to generate artificial topography, import a digital elevation model of an area of interest, create a planar surface or a sequence of surfaces, make a simple geologic map, add structure contours, and create a cross-section in a 3D environment.

Many structural geology courses rely on classic lab manuals containing simple problems for students to solve. SketchUp can be used to recast these classic exercises into 3D models. One of the most exciting aspects of creating 3D models with SketchUp, however, is the ability to generate a host of new problems with minimal effort; such exercises are otherwise very time consuming to create.

Models can be disseminated directly as electronic SketchUp (.skp) files, which students can explore and modify. SketchUp models can be exported as COLLADA digital asset exchange (.dae) files, and incorporated into an iBook as interactive 3D models using iBooks Author for IOS devices. The .dae files can also be uploaded to Sketchfab, a web service designed to publish and display interactive 3D models. Once uploaded to Sketchfab, the models may be embedded in a webpage where anyone with a WebGL enabled browser can view them.

MATHEMATICS AND STATISTICS

Triple Crossing Number of Knots and Links
Colin Adams

Journal of Knot Theory and Its Ramifications 22, 1350006-1 – 1350006–17, 2013.

A More Sums Than Differences (MSTD) set is a set of integers A of {0, ..., n-1} whose sumset A+A is larger than

The Silence of the Lemmas
Colin Adams

Mathematical Intelligencer, 34, no. 2, 27-28, 2012.

The Cabinet of Dr. Mobius
Colin Adams

Mathematical Intelligencer, 34, no. 3, 35-40, 2012.

From Doodles to Diagrams to Knots
Colin Adams with Noel MacNaughton and Charmaine Sia

Mathematical Magazine, 86, no. 2, 83-96, 2013.

Milestones in the Discovery of the Numbers
Colin Adams

Math Horizons, 11-13, 2012.

Letter or Recommendation
Colin Adams

Mathematical Intelligencer, 34, no. 4, 12-14, 2012.

The Tale of Paul Buniyan
Colin Adams

Intro Stats, 4th Edition
Richard De Veaux with Paul Velleman and David Bock

Stats: Modeling the World, 3ed Edition
Richard De Veaux with Paul Velleman and David Bock

Algebraic Geometry: A Problem Solving Approach
Thomas Garrity with Richard Belshoff, Lynette Boos, Ryan Brown, Carl Lienert, David Murphy, Junalyn Navarra-Madsen, Pedro Poitevin, Shawn Robinson, Brian A. Snyder and Caryn Werner

Simultaneous Confidence Intervals for Comparing Margins of Multivariate Binary Data
Bernhard Klingenberg and *Ville Satopää '11*

In many applications two groups are compared simultaneously on several correlated binary variables for a more comprehensive assessment of group differences. Although the response is multivariate, the main interest is in comparing the marginal probabilities between the groups. Estimating the size of these differences under strong error control allows for a better evaluation of effects than can be provided by multiplicity adjusted P-values.

Simultaneous confidence intervals for the differences in marginal probabilities are developed through inverting the maximum of correlated Wald, score or quasi-score statistics. Taking advantage of the available correlation information leads to improvements in the joint coverage probability and power compared to straightforward Bonferroni adjustments. Estimating the correlation under the null is also explored. While computationally complex even in small dimensions, it does not result in marked improvements. Based on extensive simulation results, a simple approach that uses univariate score statistics together with their estimated correlation is proposed and recommended. All methods are illustrated using data from a vaccine trial that investigated the incidence of four pre-specified adverse events between two groups and with data from the General Social Survey.

The Effect of Short Formative Diagnostic Web Quizzes and Minimal Feedback
Bernhard Klingenberg, with Bälter, O. Enström, E.

Explicit Constructions of Large Families of Generalized More Sums Than Differences Sets
Steven Miller with *Sean Pegado '11* and *Luc Robinson '12*

A More Sums Than Differences (MSTD) set is a set of integers A of {0, ..., n-1} whose sumset A+A is larger than its difference set A-A. While it is known that as $n\to\infty$ a positive percentage of subsets of {0, ..., 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, ..., n-1} is at least C/n4 for some C>0, significantly larger than the

previous constructions, which were on the order of 1/2n/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 Miller, Orosz and Scheinerman, and we find that for any ε > 0 the density of such sets is at least C/nε. 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.

Quadratic fields with cyclic 2-class groups
Steven Miller with *Carlos Dominguez '13* and Siman Wong

Journal of Number Theory 133, no. 3, 926-939, 2013.

For any integer k ≥1, we show that there are infinitely many complex quadratic fields whose 2-class groups are cyclic of order 2k. The proof combines the circle method with an algebraic criterion for a complex quadratic ideal class to be a square. In memory of David Hayes.

First Order Approximations of the Pythagorean Won-Loss Formula for Predicting MLB Teams Winning Percentages
Steven Miller with Kevin Dayaratna

By The Numbers, The Newsletter of the SABR Statistical Analysis Committee 22, no 1, 15-19, 2012.

We mathematically prove that an existing linear predictor of baseball teams' winning percentages (Jones and Tappin 2005) is simply just a first-order approximation to Bill James' Pythagorean Won-Loss formula and can thus be written in terms of the formula's well-known exponent. We estimate the linear model on twenty seasons of Major League Baseball data and are able to verify that the resulting coefficient estimate, with 95% confidence, is virtually identical to the empirically accepted value of 1.82. Our work thus helps explain why this simple and elegant model is such a strong linear predictor.

Low-lying zeros of number field L-functions
Steven Miller with Ryan Peckner

Journal of Number Theory 132, 2866-2891, 2012.

One of the most important statistics in studying the zeros of L-functions is the 1-level density, which measures the concentration of zeros near the central point. Fouvry and Iwaniec proved that the 1-level density for L-functions attached to imaginary quadratic fields agrees with results predicted by random matrix theory. In this paper, we show a similar agreement with random matrix theory occurring in more general sequences of number fields. We first show that the main term agrees with random matrix theory, and similar to all other families studied to date, is independent of the arithmetic of the fields. We then derive the first lower order term of the 1-level density, and see the arithmetic enter.

Leading, learning and herding
Steven Miller with Daniel Stone

Mathematical Social Sciences 65, 222-231, DOI information: 10.1016/j.mathsocsci.2012.12.002, 2013.

We analyze a game theoretic model of social learning about a consumption good with endogenous timing and heterogeneous accuracy of private information. We show that if individuals value their reputation for the degree to which they are informed, this reduces the incentive to learn by observing others and exacerbates the incentive to consume the good before others, i.e., to attempt to be an "opinion leader." Consequently, reputation concerns reduce the average delay of consumption of new goods, and increase (reduce) the probability of herding on consumption (non-consumption).

The Average Gap Distribution for Generalized Zeckendorf Decompositions
Steven Miller with O. Beckwith, A. Bower, L. Gaudet, R. Insoft, S. Li, and *P. Tosteson '13*

The Fibonacci Quarterly 51, 13-27, 2013.

An interesting characterization of the Fibonacci numbers is that, if we write them as F1 = 1, F2 = 2, F3 = 3, F4 = 5, …, then every positive integer can be written uniquely as a sum of non-adjacent Fibonacci numbers. This is now known as Zeckendorf's theorem, and similar decompositions exist for many other sequences {Gn+1 = c1 Gn + ... + cL Gn+1-L} arising from recurrence relations. Much more is known. Using continued fraction approaches, Lekkerkerker proved the average number of summands needed for integers in [G_n, Gn+1) is on the order of CLek n for a non-zero constant; this was improved by others to show the number of summands has Gaussian fluctuations about this mean.

Kologlu '12, Kopp, Miller and Wang recently recast the problem combinatorially, reproving and generalizing these results. We use this new perspective to investigate the distribution of gaps between summands. We explore the average behavior over all m in [Gn, Gn+1) for special choices of the ci's. Specifically, we study the case where each ci in {0, 1} and there is a g such that there are always exactly g-1 zeros between two non-zero ci's; note this includes the Fibonacci, Tribonacci and many other important special cases. We prove there are no gaps of length less than g, and the probability of a gap of length j > g decays geometrically, with the decay ratio equal to the largest root of the recurrence relation. These methods are combinatorial and apply to related problems; we end with a discussion of similar results for far-difference (i.e., signed) decompositions.

Closed Form Continued Fraction Expansions of Special Quadratic Irrationals
Steven Miller with Dan Fishman

We derive closed form expressions for the continued fractions of powers of certain quadratic surds. Specifically, consider the recurrence relation Gn+1 = m Gn+ l Gn-1 with G0 = 0, G1 = 1, m a positive integer and l = ±1 (note m = l =1 gives the Fibonacci numbers). Let $\varphi_{m,l}$ = limn $_à$ ∞ Gn / Gn-1. We find simple closed form continued fraction expansions for $\varphi_{m,l}^k$ for any integer k by exploiting elementary properties of the recurrence relation and continued fractions. This paper is dedicated to the memory of Alf van der Poorten.

Distribution of Missing Sums in Sumsets
Steven Miller with Oleg Lazarev and Kevin O'Bryant

For any finite set of integers X, define its sumset X+X to be {x+y: x, y in X}. In a recent paper, Martin and O'Bryant investigated the distribution of |A+A| given the uniform distribution on subsets A of {0, 1, ..., n-1}. They also conjectured the existence of a limiting distribution for |A+A| and showed that the expectation of |A+A| is 2n - 11 + O((3/4) n/2). Zhao proved that the limits m(k) := limn $_à$ ∞ Prob(2n-1-|A+A|=k) exist, and that the sum of the m(k) equals 1.

We continue this program and give exponentially decaying upper and lower bounds on m(k), and sharp bounds on m(k) for small k. Surprisingly, the distribution is at least bimodal; sumsets have an unexpected bias against missing exactly 7 sums. The proof of the latter is by reduction to questions on the distribution of related random variables, with large scale numerical computations a key ingredient in the analysis. We also derive an explicit formula for the variance of |A+A| in terms of Fibonacci numbers, finding Var(|A+A|) is approximately 35.9658. New difficulties arise in the form of weak dependence between events of the form {x in A+A}, {y in A+A}. We surmount these obstructions by translating the problem to graph theory. This approach also yields good bounds on the probability for A+A missing a consecutive block of length k.

Virus Dynamics on Spoke and Star Graphs
Steven Miller with Thealexa Becker, *Alec Greaves-Tunnell '13,* Leo Kontorovich and Karen Shen

The field of epidemiology has presented fascinating and relevant questions for mathematicians, primarily concerning the spread of viruses in a community. The importance of this research has greatly increased over time as its applications have expanded to also include studies of electronic and social networks and the spread of information and ideas. We study virus propagation on a non-linear hub and spoke graph (which models well many airline networks). We

determine the long-term behavior as a function of the cure and infection rates, as well as the number of spokes n. For each n we prove the existence of a critical threshold relating the two rates. Below this threshold, the virus always dies out; above this threshold, all non-trivial initial conditions iterate to a unique non-trivial steady state. We end with some generalizations to other networks.

Existence of Isoperimetric Regions in Rn with Density
Frank Morgan and Aldo Pratelli

Ann. Global Anal. Geom., 2012.

We prove the existence of isoperimetric regions in Rn with density under various hypotheses on the growth of the density. Along the way we prove results on the boundedness of isoperimetric regions.

Are Large Perimeter-Minimizing Two-Dimensional Clusters of Equal-Area Bubbles Hexogonal or Circular?
S. J. Cox, *Frank Morgan* and F. Graner

Proc. R. Soc. Lond. Ser. A Math. Phys. Eng. Sci., published online 24 October 2012.

A computer study of clusters of 10000 equal-area bubbles shows for the first time that rounding conjectured optimal hexagon planar soap bubble clusters reduces perimeter.

Math Now - Commencement Can Wait
Frank Morgan

Huffington Post Blog, 28 May 2012.

A week of mathematics up and down the East coast.

Why is Summer so Early
Frank Morgan

Huffington Post Blog, 17 June 2012.

Too many leap years make summer come earlier.

I Win Soap-Bubble-Cluster Controversy
Frank Morgan

Huffington Post Blog, 22 June 2012.

A report on recent work on the shape of large soap bubble clusters.

Spilled Orange Juice on My Way to a Math Conference in Spain

Frank Morgan

Huffington Post Blog, 30 June 2012.

Adventures of a traveling mathematician.

Why a Laptop is Not a Computer
Frank Morgan

Huffington Post Blog, 24 July 2012.

Computers should have more cut and paste registers.

U.S. Presidential Election Paradox
Frank Morgan

Huffington Post Blog, 16 October 2012.

You could win the U.S. Presidential election with under 22% of the popular vote.

Why I Don't Like Energy Efficient Light Bulbs
Frank Morgan

Huffington Post Blog, 24 November 2012.

Heat-producing light bulbs let me set my thermostat lower.

How Often Should I Rebalance My Investments?
Frank Morgan

Huffington Post Blog, 3 December 2012.

A report on joint work with student Walter Filkins '12.

Measurable Time-Restricted Sensitivity
Cesar E Silva with *Domenico Aiello '11*, Hansheng, Diao, Zhou Fan, Daniel O. King, Jessica Lin

Nonlinearity, 25, 3313-3325, 2012.

We develop two notions of sensitivity to initial conditions for measurable dynamical systems, where the time before divergence of a pair of paths is at most an asymptotically logarithmic function of a measure of their initial distance. In the context of probability measure-preserving transformations on a compact space, we relate these notions to the metric entropy of the system. We examine one of these notions for classes of non-measure-preserving, nonsingular transformations.

Investigation of Topics in U-statistics and Their Applications in Risk Estimation and Cross Validation
Qing Wang

Penn State University Library (electronic resource), Ph.D. Dissertation, 1-187, 2012.

PHYSICS

Free Energy Cost of Stretching mRNA Hairpin Loops Inhibits Small RNA Binding
Yuzhong Meng '11 and *Daniel P. Aalberts*

Biophys, J 104, 482-487 (2013)

Small RNA-mRNA binding is an essential step in RNA interference, an important cellular regulatory process. Calculations of binding free energy have been used in binding site prediction, but the cost of stretching the mRNA loop when the small RNA-mRNA duplex forms requires further exploration. Here, using both polymer physics theory and simulations, we estimate the free energy of a stretched mRNA loop. We find loop stretching significantly increases the free energy of 3' supplementary/compensatory miRNA binding and siRNA binding to mRNA hairpin loops. We also make the observation that sites where 3' supplementary binding is available may bind at the seed only, and that loop stretching often favors seed-only binding over seed plus 3' supplementary binding in mRNA hairpins.

Visualizing RNA base pairing probabilities with RNABOW diagrams
Daniel P. Aalberts and *William K. Jannen '09*

There are many effective ways to represent a minimum free energy RNA secondary structure that make it easy to locate its helices and loops. It is a greater challenge to visualize the thermal average probabilities of all folds in a partition function sum; dot plot representations are often puzzling. Therefore, we introduce the RNAbows visualization tool for RNA base pair probabilities. RNAbows represent base pair probabilities with line thickness and shading, yielding intuitive diagrams. RNAbows aid in disentangling incompatible structures, allow comparisons between clusters of folds, highlight differences between wild-type and mutant folds, and are also rather beautiful.

Noiseless Optical Amplifier Operating on Hundreds of Spatial Modes
Kevin M. Jones, McElfresh Professor of Physics, and others

We implement a noiseless optical amplifier using a phase-sensitive four-wave mixing process in rubidium vapor. We observe performance near the quantum limit for this type of amplifier over a range of experimental parameters and show that the noise figure is always better than would be obtained with a phase-insensitive amplifier with the same gain. Additionally, we observe that the amplifier supports hundreds of spatial modes, making it possible to amplify complex two-dimensional spatial patterns with less than a 10% degradation of the input signal-to-noise ratio for gains up to 4.6. To confirm the multimode character of the amplifier, we study the noise figure as a function of spatially-varying losses. Additionally, we investigate the spatial resolution of the amplifier and show that it supports a range of spatial frequencies from 1.3 to more than 35 line pairs per millimeter.

Measurement of the scalar polarizability within the 5P1/2-6S1/2 410-nm transition in atomic indium
G. Ranjit, N.A. Schine '13, A.T. Lorenzo '11, A.E. Schneider '12, and *P.K. Majumder*

We have completed a measurement of the Stark shift in 115In within the 410-nm 5P1/2-6S1/2 transition. We measure the Stark shift constant to be $kS=-122.92(33)$ kHz/(kV/cm)2, corresponding to a difference in the 6S1/2- and 5P1/2-state polarizabilities, $\Delta\alpha_0$ (in atomic units), of 1000.2 ± 2.7 a03. This result is a factor of 30 more precise than previous measurements and is in excellent agreement with a new theoretical value based on an ab initio calculation of the wave functions in this three-valence-electron system. The measurement was performed in an indium atomic-beam apparatus, used a GaN laser diode system, and exploited a FM spectroscopy technique to extract laser transmission spectra under conditions where our interaction region optical depth was typically less than $10-3$.

Thallium 7p lifetimes derived from experimental data and ab initio calculations of scalar polarizabilities
M.S. Safronova and *P.K. Majumder*

Two different theoretical methods have been used to complete a calculation of polarizability in the thallium 6p1/2, 7s, and 7p1/2 states. The predictions of the two methods agree to within 1% for the 6p1/2 and 7s states and 2% for the 7p1/2 state. We find that the theoretical expression for the 6p1/2-7s transition polarizability difference $\Delta\alpha_0$ is dominated (greater than 90% contribution) by mixing of the 7s state with the 7p1/2 and 7p3/2 states. By comparing the theoretical expression to an existing measurement of $\Delta\alpha_0$ [Doret et al. Phys. Rev. A 66 052504 (2002)], highly accurate values for the thallium 7p excited-state lifetimes have been extracted. The scalar polarizability of the 7p1/2 state is also computed, anticipating an experimental determination of this quantity, which will then enable a high-precision determination of the 6dj-7pj   transition rates and provide a benchmark test of the two theoretical approaches in the near future.

Quantum walks on trees with disorder: Decay, diffusion, and localization
S.R. Jackson, T.J.Khoo, and *F. W. Strauch*

Quantum walks have been shown to have impressive transport properties compared to classical random walks. However, imperfections in the quantum-walk algorithm can destroy any quantum-mechanical speedup due to Anderson localization. We numerically study the effect of static disorder on a quantum walk on the glued trees graph. For small disorder, we find that the dominant effect is a type of quantum decay, and not quantum localization. For intermediate disorder, there is a crossover to diffusive transport, while a localization transition is observed at large disorder, in agreement with Anderson localization on the Cayley tree.

All-Resonant Control of Superconducting Resonators
F. W. Strauch

An all-resonant method is proposed to control the quantum state of superconducting resonators. This approach uses a tunable artificial atom linearly coupled to resonators, and allows for efficient routes to Fock state synthesis, qudit logic operations, and synthesis of NOON states. This resonant approach is theoretically analyzed, and found to perform significantly better than existing proposals using the same technology.

Absolute Dynamical Limit to Cooling Weakly Coupled Quantum Systems
X. Wang, S. Vinjanampathy, F. W. Strauch, and K. Jacobs

Here we address the question of just how cold one can cool a quantum system, given that the size of the control forces is limited. We solve this problem fully, within the dual regimes of (i) weak coupling, defined as that in which the thermalization dynamics of the system is preserved, and (ii) relatively strong control, being that in which appreciable cooling can be achieved. State-of-the art cooling schemes are presently implemented in this regime. Given that the maximum rate of coupling to the system is bounded, we identify a control protocol for cooling, and provide detailed structural arguments, supported by strong numerical evidence, that this protocol is globally optimal. From this we obtain simple expressions for the absolute limit to cooling. The methods developed can also be used to obtain optimal controls for a broad class of state-preparation problems..

Real Vector-Space Quantum Theory with a Universal Quantum Bit
Antoniya Aleksandrova '11, Victoria Borish '12, and William K. Wootters

We explore a model of the world based on real-vector-space quantum theory. In our model the familiar complex phase appearing in quantum states is replaced by a single binary object that we call the ubit, which is not localized and which can interact with any object in the world. Ordinary complex-vector-space quantum theory can be recovered from this model if we simply impose a certain restriction on the sets of allowed measurements and transformations (Stueckelberg's rule), but in this paper we try to obtain the standard theory, or a close approximation to it, without invoking such a restriction. We look particularly at the effective theory that applies to a subsystem when the ubit is interacting with a much larger environment. In a certain limit it turns out that the ubit-environment interaction has the effect of enforcing Stueckelberg's rule automatically, and we obtain a one-parameter family of effective theories—modifications of standard quantum theory—that all satisfy this rule. The one parameter is the ratio s/ω, where s quantifies the strength of the ubit's interaction with the rest of the world and ω is the ubit's rotation rate. We find that when this parameter is small but not zero, the effective theory is similar to standard quantum theory but is characterized by spontaneous decoherence of isolated systems.

PSYCHOLOGY

Estudios Empiricos Sobre Mechanismos de Defensa (Empirical Studies of Defense Mechanisms)
Phebe Cramer

Subjetividad y procesos cognitivos, Argentina: Universidad de Ciencias Empresariales y Sociales, 2013.

This paper reviews the history of the concept of defense mechanism, and explains the theory I have proposed for defense mechanism development. It also describes and illustrates the coding method I have created for assessing the use of defense mechanisms. The paper then demonstrates how the coding method has been applied to the study of personality disorders.

How the Opinions of Racial Minorities Influence Judgments of Discrimination
Jennifer Randall Crosby & B. Monin

Basic and Applied Social Psychology (in press).

In three studies, we investigated how judgments of racial discrimination were influenced by opinions attributed to target versus non-target group members. In Study 1, Blacks individuals were judged to be better sources of information about racial discrimination than White individuals. In Study 2, participants were more influenced by Black peers than by White peers in judgments of whether specific behaviors constituted discrimination. In Study 3, the influence of Black peers was moderated by internal concern with prejudice, and mediated by the perceived credibility of the peer. We discuss these findings in terms of targeted social referencing, whereby members of relevant target groups exert more influence than members of non-target groups over assessments of, and responses to, discrimination.

The Case for Curiosity
Susan Engel

Educational Leadership 70, 36-40, 2013.

Curiosity is essential to learning, but in scarce supply in most schools.

Anger and Positive Reactivity in Infancy: Effects on Maternal Report of Surgency and Attention Focusing in Early Childhood
Jie He, *Amie Ashley Hane,* Kathryn Amey Degnan, Heather A. Henderson, Qinmei Xu, & Nathan A. Fox

Infancy, 18, 184-201, 2013.

We examined two aspects of temperamental approach in early infancy, positive reactivity and anger, and their unique and combined influences on maternal reports of child surgency and attention focusing at 4 years of age. One hundred and fourteen infants were observed for their positive reactions to novel stimuli at 4 months, and their anger expressions during arm restraint at 9 months. Child surgency and attention focusing at age 4 years were assessed by maternal report. Infants who expressed more anger to restraint were rated higher in surgency during early childhood relative to infants who expressed less anger. The effects of positive reactivity to novelty on attention focusing were moderated by anger to restraint. These findings suggest that infant temperamental approach tendencies are multifaceted and have both unique and combined influences on later maternal report of attention and social behavior.

Reactive Temperament and Sensitivity to Context in Childcare
Deborah Phillips, Nancy A. Crowell, Amy L. Sussman, Megan Gunnar, Nathan Fox, *Amie Ashley Hane*, & Joanna Bisgaier

Social Development, 21, 628-643. 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.

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

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.

The Narrowing of Theoretical Orientations in Clinical Psychology Doctoral Training
Laurie Heatherington, Stanley B. Messer, Lynne Angus, Timothy J. Strauman, Myrna L. Friedlander, & Gregory G. Kolden

The focus of this article is the increasingly narrow range of therapeutic orientations represented in clinical psychology graduate training programs, particularly within the most research-oriented programs. Data on the self-reported therapeutic orientations of faculty at "clinical science" Ph.D. programs, Ph.D. programs at comprehensive universities in clinical and in counseling psychology, Psy.D. programs at comprehensive universities, and Ph.D. or Psy.D. programs at freestanding specialized institutions reveal a strong predominance of faculty with cognitive-behavioral orientations at the more science-focused programs, and a narrower range of orientations than in the more practice-focused programs. We discuss the implications of this trend for the future development of clinical psychology and provide suggestions for addressing the attendant concerns.

How Do Therapists Ally With Adolescents in Family Therapy?
Cristina Muñiz de la Peña, Myrna L. Friedlander, Valentín Escudero, & *Laurie Heatherington*

Sequential analyses examined associations between the working alliance and therapist–adolescent communication patterns in 10 Spanish cases of brief conjoint family therapy. Early sessions with strong versus problematic alliances, rated by observers, were selected for coding of relational control communication patterns. No differences were found in the frequency of exchanges, but competitive responding by the therapists (reflecting an interpersonal struggle for control) was significantly more likely in problematic alliance sessions than in strong alliance sessions. Cases in which the adolescent's alliance with the therapist remained positive from Session 1 as compared with Session 3 showed a decrease in the likelihood of competitive symmetry. Notably, when the quality of the alliance deteriorated over time, the therapists were increasingly more likely to respond to the adolescents' domineering messages in a competitive manner. Results underscore the need to avoid competitive responding in order to ally with adolescents in conjoint family treatment.

Managing Negative Reactions to Clients in Family Therapy
Laurie Heatherington, Myrna L. Friedlander, & Valentín Escudero

In J.C. Muran, A.Wolf, & M. Goldfried (Eds.). *Managing Negative Reactions to Clients: From Frustration to Compassion*. Washington, DC: American Psychological Association, 2012.

This chapter describes the range of possible negative reactions to clients originating from the family's dynamics, from within the therapist, and from the wider systems surrounding the therapy, and offers guidelines for managing those reactions.

Social Psychology (9th edition)
Saul Kassin, Steven Fein, & Hazel Rose Markus

Belmont, CA: Cengage Learning, 2014.

The Forensic Confirmation Bias: Problems, Perspectives, and Proposed Solutions
Saul M. Kassin, I. Dror, & J. Kukucka

Journal of Applied Research in Memory and Cognition, 2, 42-52. 2013.

As illustrated by the mistaken, high-profile fingerprint identification of Brandon Mayfield in the Madrid Bomber case, and consistent with a recent critique by the National Academy of Sciences (2009), it is clear that the forensic sciences are subject to contextual bias and fraught with error. In this article, we describe classic psychological research on primacy, expectancy effects, and observer effects, all of which indicate that context can taint people's perceptions, judgments, and behaviors. Then we describe recent studies indicating that confessions and other types of information can set into motion forensic confirmation biases that corrupt lay witness perceptions and memories as well as the judgments of experts in various domains of forensic science. Finally, we propose best practices that would reduce bias in the forensic laboratory as well as its influence in the courts.

New Application of Psychology to Law: Improving Forensic Evidence and Expert Witness Contributions
I. Dror, *Saul M. Kassin*, & J. Kukucka

Journal of Applied Research in Memory and Cognition, 2, 78-81, 2013.

Psychology has made a tremendous contribution to law by showing the malleability of eyewitness perception and memory and developing best practices for obtaining eyewitness identifications. We suggest that even expert scientific witnesses, which the courts heavily relies on as objective and impartial, are also susceptible to bias from various psychological influences. For example, forensic examiners' interactions with detectives and exposure to information about the case can bias their judgments. We discuss the ten commentaries on these issues across a range of forensic domains and affirm what reforms are needed.

Police-Induced Confessions: An Empirical Analysis of their Content and Impact
S. Appleby, L. Hasel, & *Saul M. Kassin*

Psychology, Crime and Law, 19, 111-128, 2013.

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.

Why Confessions Trump Innocence
Saul M. Kassin

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 details 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

bootES: Bootstrap effect sizes (Version 1.01)
Daniel Gerlanc '07, Kris N. Kirby

BootES: An R package for bootstrap confidence intervals on effect sizes
Kris N. Kirby & *Daniel Gerlanc '07*

Bootstrap Effect Sizes (bootES; Gerlanc & Kirby, 2012) is a free, open source software package for R (R Development Core Team, 2012), which is a language and environment for statistical computing. BootES computes both unstandardized and standardized effect sizes (such as Cohen's d, Hedges's g, and Pearson's r), and makes easily available for the first time the computation of their bootstrap CIs. In this article we illustrate how to use bootES to find effect sizes for contrasts in between-subjects, within-subjects, and mixed factorial designs, and to find bootstrap CIs for correlations, and differences between correlations. An appendix gives a brief introduction to R that will allow readers to use bootES without having prior knowledge of R.

Why Interleaving Enhances Inductive Learning: The Roles of Discrimination and Retrieval
Monica S. Birnbaum, *Nate Kornell,* Elizabeth Ligon Bjork, & Robert A. Bjork

Kornell and Bjork (Psychological science 19:585-592, 2008) found that interleaving exemplars of different categories enhanced inductive learning of the concepts based on those exemplars. They hypothesized that the benefit of mixing exemplars from different categories is that doing so highlights differences between the categories. Kang and Pashler (Applied cognitive psychology 26:97-103, 2012) obtained results consistent with this discriminative-contrast hypothesis: Interleaving enhanced inductive learning, but temporal spacing, which does not highlight category differences, did not. We further tested the discriminative-contrast hypothesis by examining the effects of interleaving and spacing, as well as their combined effects. In three experiments, using photographs of butterflies and birds as the stimuli, temporal spacing was harmful when it interrupted the juxtaposition of interleaved categories, even when total spacing was held constant, supporting the discriminative-contrast hypothesis. Temporal spacing also had value, however, when it

did not interrupt discrimination processing.

Self-regulated Learning: Beliefs, Techniques, and Illusions
Robert A. Bjork, John Dunlosky, and *Nate Kornell*

Annual Review of Psychology, 64, 417-444, 2013.

Knowing how to manage one's own learning has become increasingly important in recent years, as both the need and the opportunities for individuals to learn on their own outside of formal classroom settings have grown. During that same period, however, research on learning, memory, and metacognitive processes has provided evidence that people often have a faulty mental model of how they learn and remember, making them prone to both misassessing and mismanaging their own learning. After a discussion of what learners need to understand in order to become effective stewards of their own learning, we first review research on what people believe about how they learn and then review research on how people's ongoing assessments of their own learning are influenced by current performance and the subjective sense of fluency. We conclude with a discussion of societal assumptions and attitudes that can be counter-productive in terms of individuals becoming maximally effective learners.

When and Why a Failed Test Potentiates the Effectiveness of Subsequent Study
Matthew Jensen Hays, *Nate Kornell*, and Robert A. Bjork

Journal of Experimental Psychology: Learning, Memory, & Cognition, 39, 290-296, 2012.

Teachers and trainers often try to prevent learners from making errors, but recent findings (e.g., Kornell, Hays, & Bjork, 2009) have demonstrated that tests can potentiate subsequent learning even when the correct answer is difficult or impossible to generate (e.g., "What is Nate Kornell's middle name?"). In 3 experiments, we explored when and why a failed test enhances learning. We found that failed tests followed by immediate feedback produced greater retention than did a presentation-only condition. Failed tests followed by delayed feedback, by contrast, did not produce such a benefit—except when the direction of the final test was reversed (i.e., the participants were provided with the target and had to produce the original cue). Our findings suggest that generating an incorrect response to a cue both activates the semantic network associated with the cue and suppresses the correct response. These processes appear to have 2 consequences: If feedback is presented immediately, the semantic activation enhances the mapping of the cue to the correct response; if feedback is presented at a delay, the prior suppression boosts the learning of the suppressed response.

Tests Enhance Learning—Compared to What?
Nate Kornell, Veronica C. Rabelo '11, and *Patricia Jacobs Klein '11*

Journal of Applied Research in Memory and Cognition, 1, 257-259, 2012.

Paclitaxel is a chemotherapy drug that has been used to treat cancer since the 1960s. It is relatively inexpensive because there is a generic version. In recent years, more expensive drugs have been developed to replace paclitaxel. After successful clinical trials, both Abraxane and Ixempra have been approved by the FDA. For their makers, this is the good news. The bad news is that, according to a study released in June 2012, neither of the newer drugs works as well as paclitaxel (Berkrot, 2012). New drugs are initially compared to placebos. But in medicine, being more effective than the placebo is not enough. To become a recommended treatment, a new drug should be better than the current treatment. The same is true in education. Roediger and Pyc (2012) make this point clear: "The gold standard of educational innovation for any kind of new educational technique should be a strong research base showing that the new method produces positive results relative to standard practice (Whitehurst, 2010)." Roediger and Pyc's (2012) article ably describes three principles that enhance learning: distributed practice, explanatory questioning, and the one we focus on here, test-enhanced learning. In the literature to date, the value of testing has been demonstrated by comparing tests to two other activities: restudying the same information in the same way as before, or not restudying at all (Roediger & Pyc). Tests appear to be better than restudying. But is restudying an effective standard practice, like paclitaxel, or is it more like a placebo? In this article, we consider the value of tests as compared to various different learning activities.

Social Context of Bullying: Do Misperceptions of Group Norms Influence Children's Responses to Witnessed Episodes?

Marlene J. Sandstrom, Heather Makover '10, & Maria Bartini

This study explores the association between norm misperception and behavioral responses to witnessed bullying episodes. We hypothesized that pluralistic ignorance (PI) could explain individual differences in behavioral responses. According to PI theory, children who believe that victims deserve protection may inhibit defending behavior if they assume their attitudes are out of step with their peers. A total of 446 fourth and eighth graders described their personal attitudes and perceptions of peers' attitudes about bullying, as well as their behavioral responses when they witnessed a bullying episode. Consistent with PI theory, children perceived their personal attitudes as more prosocial than those of their classmates. Further, misperception of group norms was associated with children's reports of behavioral responses to bullying; children who overestimated peers' approval of bullying reported lower levels of defending the victim and higher levels of joining in.

Family Therapy
Jay Lebow & *Catherine B. Stroud*

The chapter reviews the history of couple and family therapy, the main approaches and models, and research investigating these interventions. In addition, the roles of culture, ethnicity, and gender are discussed.

Studies of Implicit Prototype Extraction in Patients With Mild Cognitive Impairment and Early Alzheimer's Disease
Robert M. Nosofsky, Stephen E. Denton, *Safa R. Zaki,* Anne F. Murphy-Knudsen, & Frederick W. Unverzagt

Studies of incidental category learning support the hypothesis of an implicit prototype-extraction system which is distinct from explicit memory (Smith, 2008). In those studies, patients with explicit-memory impairments due to damage to the medial-temporal lobe performed normally in implicit categorization tasks (Bozoki, Grossman, & Smith, 2006; Knowlton & Squire, 1993). However, alternative interpretations are that: i) even people with impairments to a single memory system have sufficient resources to succeed on the particular categorization tasks that have been tested (Nosofsky & Zaki, 1998; Zaki & Nosofsky, 2001); and ii) working memory can be used at time of test to learn the categories (Palmeri & Flanery, 1999). In the present experiments, patients with amnestic mild cognitive impairment or early Alzheimer's disease were tested in prototype-extraction tasks to examine these possibilities. In a categorization task involving discrete-feature stimuli, the majority of subjects relied on memories for exceedingly few features, even when the task structure strongly encouraged reliance on broad-based prototypes. In a dot-pattern categorization task, even the memory-impaired patients were able to use working memory at time of test to extract the category structure (at least for the stimulus set used in past work). We argue that the results weaken the past case made in favor of a separate system of implicit-prototype extraction.

The Role of Gaze Direction in Face Memory in Autism Spectrum Disorder
Safa R. Zaki & Shannon A. Johnson

We tested the hypothesis that the direction of gaze of target faces may play a role in reported face recognition deficits in those with an autism spectrum disorder (ASD). In previous studies, typically developing children and adults better remembered faces in which the eyes were gazing directly at them compared with faces in which the eyes were averted. In the current study, high-functioning children and adolescents with an ASD and age- and IQ-matched typically developing controls were shown a series of pictures of faces in a study phase. These pictures were of individuals whose gaze was either directed straight ahead or whose gaze was averted to one side. We tested the memory for these study

faces in a recognition task in which the faces were shown with their eyes closed. The typically developing group better remembered the direct-gaze faces, whereas the ASD participants did not show this effect. These results imply that there may be an important link between gaze direction and face recognition abilities in ASD.

Behavioral Effects of Repeated Handling Differ in Rats Reared in Social Isolation and Environmental Enrichment
Laurel Pritchard, *Tracey Van Kempen '05,* and *Betty Zimmerberg*

The post-weaning social environment has profound effects on behavior and physiology in rodents. Social isolation increases anxiety-like behaviors and novelty-induced locomotor activity, while environmental enrichment decreases these behaviors. In some cases, the effects of social isolation are ameliorated by repeated handling. The goal of the present study was to determine whether the effects of handling differ in rats reared in social isolation and those reared in an enriched environment. After weaning, male Long-Evans rats were housed individually (ISO)(3) or in groups in an enriched environment (EE). During adulthood, rats from each housing condition received four, once-daily, brief handling sessions or remained undisturbed in the home cage. All rats were then tested in the open field, elevated plus maze, and for behavioral responses to d-amphetamine (1.0mg/kg). EE rats spent more time on the open arms of the elevated plus maze and were more likely than ISO rats to emerge from the start box in the open field, suggesting lower anxiety. Handling significantly decreased open arm time in EE rats and marginally increased open arm time in ISO rats. Housing condition did not affect amphetamine-stimulated locomotor activity, but handling altered the time course of the amphetamine response. ISO rats exhibited significantly fewer stereotyped behaviors than did EE rats, but repeated handling eliminated this difference. These findings support previously published studies that suggest brief handling of adult rats may at least partially ameliorate the effects of post-weaning social isolation on anxiety-like behaviors and psychostimulant sensitivity. Furthermore, there are complex interactions between the effects of housing environment and handling, suggesting that handling may be perceived and/or processed differently, depending on the animal's housing environment.