Smith Scientific
Issue 3
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1 Letter from the Editor

Smith Scientific is a recent addition to the publications created on Smith campus. This journal aims to raise awareness of the student and faculty research done in STEM fields by writing about recent developments in a way that is accessible to all Smithies.

We have published hard copies of two editions, but have recently struggled to format the articles written during the 2012-2013 and 2013-2014 school years. We apologize to those writers, students, and professors whose work was not brought to light until now. Our updated goal is to make our articles available in this electronic format to speed up the distribution process (with the added benefit of being more eco-friendly).

Thank you for your patience, and we hope you enjoy reading about all of the hard work being done in our Smith community. If you have any interest in writing for Smith Scientific or having your work be featured in an upcoming issue, please e-mail scientific@smith.edu.

Sincerely,
Sara Stoudt
Editor-in-Chief
2  Cover Story

2.1  Science at Smith College with Lale Burk by Aunaly Palmer

Inside the lab of the inorganic qualitative chemistry course at The American College for Girls in Istanbul, Turkey, Professor Lale Burk discovered her passion for chemistry. The focus of the class was to use the physical properties of solutions to identify the components of an unknown solution. Made from metallic salts, the solutions were a multitude of vibrant colors, including sapphire blues and emerald greens. In the mixture of the striking colors and the beauty of analytical chemistry, Professor Burk discovered her love of chemistry. In the fall of 1962, Burk left Istanbul and traveled halfway around the world to Northampton, Massachusetts. She had been admitted to the Masters in Chemistry program at Smith College. At the time, Smith only had one science building on campus: Stoddard Hall. The focus of Professor Burk’s Master’s thesis was the diterpene elliotinol, a naturally occurring hydrocarbon extracted from the resin of the slash pine. She would begin with large drums filled with pine resin. After purifying the resin, the essential oil was extracted, from which she isolated and analyzed her final product. Her thesis was completed in May of 1964, and soon after she began to work toward her Ph.D.

In 1966, Professor Burk packed up her lab in Stoddard Hall and moved into Sabin-Reed, the new science building on campus. Sabin-Reed was built to accommodate the expansion of Smith’s science program. For women across the country, the 1960s were a time of change, reflecting the spreading idea that women could work the same jobs as men and earn the same pay. With the change in attitude of the nation came an influx in the number of women majoring in the sciences.

The science program at Smith continued to grow and eventually Bass, McConnell, Sabin-Reed, and Burton Halls did not offer enough space to accommodate the increase in students studying science and the research they were conducting. In the spring of 2007, construction began on Ford Hall and was finished in fall 2009. Professor Burk’s newest office is in Ford Hall, nestled in the back corner of the third floor. Windows let in light along one wall, with plants growing in pots lining a desk. Bookshelves line the other two walls, and contain a variety of chemistry books and publications.

Professor Burk planned on moving back to Turkey in 1968 after completing her Ph.D. However, while working on her thesis, she met John Burk, a professor of botany who also had an office in Sabin-Reed. Their relationship blossomed and Professor Burk’s plans changed. They eventually married, and she took up a teaching job at Smith. Now, after 51 years at Smith, Professor Burk is retiring.

During her time at Smith College, Professor Burk has had the opportunity to observe science advance and change. The expanding knowledge base has allowed scientists to understand the reality of the toxicity of the chemicals they work with on a daily basis. When Professor Burk was working in Stoddard Hall, fume hoods were rarely used and gloves were hardly a necessity. Now, almost every experiment is completed in a fume hood and everyone wears lab coats, closed-toed shoes, gloves, and safety goggles.

Currently, Professor Burk teaches "Perspectives in Chemistry: Chemistry of Art Objects." One of the focuses of the class is the chemistry behind the multitude of colors artists use to create their works of art. Professor Burk connects the worlds of art and chemistry through the examination of pigments. She finds that chemistry has the tendency to become extremely insular, losing its connection to the world outside. Just as the vibrant unknown metallic compounds she studied while in college in Turkey inspired her when she was a teenager, the multitude of hues found in artists works inspire her teaching today.

Over her career at Smith, Professor Burk has studied and published articles that span across
the liberal arts. She has studied many organic compounds isolated from the essential oils of plants, the structure of the compounds, and the way in which asymmetric syntheses of these compounds occur. She has written about the integration of German scholars into Turkish universities after fleeing from Nazi Germany in the 1930s and '40s. For example, she has studied the life of German scientist Fritz Arndt, who is responsible for discovering the Arndt-Eistert reaction, which elongates the carbon chain before a carboxylic acid by one carbon. He was also integral in the development of resonance theory and greatly impacted the development of chemistry in Turkey after the Nazis forced him to leave Germany in 1933. Through the breadth of her work, it is evident that Professor Burks legacy that she leaves behind at Smith College is rich from her embracement of the liberal arts and her ability to synthesize the union of diverse subjects such as art, history, and chemistry.
3 Astronomy and Physics

3.1 Curiosity by Heather Kurtz

"Astronomy is the search for the underlying fundamental processes that govern the universe."

Darby Dyar

For centuries, people have been curious about the planet Mars. The question we crave to answer is: if there was or is life on Mars. Luckily, NASA sent the rover Curiosity to uncover the answer, and a great deal has been accomplished since Curiosity left Earth. One of the scientists involved in the Curiosity project is Professor Darby Dyar of Mount Holyoke College.

The dimensions of Curiosity are 10 feet long, 9 feet wide, and 7 feet high with a weight of almost 2000 pounds. There are many tools on the rover to analyze the soil from Mars. Curiosity is the first rover to have landed on Mars without airbags, versus previous Mars Rovers, namely Spirit and Opportunity. Curiosity is expected to work for at least one Martian year studying the Gale Crater, a 96-mile wide crater in the Eastern hemisphere. The goal of Curiosity is to study Mars and tell us whether there is water underground and what the rocks are made of. One of the many tools on Curiosity is the Sample Analysis at Mars (SAM). SAM searches for organics and carbon-based molecules in soil samples. As these molecules are essential to life, SAM is searching for signs of any past or present life on Mars. So far Curiosity has used SAM to test its system. In addition to SAM, Chem Cam is another useful feature, which was developed in part by Darby Dyar.

Dr. Dyar first became involved with this project because of her work in geology. She has a large range of spectroscopy samples from her research and was able to use that knowledge to help build the Chem Cam and analyze the data from Curiosity. The Chem Cam is used with a laser to heat the rock and collect spectroscopic data. The results of how Chem Cam reads this data tells us the make up of the rocks, such as the elements present and the abundance of each.

When asked about why the work with the Mars rover is so valuable, Dyar replied that it is about getting people interested in science, especially women. The more interest and excitement there is around science, the more people are going to be curious and want to learn more. Part of what Dyar hopes will result from this rover expedition is an improved laser technology and that the students involved will learn to think critically and solve the problem at hand.

Each day, new instructions are sent to Curiosity on what to examine and where to look. In addition, Curiosity brings back new discoveries and new insights about the planet Mars. Unfortunately, in April, there will be a time where the rover will not be communicating with the Earth because Mars and the Earth will be on opposite sides of the Sun. So there will be a break in the amazing discoveries, but when communication starts again so will all the discoveries.

3.1.1 Citations


3.2 Women in Physics: A Report from Abroad by Lydia Shannon

Smith College is the ideal place to be inspired by women in physics or any other field of science. With its all-female student population, full of driven, young women continuously aided by a small and select group of professors who are devoted to the education and encouragement of females in the academic world, there's really no better place to be. But not every woman in the world trying to make it in science is as privileged as Smith students. Women’s colleges are rare in the U.S. and even rarer outside of it. Most female students of science attend large, coed universities with hundreds of other men and women, all striving for the same end goal, and often competing to get there. So where, in such a crowded and necessarily self-motivated educational system, can a young female student find the inspiration and confidence to compete among the masses?

In the physics building at the University of Hamburg, Germany, a hallway leading from the front entrance to ground floor study room contains a display of posters dedicated to group of women honorably named Lise Meitners Tochter, "Lisa Meitners Daughters." Lisa Meitners work was one of physics most glaring examples of women's scientific achievement being overlooked by the Nobel Prize committee for personal negative opinions. Lise was an essential player in the discovery of nuclear fission but was omitted from the Nobel Prize, which was awarded to her colleague Otto Hahn. The caption above the series of posters simply reads Physikerinnen stellen sich vor, "Women Physicists Imagine." Each poster includes a photo and description of a European woman who has been honored for her achievements in and contributions to the study of physics.

Prof. Dr. Cornelia Denz is a nonlinear photonics physicist from Frankfurt and she is currently Speaker for Nonlinear Science at the University of Munster in Germany, where she received the Frauenförder Prize for women's advancement. In 1933 she was awarded the Lise-Meitner Prize and in 1999 she received the Prize of Adolf-Messer-Stiftung for the aid of research of young scientists.

German-born Mag. Dr. Doris Steinmuller-Nethl is a material physics and product development researcher and a current member of the Steering Board of the Diamond Centre at the University of Uppsala in Sweden. In 2000 she was named winner in the category Most Innovative European Enterprise for the European Awards for the Spirit of Enterprise.
Univ.-Doz. Dr. Beatrix C. Hiesmayr is a quantum and particle physicists from Austria and current Chairman of the Technical Committee for Nuclear and Particle Physics for the Austrian Physical Society. In 2002 she received the Bank Austria Prize and the Theodor Krner Prize in 2003 for the promotion of science and the arts.

Prof. Dr. Ekaterina Shamonina is a Russian electromagnetic and metamaterial physicist and current holder of the Endowed Chair for Advanced Optical Technologies at the Friedrich-Alexander University in Erlangen-Nürnberg, Germany. In 2006 she was awarded the Hertha-Sponer Prize for outstanding scientific work of a young physicist.
These posters allow the many achievements of modern women in physics to be seen by all who pass by. The title Lise Meitners Tochter conveys the idea that they are symbolic for righting the wrong done to a brilliant physicist decades before, and the phrase Physikerinnen stellen sich vor communicates the promise of the success of Physikerinnen for decades to come. These posters display the recognition of the achievements of female physicists and encourage all female students to pursue, without fear of persecution, that goal of contributing to one of the greatest areas of scientific knowledge.

3.3 Scientific Inquiry: A Physics Education Teaching Method by Abigail Azari and Jennifer Podel

Many high school physics classes are abound with equations, problem sets and, maybe if you are extremely lucky, a frustrating lab experience. These often do not appeal to the average high school student. What if instead of teaching numbers and memorization, physics courses were a way to explore the physical reality of the world? What if the courses taught students to harness those inklings of curiosity that we feel when faced with a phenomena we do not understand and apply this curiosity to create an experiment, which will quantify such a phenomena? This is what Jennifer Podel is working to create in the local high school science classroom with Professor Nalini Easwar.

Through a special studies project funded by the National Science Foundation and the American Physical Society, Jennifer Podel worked with students and Eric Newman, a teacher at the Northampton High School, to help them design their own experiments to learn more about granular materials. This project began with faculty at Western New England University who worked with students at Amherst Regional Middle School. Podel began her interactions with the project in its second phase. Podel planned out a short inspirational lesson about granular material. This included group activities, pictures, YouTube videos, and a collection of hands on experiments, which were designed to be interesting and just counterintuitive enough that the students were still willing to accept what they saw, and be curious about it. This lesson was followed by several class
periods of work, where the students built and ran their own experiments, then several more sessions where the students worked on analyzing the data they had collected. This all concluded with a final presentation poster session.

The motivational lesson consisted of a group brainstorming session as to what granular material is (sand, cereal, rice, etc), what forms it takes (gas, liquid, solid), and then a section on what granular materials are used in and why it is important to know about them. Granular materials are incredibly useful to learn about for landslide awareness, prediction, and manufacturing processes, specifically of pharmaceuticals. One rather famous example that Podel brought up was the stranding of the Mars Exploration Rover, Spirit. Another example, which coincided nicely with the students robotics club, was the University of Chicago's robotic hand that uses coffee grains and suction to pick up a large variety of objects.

The students, given this motivational speech and several hands-on examples, were then allowed to explore the facet of granular material that most interested them. Certain projects looked at the flow rate of materials through different apertures, the phenomena of large and small grain sizes mixing under agitation, and how different materials form piles when dropped for example. A poster session was held at Smith College at McConnell Hall, where all the students presented their results in groups to faculty, Smith students, and other interested parties. This project and research was presented by Podel at the American Physics Society National Conference in March. Podel brings scientific inquiry to the classroom in a unique way. The methods used in this project allowed students to be engaged in their own education and explore science and analytical tools.

3.4 Physics Students Experiences in Research: Presentation at National Physics Conference by Abigail Azari and Brenda Caballo-Ramirez

Brenda Caballo-Ramirez ('14) and Jennifer Podel ('14) have been working with Professor Nalini Easwar investigating granular materials. They presented their research in March at the national meeting of the American Physical Society as the only undergraduate students in their respective sessions. Caballo-Ramirez's research focused on the specifics of granular materials while Podel's research focused on the usage of granular materials in the classroom.

Granular flow is a subset of the study of complex materials. As can be read from Podel's research experience, granular material can be complicated and difficult to model and study. Caballo-Ramirez's research focuses on gravity granular flow situations. Gravitationally driven granular flow is when a granular material (sand, marbles, etc) is allowed to flow vertically down due to gravitational forces. This is a complicated system that involves many considerations. For example, the flow is very rapid, so any interactions between the grains happen quickly, making observations difficult to collect. Also, when rigid grains (M&Ms, rice, etc) flow, all interactions are collisional. As such, any energy loss in the system of flowing grains is due to inelastic collisions and not friction. In other words, the objects lose energy through hitting each other as opposed to scraping each other. Caballo-Ramirez uses a hopper, a vertical container with a gate at the bottom, which allows granular material to flow through the bottom to study granular materials. At the hopper wall and some distance into the hopper, there is a shear zone, or a zone where the materials behave differently. At the shear zone there is a spatial increase in the velocity of the grains. In fact, the velocity of the grains increases exponentially and settles to some constant value in the bulk of the flow. Caballo-Ramirez studies this shear zone to see what parameters (width of the hopper, size of the grains, or overall velocity of the grains) might determine the size of the shear zone.

At the APS meeting, Caballo-Ramirez presented her research in a session dedicated to granular
flow. All of the people who presented, excluding Brenda Caballo-Ramirez and Jennifer Podel were professors or assistant professors. Caballo-Ramirez states that, "Learning about what others had seen in their research, and how mine correlated with them, was exciting. My presentation was well received and I’m glad to have had the opportunity to take part in this meeting." Brenda would like to thank Nalini Easwar for letting her have this experience.

3.5 Modelling the Expansion and Collapse of Bose-Einstein Condensates by Lydia Shannon

Bose-Einstein condensates are a special state of matter in which a macroscopic number of atoms are trapped in the lowest quantum energy level of a container. This is done by cooling the atoms to a very low temperature. The properties of this matter allow all of the atoms in the condensate to be described by one quantum mechanical wave function. Quantum mechanics typically describes the behavior of very small objects, such as single electrons, however, one BEC usually contains around 105 or 106 atoms. With thousands or millions of particles all described by a single wave function, BECs allow us to view quantum mechanical effects on a macroscopic scale.

In order to measure properties of these condensates, the cooled gas must be released from a potential trap and allowed to expand and collapse. In my numerical thesis project with Professor Courtney Lannert, I explore the three-dimensional system of a shell shaped BEC, created when the BEC is trapped between two spherical potentials. This is done studying simulations of expansions and collapse of the BEC in Matlab. We look at the change in the curve created by the one-dimensional plot of the BECs probability density in the trap with one other axis (x, y, or z) as expansion and collapse takes place.

Upon release of the BEC into the harmonic potential, self-interference fringes and central mass accumulation are observed in the system. By manipulating the parameters of the trap, spherically symmetric collective modes, caused by the oscillation of the BEC within the trap, can also be observed.

Our goal in studying these properties is to quantify different behaviors of the BEC under the constraints of the harmonic trap and upon release of the trap. For the self-interference fringes we look for a relationship between the initial state of the condensate, defined by its initial "thickness",
and the spacing of the interference fringes. For the collective modes we look to identify certain "breathing modes" associated with the "thin shell" limit for the potential trap. These breathing modes are specific formations of the collective modes created when the BEC is perturbed within the harmonic trap.

The study of BECs has many applications both in and out of quantum mechanics. It will likely provide insight into the strange phenomenon of superconductivity and it offers a macroscopic way to view the microscopic world.

3.5.1 Citations


3.6 Analyzing a High-Redshift Galaxy Cluster by Isabel Lipartito

How far back in cosmic history clusters of galaxies formed is a major question in extragalactic astronomy. Galaxy clusters make up the largest scale structures of the universe. The farthest galaxy cluster currently known is at redshift 1.62, corresponding to nearly 10 billion years ago. We do not yet know if this is the earliest point in time for galaxy clusters or if they go back even further to the start of the universe 13.7 billion years ago. A candidate galaxy cluster at redshift 2.3 was previously identified through the work of Professor James Lowenthal of Smith College. Analysis of the emission spectrum of a quasar at redshift 2.6, QSO PHIL 957, revealed a Damped Lyman-alpha Absorber (DLA)- a huge intervening cloud of neutral hydrogen- at redshift 2.3. Further observations with the Hubble Space Telescope (HST) and other telescopes revealed 19 emission galaxies associated with the DLA, including the Coup Fourr Galaxy, a Lyman-alpha emitting galaxy and 18 other galaxies within 2 Mpc. This strong overdensity is one of the best current candidates for a massive, high-redshift, gravitationally bound cluster of galaxies. If these galaxies are at the same redshift, we should detect strong Lyman-alpha peaks at 400 nanometers for each of the 13 galaxies studied.

Images of the entire cluster, along with spectra for 13 of its 20 objects, were obtained using the Gemini North Telescope in 2010. Imaging and spectroscopy was performed on this galaxy cluster- resulting in detected Lyman-alpha peaks at 400 nanometers in only 3 galaxies, indicating that these three, at least, are all at redshift 2.3. Also achieved was a clearer, publishable set of spectra along with a high-quality image of the cluster.

We are presently in the process of completing photometry on the galaxies, which involves measuring the intensity of emitted light in various wavelengths. It is possible that we will be able
to confirm the redshift for several galaxies by comparing the measured intensity of light at different wavelengths coming from these distant galaxies to models of what the spectrum should look like if we were at the source.

This project explores a significant question whose answers have strong implications for astronomy. The confirmation of this cluster would overturn previous assumptions about when galaxy cluster formation occurred and may demand revision to current models about the nature of the early universe and its evolution.

![Galaxy Cluster](image)

### 3.6.1 Citations

1. Picture: NASA, ESA, ESO, CXC, and D. Coe (STScI)/J. Merten, Composite image of the galaxy cluster Abell 2744, 2000, (Heidelberg/Bologna)

### 3.7 2 Cool Physics by Jessica Morgan

The introductory series for the physics major at Smith has recently become an item of interest. It has been redesigned and renamed as "Two Cool."

The "Two Cool" program began in the 2013 Spring Semester and it is the sum of the additives: "CO-oriented Observations and Lectures in a COlaboratively Oriented Learning environment," in which "COOL + COOL = 2 COOL." The purpose of this program is to provide students with a hands-on, interactive way to learn physics rather than the lecture based system previously used. It has been studied that when students are placed in a lecture based course, they usually only absorb the first ten minutes of the information presented to them. So rather than present PowerPoint slides to their students, the professors at Smith College have decided to revamp their classes.

In this new program, professors have lengthened their classes and gotten rid of the lab sections for introductory physics. Instead, students conduct different laboratory experiments during their class periods. These labs are usually no more than an hour long. At the start of every class, students answer two minute questions and work together as a group to solve them. After the two minutes the professor presents the answer to the problem, and the students discuss it as a group. Then students conduct a laboratory exercise and sit through a short mini-lecture.

In the introductory Two Cool courses, LAs (learning assistants) help students to understand the concepts presented. Those serving as LAs are physics majors who are trying to solidify the basic physics concepts.
While the material presented in the classroom setting is the same, each class is different. Professors try to use different practice problems and do not assume that their students know everything. In addition, they use short term feedback to help identify the needs of their students and change the class curriculum accordingly.

All those dreading their future introductory physics classes, you have no need to fear, because physics is now just "Two Cool."

3.7.1 Citations

1. Pictures: Physics Department, Fun with Physics, 2005, Smith College

3.8 Frustrated Spins by Kelsea Gill

Particles have an intrinsic magnetic moment called "spin." In a system of two particles, the lowest possible energy is achieved when the spins are anti-parallel. In this scenario, the two spins cancel each other out and we are left with a system with zero spin. This becomes more complicated if we introduce a third spin. All three particles want to be anti-parallel but one particle is always left out. Such a system where not all of the interactions between particles can achieve the lowest energy state is called "frustrated." Frustrated systems have multiple degenerate ground states and therefore violate the third law of dynamics by having non-zero entropy even at zero temperature. Therefore, developing a stronger understanding of the thermodynamics of these systems are of great interest and will help strengthen their applications in technologies such as magnetic refrigerants and magnetic recording devices.

In my thesis, we studied the thermodynamic properties of Heisenberg spins on the frustrated Triangular Kagome Lattice (TKL) in zero external magnetic field. Heisenberg spin describes spin in terms of quantum mechanics. This differs from the classical model of spin, Ising Spin, because quantum mechanics allows particles to exist in a superposition of discrete states. This research is an expansion of an undergraduate thesis by Bilin Zhuang, in which she used the classical Ising model to study the thermodynamics of the Triangular Kagome Lattice, using a small model approximation of the TKL. In our research, we continue to use these approximation models but with a greater focus on the quantum mechanics of the TKL and its effect on the TKL’s thermodynamic properties. In order to do so, we used exact diagonalization, by examining geometrical elements of the system first and extrapolating to include the whole system. Using the Heisenberg model we are able to get results for the specific heat and magnetic susceptibility of the TKL and compare it to the results for the classical Ising model.
3.8.1 Citations

1. David M. Harrison, Dept. of Physics, Particle Spin, 2003, Univ. of Toronto
4 Biochemistry

4.1 Student Thesis Spotlight: Colby Loew by Robin Bessemer

Colby Loew, a self-professed small town girl from "a dead-end dirt road," has come a long way in her four years at Smith. This May, she will graduate as Smith's sole biochemistry honors student. Loew has always had her eye on research - she cited the research opportunities as one of the main reasons she came to study at Smith. She began working with Dr. Cristina Suarez in the chemistry department through the SURF program. As a part of that work, she helped use an extrusion method for producing liposomes, which are vesicles made out of a lipid bilayer. The process entails a suspension of lipids, which is squeezed through a filter to produce lipid particles of a defined size.

Loew continued researching in the Suarez lab and is now finishing up her thesis. She is using liposomes to look at how ionophores (molecules that transport ions across a lipid membrane) transport cations (positively charged ions). Although she is optimistic about the project, it hasnt been free of difficulties. She has had to revert back to a more labor-intensive method for producing liposomes that involves lab work every twelve hours.

While that seems intense, Colby doesnt cite lab time as the hardest part of a thesis, but rather being able to manage time and sitting down to write. For her, a thorough job is important, as she will face an hour-long defense of her thesis, a process that neither the Biology nor Chemistry departments follow. The hours of lab time, the writing, and the grueling defense seemed daunting at first. In fact, Colby wasn't planning on doing a thesis at all. However, she said, "Last year, I was thinking about how I want to feel when I leave Smith, and I want to feel like Ive really accomplished something. I want to feel like I pushed myself, and that I proved to myself that I could take on a project like that and focus and do it. I didn't want my fear of failing to hold me back, because I knew that if I really tried, and had good support, I knew that I could end up doing it."

When asked if she had any advice for future thesis writers, Colby said, "Just do it. Don't be afraid. If the reason you don't want to work on a thesis is because you are afraid, that is the wrong reason not to do it. If you care about research, and if you care about the project you are working on, then it is totally worth it."

4.2 Smith Alumna Named Chief Scientific Officer at Howard Hughes

Medical Institute by Martha Dillon

This January marked a change at the Howard Hughes Medical Institute (HHMI) as Dr. Erin K. O'Shea, a Smith alumna ('88), was named the new Vice President and Chief Scientific Officer. HHMI is a nonprofit organization founded in 1953 that promotes biomedical research and science education across the country. In her new role, Dr. O'Shea will focus on the biomedical research aspect as she now directs the flagship program "Investigators", which supports over 330 scientists in over 70 different laboratories throughout the United States. Reflecting on her first few months on the job, Dr. O'Shea thinks that "interacting with the great scientists who are HHMI Investigators" will be the best part of her new job.

In addition to running the Investigators program, Dr. O'Shea maintains her own lab at Harvard University. The lab studies three different fields: transcriptional control, a cyanobacterial circadian clock, and the mechanism of drug actions. She describes her decision to focus on these aspects "[s]imply because they are problems I find fascinating, and they are things I could convince others to work on.”

The transcriptional control project looks at how environmental based signaling can change which proteins are transcribed, how osmotic stress can influence gene expression, and how cooperation
and competition between different transcription factors influence which proteins are expressed in
the cell. The lab studies the unique oscillations of the cyanobacteria's circadian rhythm that derive
from modifying three key proteins by adding phosphates from ATP, the common energy storage
compound of all cells. This contrasts to the more commonly found clock, seen in animals like mice
and humans, which depends on the formation of new proteins in response to the environment.
In the drug action projects, researchers apply statins, chemotherapy drugs and other medications
to mutated cells to see which genes the medications interact with to produce their respective
therapeutic results.

When looking for members to add to her team, Dr. O'Shea believes "independence, creativity,
motivation, and a passion for science" are key traits. For those who are looking to start a career as
a researcher, however, the most important factor is experience. She recommends any experience,
such as volunteering or working as a research technician, as a great first step.

Dr. O'Shea's personally got her start in research partly out of effort to avoid mowing lawns
and painting for her fathers construction business during the summer, and partly out of her love
for science. Her first step was to join a Smith College lab the summer after her freshman year to
study chemical reaction kinetics. By her senior year, she had moved into Professor Scordilis lab
for her thesis. This experience confirmed her career path as it "made [her] realize how much [she]
enjoyed the process of discovery and doing research." From where she is now, this sense of direction
and the confidence she gained are the reasons she believes that coming to Smith was the single best
decision she could have made for her career in science.

4.2.1 Citations

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   HHMI News: Erin O'Shea Named Vice President and Chief Scientific Officer at HHMI.

3. O'Shea, Erin, PhD. E-mail interview. 3 Apr. 13.

5 Biology

5.1 Population Dynamics of Microbial Communities by Carmen Hernandez

We live in a biologically diverse world; there is almost an innumerable amount of species that exist (plants and animals). While "macrobial" species seem to dominate our imagination and minds, we seem to have a lack of regard for our microbial brethren. These are the organisms that have existed even before the dawn of the first multicellular system. To put this in perspective, we could potentially give a rough estimate of 6 million extant microbial species, but unfortunately this may be a gross underestimation (1). Therefore, to have a more complete understanding of the world around us, we need to come to a better understanding of our microbial world and their dynamic interplay. The purpose of my thesis is to understand these patterns and add onto the growing knowledge of this area of biology.

The organism I am focusing on is *Chilodonella uncinata*, a ciliate that is fairly ubiquitous in freshwater environments (i.e. ponds, lakes, collections of rainwater, etc). What makes this organism truly extraordinary is its genetic diversity, despite an identical morphology. When these organisms were first characterized, they were classified based on their physical characteristics (a.k.a. "morphospecies") (2). However, previous work in the Katz lab reveal that there are multiple cryptic species (species within a morphospecies that are genetically divergent) present within this already defined taxa (3). Based on multigene analyses focusing on conserved genetic regions (actin, alpha-tubulin, and nuclear small sub-unit ribosomal DNA), we have found that they all maintain the same tree topology, and we can be sure that they are cryptic species, as no recombination is present (3). Yet, in a fourth analysis on mitochondrial small sub-unit ribosomal DNA, they found that there are longer branching patterns, indicating there is a faster rate of divergence (3). Further work on the diversity of the species included isolating cells from nature. Comparing the phylogenetic analyses from these isolated cells to the previous results showed that further cryptic species exist and that they are more divergent than the lab lines (4). Additionally, during the collection process of the individual cells, it was found that at any one time in any one location, only one genetic haplotype (or genetic variant) was found (4).

Based off this conclusion, my thesis is constructed to look more deeply into *C. uncinata* population dynamics. However, instead of just isolating single cells, I investigated more into community fingerprinting through a process known as denaturing gradient gel electrophoresis (DGGE). This is an extremely sensitive type of gel electrophoresis in which bands are separated by sequence as opposed to fragment size, as in agarose gel electrophoresis. Understanding that *C. uncinata* is underlain by multiple cryptic species, I exploited this to design primers that are specific enough for the species, but general enough so that it can amplify as many haplotypes types as possible. To prepare the samples for DGGE, I collected water every four hours in a 24-hour cycle. Then I filtered the water through three filters, two of which I would save and prepare for genome extraction. After I extracted the total community DNA, I used the polymerase chain reaction (PCR) using the primers I designed. Then these samples would be loaded on the DGGE gel to run for a period of 25 hours.

Preliminary results from my experiment demonstrate considerable population interplay. One of the interesting discoveries is that *C. uncinata* appears to have greater haplotype diversity and abundance during the nighttime hours than during the daytime hours (Figure 1). Looking further into each individual sample that was collected from the nighttime, there is co-dominance between two haplotypes (bands DGGE1 and DGGE2). This ostensibly negates my original hypothesis that
there was only going to be one haplotype per sample. However, once the daylight hours came, only one genetic haplotype was visible (though this may be due to PCR inhibitors that surface only when the sun is out), partially revalidating my original hypothesis. The second discovery is that different haplotypes have different levels of fitness within just one environment. In the Figure, there is only one appearance of the band DGGE5 during the transition from night to day; this implies that there are other genetic haplotypes that were able to adapt and proliferate better given their ambient conditions. Alternatively this may indicate that there are other factors contributing to the disappearance of certain genetic haplotypes, such as nutrient availability (i.e. deeper within the pond).

My research has helped to uncover previously unknown population dynamics and further paths of study on *C. uncinata*. In the future, collections to look at the total number of genetic haplotypes can be focused during the nighttime hours using community methods as opposed to the more convenient daytime hours using single cell methods. With this small step to understanding potentially other cryptic species population dynamics, the once invisible world has become just a little more visible and tangible.

![Figure 1: The two DGGE gels using mtSSU-rDNA, which represent samples A-BB from September 30, 2012 ("M" designates for the marker/ladder of the gel). There are four main repeating bands DGGE1, DGGE2, DGGE3, and DGGE4. There is also a band, which is only found once (DGGE5) that demonstrates the varying fitness of the haplotypes.](image)

5.1.1 Citations


5.2 A Garlic a Day Keeps the Doctor Away (Or Almost)! by Ava Sharma

Antibiotics are among the most frequently prescribed medications in modern medicine, and have become ineffective as a consequence of overuse and subsequent pathogenic resistance. Normally, when an antibiotic is first registered, it kills most of the targeted bacteria. With repeated exposure, however, the few bacteria that are left become genetically resistant to the antibiotic and resume multiplying. Gradually, the infection itself becomes resistant to its specific antibiotic. The mass consumption and over-prescription of antibiotics in the past 50 years has led to an increase in the population of antibiotic-resistant strains of bacteria. Alternate solutions will have to be devised, and one approach taken by researchers is the use of antibacterial properties of natural foods in inhibiting antibiotic-resistant microbes. Major advantages of natural foods are that they are completely natural and have less side effects in contrast to synthetic antibiotics.

I decided to proceed with further investigating the antibacterial properties of garlic (Allium sativum) because it has been regarded worldwide as a medicinal panacea for thousands of years. Egyptians worshipped garlic and placed clay models of garlic bulbs in the tomb of Tutankhamen. Garlic was so highly prized that it was even used as currency in Egypt. In China, Emperor Hung-ti of Xia of the first Chinese dynasty was reported to have journeyed up a mountain with his ill followers whose lives were apparently saved by consuming wild garlic. Western folklore holds that garlic repelled vampires and provided protection against the Evil Eye. In early 18th century France, garlic was consumed to ward off the plague. The first scientific study on the health benefits of garlic was conducted in 1858 by Louis Pasteur, who confirmed the antibacterial properties of garlic. In the same year, Albert Schweitzer used garlic successfully against amoebic colitis. During both World Wars I and II, soldiers were given garlic to prevent gangrene.

Various researchers have confirmed that the antibacterial property of garlic is related to allicin, a bioactive ingredient. When fresh garlic is crushed, the enzyme alliinase is released, and converts the odorless compound alliin into allicin, which bears the typical odor of garlic (Figure 2). Allicin has a very short half-life and rapidly converts to other sulphur-compounds such as ajoene, making it very difficult to work with. Allicin and ajoene, however, have been the main subject of research for scientists investigating the antimicrobial properties of garlic. These compounds block enzymes that are necessary for the metabolism of various micro-organisms. They have been shown to inhibit the growth of more than 23 micro-organism, with no resistance to allicin by microbes so far.

![Figure 2: The enzymatic reaction between alliin and alliinase which produces allicin; generation of allicin in a garlic clove](image)

Allicin molecules have been shown to easily penetrate biological membranes and kill cells, but their potency is short-lived and highly unstable. This lack of stability has made it difficult to research allicin. Only within the last decade has allicin been able to be extracted and stabilized. The challenge lies in the ability to not only release large amounts of allicin from each clove of garlic, but also to capture the allicin and prevent it from decaying into other chemical compounds. The role of allicin in warding off infections may be particularly valuable in light of the growing bacterial resistance to antibiotics. The effectiveness of garlic comes from the fact that bacteria are highly
unlikely to develop resistance to Allicin as this would require modifying the very enzymes that make their activity possible.

In an individual study I conducted before I came to college, I chose to work with two very common bacteria that can cause serious infections: Escherichia coli (E. coli), a gram-negative bacteria, and Bacillus subtilis (B. subtilis), which is a gram-positive bacteria. This allows me to investigate the spectrum of the antibacterial property of garlic for potential use as a natural antibiotic in the future.

In my experiment, I measured the zone of inhibition created by liquid garlic extracts placed in agar petri dishes with a mixture of bacteria and nutrient broth. My experiment results show that garlic indeed has antibacterial properties against both gram-positive and gram-negative bacteria, with gram-positive bacteria being more susceptible to garlic's antibacterial properties. My data also indicate that the antibacterial property of garlic depends on temperature, with the optimal temperature being around 40 degrees C. As temperature rises, the antibacterial property is reduced, losing all efficacy at around 80 degrees C.

My experiment results would seem to indicate that eating garlic could prove beneficial and while it may or may not keep the doctor away, it can certainly keep the bacteria at bay!

5.3 Diagnostics Kit for a Neglected Tropical Disease by Ridwana Fairuz

Dengue is a viral disease that occurs in many parts of the world, but is especially prominent in tropical and subtropical countries due to the floods during the monsoon rains. In recent years, it has become an international public health concern. Severe dengue (previously known as dengue hemorrhagic fever) was first recognized in the 1950s when dengue epidemics occurred in the Philippines and Thailand. Today, it affects mainly Asian and Latin American countries, and the WHO estimates that the incidence of dengue infection has increased 30-fold over the last 50 years. About 50-100 million infections occur annually in over 100 endemic countries, and these infections are spreading to new areas.

The dengue virus (DEN) of the genus Flavivirus in the family of Flaviviridae has four distinct serotypes: DEN-1, DEN-2, DEN-3 and DEN-4. This mosquito-borne disease, transmitted when the Aedes aegypti adult female takes a blood meal, causes severe flu-symptoms and occasionally death. An infected mosquito can transmit the virus throughout its life, causing infection in infants, children and adults. The virus circulates in the blood of the infected person for 2-7 days, causing symptoms ranging from a mild to high fever, severe headache, pain behind the eyes, rash, and muscle and joint pain. The dengue virus can be transmitted from the infected person to the mosquito after the first symptoms appear, which is usually during 4-5 days, with a maximum of 12 days.

Recovery from the infection by one dengue virus serotype provides lifelong immunity against that serotype. However, it is thought that this immunity can only give partial and transient protection against the other three serotypes of the virus. According to the WHO, each time a person gets an infection, the risk of developing severe dengue increases. Even today, there is no specific antiviral medicine or vaccine for dengue. Additionally, the current method to detect dengue uses serological tests that are not always sensitive, which results in a delay in diagnosing the illness. Thus, there is a need for better, low-cost rapid diagnostic tool that is highly sensitive and specific, in order to improve the diagnosis of this virus.

My research project in Professor Steve Williams lab aims to develop a sensitive and low-cost multiplex DNA assay for early detection of the dengue virus and the four dengue virus serotypes. All complete genomes available in the National Center for Biotechnology Information Genbank
for each of the four serotypes, which are approximately 10.7 kb long, were gathered. For each serotype, a consensus sequence was formed. Several different alignment programs were considered for the task. While Megalign and Clustal O were considered for their ability to create accurate and flexible alignments, problems with large volume of sequences appeared while using both programs. Seqman, a program often used to study the evolution of a genome, did well with large volume of consensus sequences under investigation.

Now that consensus sequences have been established for each serotype, the next step will be primer development. The four sequences will be compared to find areas that are variable between the serotypes. These potential regions will be studied to determine which areas are consistent within the serotype, making them good candidates for primer design. The potential primers will be examined for their potential use in a multiplex assay, and specifically used to target conserved sequences in the DNA of dengue. PCR can be used for diagnostic analyses of the viral genome. The high sensitivity of a multiplex assay will permit virus detection soon after infection and even before the onset of disease. It is therefore hoped that this research project will lay the foundations for the development and implementation of a more sensitive and lower cost multiplex DNA assay kit for early detection of the four dengue virus serotypes. In the future, this could enable healthcare professionals, especially in resource-limited environments, to accurately diagnose the virus and its serotype to reduce the chance and incidence of death.

5.4 Nematode Parasites of Marine Mammals: Phylogenetic and Statistical Analysis of Coevolution by Caroline Keroack

Parasitic infections pose a great threat to large marine mammals that have long gestation periods and bear very few offspring over life time. Nematodes, including lungworms, gastrointestinal worms, heart and other filarial worms, are a major type of parasites of large marine mammals [1]. They can infect almost every crevice of the body, from the sinuses to the kidneys, significantly affecting the existence of hosts. Understanding evolutionary relationships between these parasites and their evolutionary history in respect to the hosts are essential in protecting the affected marine mammals. Thus far, the life cycle of cetacean nematode parasites has not been established, and the life cycle of phocid filarial parasites remains unclear [2]. The evolutionary relationships between most nematodes are still unclear, but could be elucidated using molecular techniques [3].

Appreciating the relationship between nematodes and their hosts begins by understanding the shared evolutionary path between the two. Coevolution is the result of the arms race between host and parasite defenses: that organisms must constantly adapt to maintain the status quo, if either wins the relationship between the two ends and one species becomes extinct [4]. To assess the extent of coevolution, the level of congruence, or how well one phylogenetic tree mirrors the other, between the host and parasite trees must be established. Congruence of phylogenetic trees can reveal the specificity of certain parasites to their hosts, as well as the ability of a parasite to infect multiple host species.

Marine mammals tend to have fairly spread out distributions, thus it comes as little surprise that most marine mammal parasites seem to be generalists or have at least some capacity to infect more than one host. In rare cases parasites can be specialists, only infecting one single host genotype. Additionally, hosts can support multiple parasite species, further complicating the relationships between hosts and parasites. Considering the unique features and vastness of the marine environment, coevolutionary analysis is particularly important in assessing the potential hazard of these parasites and their potential virulence, but the reconstruction of the complicated host-parasite relationships requires sophisticated methods for proper elucidation [5].
Our hypothesis states that the host phylogeny does not predict the parasite phylogeny. Phylogenies, as well as their coevolutionary models, are traditionally constructed using single genes or a combination of several genes. However, single genes may lack sufficient data to elucidate particularly tangled trees or tanglegrams. Therefore, the full genome may be a more proper sequence for statistical coevolutionary analysis. With the advent of genome study and sequencing, phylogenetic reconstructions can be completed using full nuclear or mitochondrial genomes. Mitochondrial genomes are inherently easier to sequence because these genomes are shorter than nuclear genomes. Furthermore, the mitochondrial genome is unique for the lack of recombination and uniparental transmission, making it a good target for phylogenetic study [6].

Inferring phylogeny based on mitochondrial genomes is performed through sequence alignment and assessment of the gene order. The Procrustes Approach to Cophylogeny (PACo), developed by Balbuena et al, is a statistical analysis based on the superimposition of shapes, in this case genetic distance matrices and trees. This method is apt for mitochondrial alignments, which are often disjointed due to large differences in size and gene arrangement. Even so, significant challenges exist in regards to obtaining these mitochondrial genomes. Thus, the traditional single gene method will also be employed to ensure the coevolutionary analysis. The gene used for the traditional method is the cytochrome oxidase subunit 1 (COI) gene, an available sequence from public databases. Additionally, COI sequences will be used for the purpose of identifying or confirming the species identity of the nematode specimens. Twelve of these specimens have been previously identified morphologically and five are unidentified. Any surprising results will be further verified using an array of genes including when possible the ribosomal 5s subunit, ribosomal 12s subunit, internal transcribed spacer-2, SSU rRNA, and cytochrome oxidase subunit II. These genes together are essentially a bar-code for nematode species and allow for confident identifications.

5.4.1 Citations


6 Chemistry

6.1 The Development of a Cobalt-Mediated Synthesis of Cyclic Alkynes by Szilvia B. Kiss

I have been involved in research since my first year at Smith, when I received a Summer Undergraduate Research Fellowship (SURF) to work in Professor Linck’s lab. My first foray into academic research was a great experience, and it is the main reason I decided to become a chemistry major. After taking organic chemistry my sophomore year, I joined the Shea lab the next summer and then continued that work during the academic year as a special studies project. I love being involved in research and there was little question that I would eventually go on to write an Honors thesis, but I was slightly concerned about how to divide up my time between academics, varsity sports, work-study, and research. Fortunately, I was selected to be a McKinley Fellow, which meant that I would be able to quit my work-study job and spend more time actively doing research. This has made a huge impact on the amount of work I was able to accomplish during my senior year, and I am happy to report that I have made much progress in my research project in large part thanks to the generous funding I received this year.

When I first started working on the synthesis of cyclic alkynes as a sophomore, I was the only one assigned to this project. This year, Signe Dahlberg-Wright ('14), ShuMing Huang ('15), and Katie Barbor ('15) joined the project, and it has been a great experience to work with them and be their mentor. The subject of my thesis and the work my group has been doing focuses on cyclic alkynes. These compounds have been successfully used in bioorthogonal strain-promoted alkyne-azide cycloadditions (SPAAC), which were first developed by Carolyn Bertozzi [1] as an alternative to the copper-catalyzed 1,3-Huisgen cycloaddition that, while being the most popular example of click chemistry [2], has found limited use in biological systems due to the cytotoxicity of the copper catalyst. The ability to selectively tag cell-surface glycans or proteins using bioorthogonal reactions has been of interest to a large number of scientists, as in vivo imaging techniques promise to yield a better understanding of the function of important biomolecules.

The reactivity of cyclic alkynes is mainly a result of ring strain resulting from the unfavorable bond angle imposed on the sp-carbons of the rings alkyne, although electronic effects have also been shown to greatly enhance reaction rates [3]. Due to the ring strain inherent in these compounds, syntheses are generally challenging. Our idea was to cobalt-complex linear alkynes, which is known to reduce the bond angle from 180 degrees to 138 degrees, and exploit this property to subsequently cyclize the alkynes in an intramolecular Nicholas reaction (Figure 3).

In a Nicholas reaction, a propargylic alcohol is cobalt-complexed; a Lewis or protic acid is then used to generate a propargyl cation that is subsequently attacked by a nucleophile, most commonly an oxygen or a nitrogen [4]. When an intramolecular nucleophile is used, an acyclic starting material can be converted to a cobalt-complexed cyclic alkyne.

Cobalt-complexed alkyne 8 was known to be available in seven synthetic steps from acyclic alkyne 1 as this strategy was used by former Shea lab members Miriam Quintal ('04) and Kristi Closser ('07) to make cyclic Pauson-Khand precursors that could go on to form tricyclic products [5], and we hypothesized that oxidative decomplexation of 8 would yield the desired cyclic alkyne 9. However, the major challenge in this synthetic route has been to find an effective oxidative decomplexation method. There are many reagents that are commonly used to achieve decomplexation and we screened a number of them; among the oxidants investigated, ceric(IV) ammonium nitrate (CAN) gave promising results. Unfortunately, due to decomposition problems, we were initially unable to isolate the decomplexed cyclic alkyne. Instead, we hoped to trap this reactive product
by adding benzyl azide to the reaction; in this fashion, I was able to isolate triazole 10 and thus confirm the formation of 9. These results were replicated with a ligand exchange reaction [6], which was effected by the addition of triphenylphosphine. Current work is aimed at isolating the cyclic alkyne intermediate and optimizing the oxidative decomplexation step.

6.1.1 Citations


6.2 Named Reactions Discovered and Developed by Women

Interview By Angela Tai and Naina Zaman, Written By Angela Tai

We sat down with Kevin Shea, an Associate Professor of Chemistry at Smith College, as he told us the story behind a paper published about the role of some prominent women in organic chemistry. The article, "Named Reactions Discovered and Developed by Women", written by Shea and Julie Olson ('10), highlights very essential contributions to the organic chemistry world by female chemists. Although certain reactions are named after specific people, many times there are other people who play very important and critical roles in finding and developing these reactions.

Shea became interested in researching named organic reactions after hearing Helene Lebel of the University of Montreal speak at the Organic Reactions and Processes Gordon Research Conference at Bryant University in July of 2006. That same summer, Seiko Fujii ('08), a student in Shea’s lab,
asked, “Are there [reactions] named for women?” At an all women’s college, the question may have seemed expected, yet there was intrigue to know more about the answer from beyond just Smith’s campus.

Julie Olson was a STRIDE scholar at Smith who sought to find the answer, distinguishing four reactions named after women: the Goldberg reaction, the Hunsdiecker reaction, the Jourdan-Ullman-Goldberg reaction, and the Piloty-Robinson pyrrole synthesis. Irma Goldberg worked with Fritz Ullman, who she later married after they developed the Jourdan-Ullman-Goldberg reaction. Two women, Gertrude Robinson and Clre Hunsdiecker, had the same last name as their husbands, Robert Robinson and Heinz Hunsdiecker. Gertrude and Robert worked closely together, with Gertrude having 9 single authored publications, and 19 joint publications with her husband.

Olson, after exploring archives upon archives for more on organic reactions, found many organic reactions women helped to discover. She found two hundred reactions and looked up original papers to see if the names were tradition male or female names. To no avail did she find female names, so she examined the background of each reaction named after men, and found much activity of women in finding these reactions. She then concluded that some well known chemical reactions were discovered with help of some very important women.

That brought Olson to the question: why were there so few reactions named for women? It seemed many women worked closely with their husbands - are there any organic reactions or contributions to reactions that women didn’t get credit for? There was no reservation about the fact that women were doing amazing research. Nevertheless, Shea and Olson wanted to explore the stories behind the reactions, and expand on the credit given to women who were important pioneers in the world of organic chemistry. Olson and Shea worked relentlessly and found some very interesting and surprising results, unheard of in the scientific community.

Olson presented this work at the National Organic Chemistry Symposium in 2007, and Shea presented it once more in 2011, to very positive feedback. Many chemists were excited by the work and helped Olson think of other uncharted women pertinent to discovering chemical reactions. In fact, once Olsons paper was published, it was one of the top 10 read articles on Accounts of Chemical Research (ACS) the year it was published.

Women’s work in chemistry doesn’t stop only at organic reactions. There are also reagents named for women, such as the White reagent, named after Smith alumna Christine White (’92), currently at the University of Illinois at Urbana-Champaign. Women continue to make their names known in the field of organic chemistry, and we are looking forward to more achievements and recognition. Professor Shea has expressed interest in continuing this project in the future, as he is sure that women are continuously adding to organic reactions that should be documented and as easily accessible as the reactions named after men.

Pictures provided by: Kevin Shea
Figure 4: L-R: Kevin Shea, Sarah Bashiruddin ('10), and Julie Olson ('10).

Figure 5: Shea Lab ('10) L-R: Sarah Rothstein, Sarah Perlmutter, Melissa Torres, Julie Olson, Meradith Hoddinott; Center: Kevin Shea
7 Computer Science

7.1 Printing Your Desires: A Friend or a Foe? by Krithika Venkataraman

Together, the layers grant your wishes.

Have you ever stumbled into the kitchen late at night during finals, desperately in need of coffee, only to find that your Espresso machine is missing a button? These frustrating circumstances are probably not the only time you have wished for a way to quickly produce a replacement part, or procure something without leaving the house. In a surge of technological advancement, it seems that your much wished-for genie has reached the markets in the form of a 3-D printer. This cutting-edge technology is crossing the borders of different realms, trespassing through common households and operating theaters at a rapid rate. The potential benefits of 3-D printing are plentiful, but specialists in the computer science and engineering fields worry about the impact this technology will have upon issues such as intellectual property (IP) rights and gun regulation.

Hod Lipson, a computer scientist and engineer at Cornell University, believes the benefit of 3-D printing is that "complexity is now free" [1]. The key to his belief lies in the fact that 3-D printing is an additive manufacturing process. Conventional methods are "subtractive," such as chiseling away at wood to produce a carving or removing layers of metal to sharpen blades. In 3-D printing, computer software directs more layers to be added on top of one other in a directed sequence, thereby producing very intricate designs.

In 2011, the sales rates for personal 3-D printers increased by 300%, with an average cost of $1000 per unit [1]. It seems that these printers are making their way into households and small businesses, as well as laboratories and hospitals. Women entrepreneurs, Bathsheba Grossman and Colleen Jordan, own small-scale start-ups focused on utilizing 3-D printing. They have produced a wide range of items such as multipurpose bottle openers that illustrate topology concepts, bike decorations, and small planters that don household plants as jewelry [1]. LayerWise, a Belgian company, successfully produced a patient-specific whole jaw replacement in 2012. The impressive implants structure was drafted on computer aided design (CAD) software, and directly produced using a layer-by-layer 3-D addition technology with lasers [2]. The company asserts that this method holds much promise for both bone and organ implants, with few medical complications.

With increasing awareness about the wide range of potential applications, governments are starting to pitch their monetary contributions to advance 3-D printing technology. A 2012 Reuters report described the European Unions goal to use 3-D printing technology to increase GDP from manufacturing by four percent by the end of the decade [3]. The Obama administration, too, has become involved by starting up the National Additive Manufacturing Innovation Institute in Youngstown, Ohio, which is co-funded by agencies such as NASA and the NSF [1].

Despite the promise shown thus far by 3-D printing, this innovation has left many skeptics with raised eyebrows. Joshua Pearce, a materials scientist and engineer from Michigan Technological University, who admires the new technology, also asserts that 3-D printing will give rise to much "stuff that has no value, no improvement for humanity" [1]. In addition to the increase in unnecessary material goods, there is a serious safety concern that arises. Already, a hackers’ workshop has successfully unlocked police handcuffs by manufacturing their keys. The printing of polymer containers for chemical reactions, known as "reactionware," has raised questions about the potential for illegal drug production [1]. Furthermore, a group called DEFCAD allows one to design and print gun parts. With the nations recent heated debate on gun laws, is this 3-D printing technology
just one more thing for the world to worry about? Where does the line lie between the benefits for economy, science and education, and the likelihood of a surge in misuse and terrorism?

There is now increasing pressure on legislators to be one step ahead of such technological advancements, in order to prevent them slipping into the wrong hands [4]. Moreover, 3-D printing has implications on issues such as IP, patenting and copyright. It may be a while before this technology produces quality goods that risk IP law infringement, but legislative groups have already started being proactive to ensure justice is preserved [5]. When it is clear that such a concept as 3-D printing has revolutionary potential, it is in the best interest of society as a whole to encourage these technological advancements to progress in the right direction.

7.1.1 Citations


8 Engineering

8.1 We can do it! Empowering young girls to pursue engineering and STEM fields by Brittany Bennett

What do you get when you equip 132 young girls with soldering pens, exacto knives, and other tools of destruction? That is exactly what happened when the Society of Women Engineers hosted their annual Introduce a Girl to Engineering Day (IGTED), an educational outreach event that invites 5th-8th grade girls from the local area to engage in engineering activities.

This year, the girls explored aeronautical, environmental, or mechanical engineering through a three-hour activity. The aeronautical group explored the engineering design process and the science behind aerodynamics by constructing their own balsa wood glider. Girls who signed up for the environmental group turned an ordinary computer fan into a mini wind turbine. They were even provided with the opportunity to learn how to solder and work a voltmeter. For those with a penchant for taking things apart, the mechanical group explored energy transfers and simple machines through a Rube Goldberg project. Girls divided into small groups to create a complex machine that accomplished a simple task—in this case, popping a balloon.

Outreach and mentoring events like IGTED are vital to increasing the number of women in STEM fields. According to the Society of Women Engineers, only 20% of all engineering undergraduates are women. That number is even more abysmal when you look at the intersections of race and engineering: only 5.3% are African-American and 5.4% are Latina. The gender divide in the STEM fields begins long before a student reaches college. Toy manufacturers are blatant perpetrators of the gender dichotomy. Toys like Legos, K'nex, and Transformers all foster skills like creativity and design that lead to an interest in engineering but are marketed primarily towards boys. For girls, options are limited by almost a physical divide in toy stores. Barbies, kitchen sets, and makeup kits, traditional female toys that these are the only activities that girls can do.

By the time a girl enters middle school, stereotypes and misconceptions about women's capability in STEM fields are already internalized. Such as, how women are bad at math which are perpetuated by society, authority figures, and even family members. Girls are not provided the proper encouragement from teachers to pursue math and science. Shows like "The Big Bang Theory" portray men as "nerds" and women as "flighty." Even "Mythbusters," the popular engineering show, presents two men as the stars of the show. Only 44 out of the 863 individual Nobel Laureates were women from 1901 to 2012. And this is only the surface of the gender bias in STEM fields.

The Society of Women Engineers hosts IGTED with the intention of inspiring, encouraging, and supporting girls to pursue engineering. The success of the event has been phenomenal in past years, as the feedback from parents has been overwhelmingly positive. Diana Norman of Girl Scout Troop 40101 extended her gratitude by saying, "Thank you all so much for this wonderful event The girls all had a great time and are interested in coming back next year."

Introduce a Girl to Engineering Day is just one of the many critical initiatives being taken to increase the number of women pursuing STEM careers. Even more thought and energy is needed in order to address the intersections of class, race, ability, and sexuality in the STEM fields, which SWE is highly aware of. Planning for IGTED 2014 is already underway and we hope you will join us on the adventure, whether as a student volunteer or thoughtful contributor. Who knows we may inspire a future Smithie.
8.2 Ceramic Filters by Areej Jahangir

Worldwide, approximately eighty percent of health problems are caused by contaminated water, and 884 million people do not have access to clean water. Ceramic filtration is a mechanism to purify water that is particularly suited to developing nations. These filters have the capability of removing 99.88% of many types of waterborne disease agents, including heterotopic bacteria, e. coli, and giardia (World Heath Organization). The goal of my study at the University of Hartford with Dr. David Pines was to create environmentally and economically sustainable ceramic filters that business entrepreneurs can produce and sell locally. Ceramic filters are used mostly in developing nations. These filters have porous clay wall created from clay and sawdust. The amount and type of bacteria stopped is based on pore size. In comparison to Brita filters, ceramic filters usually last two to four years while brita filters must be replaced every four months. While the cost for a ceramic filter varies from $15 to $25 per filter and a Brita filter costs $4 to $19 per filter, the life span for the filters allows the cost for a ceramic filter to be much less.

In my study on ceramic filters, I addressed the issue of the quality of water purification and the issue of affordability. The quality of water purification was considered through creating ceramic filters of three different sawdust sizes and determining which filter best improves water quality. The affordability of the ceramic filter was addressed through utilizing a two-step process for creating the filters, where the base and cylindrical shells would be made separately. This allowed for a simple and affordable technology to create the shells, as a unique one-step piece of equipment was necessary for the base and cylindrical shells to be made together, both with sawdust.

The ceramic filters in my study were created using a two-step process. This two-step process is a simple and affordable mechanism for producing ceramic filters. The bases and cylindrical shells were created separately and then attached together before being fired in the kiln to form the ceramic filters. The base was made with a mix of clay and sawdust with three different sawdust sizes 10-20 mesh, 20-30 mesh and 30-40 mesh. Mesh in this context is sawdust created with evenly spaced holes, allowing for air and water to pass through. The number of mesh signifies the number of openings each piece of sawdust had. A hydraulic press was necessary for the base in order to add pressure due to the loss of plasticity by the sawdust added. When the sawdust is added, the clay and sawdust materials separate, so a hydraulic press applies force in order to push the sawdust into the clay, thus forming one material in a sense.

The ceramic filters produced were tested using four techniques in order to see which filter had the highest hydraulic conductivity rate, greatest turbidity reduction, and highest bacteria removal capability. Turbidity reductions were measured using a Micro 100 Turbidimeter. Measuring the turbidity is done through seeing the opacity in the water due to different particles or bacteria and is a key method to test water quality. Surface water was taken from a stream in Glastonbury, CT. Bacteria removal was analyzed by placing samples of water in liquefied agar in an incubator under controlled conditions and then counting the bacteria using a magnifying lens.

The filter with sawdust size 20-30 mesh reduced turbidity the most by 28%, had the highest hydraulic conductivity of 7.72x10-6 m/s, and the best bacteria removal of 80%. The data led to the conclusion that the filter with sawdust size of 20-30 mesh would be the best for reducing health problems in developing nations.

8.3 Citations

1. Water, sanitation and hygiene. Retrieved from World Health Organization Western Pacific Region website
9 Environmental Science and Policy

9.1 Smith Women Working for Sustainability by Alison Grady

The Center for the Environment, Ecological Design, and Sustainability (CEEDS) seeks to integrate sustainable pursuits from various disciplines and levels of campus, from professor research to student organizations. CEEDS houses the Office of Sustainability, Engineering and Landscape Studies faculty, staff from the Environmental Science & Policy program, the MacLeish Field Station, and the Environmental Monitoring Initiatives [1]. The Office of Sustainability works with Facilities Management and Sustainability Representatives from each residential house to "integrate environmental sustainability practices into institutional operations" [2]. They recently established an online dashboard that monitors and displays the real-time energy and water use of many buildings on the Smith campus. (To see your houses recent energy consumption, visit: http://buildingdashboard.net/smith/#/smith/) All of these actions are working toward the long-term goals of the Smith Sustainability and Climate Action Management Plan to make the campus carbon neutral by 2030 [4].

CEEDS supports many student organizations that are focused on sustainability. The Green Team is an action group that meets every other Tuesday at lunch and works on projects like divesting from fossil fuels and planning for Earth Day. The Community Garden hosts fun projects focused on teaching people how to care for a garden, using their plot between Northrop/Gillett and Lamont. The Bicycle Kitchen promotes bike appreciation and provides bike rentals and maintenance support for students [4]. There are several CEEDS interns who run a blog (http://smithceeds.wordpress.com) reflecting on environmental events around campus, ranging from formal lectures to trips to the Field Station [5].

CEEDS also has its own concentration in Sustainable Food, requiring six courses relating to food and two practical experiences relating to food, either volunteer or paid work [6]. The Sustainable Food Concentration gives students the opportunity to learn about food and sustainability from a wide variety of disciplines, while the practical experiences allow students to put their learning into a real-world context [7].

There are many opportunities for Smith students to get involved with the sustainable initiatives on campus. Pay a visit to CEEDS (in the basement of Wright Hall, or online at www.smith.edu/ceeds/) to learn more.

9.1.1 Citations

9.2 New Head of EPA Nominated by Alison Grady

On March 4, 2013, President Barack Obama nominated Gina McCarthy, currently the "Assistant Administrator for EPA’s Office of Air and Radiation," to serve as the administrator of the Environmental Protection Agency (EPA)[1]. McCarthy has not yet been approved by the Senate [2], but she has been publicly supported by many prominent environmentalists, including California Senator Barbara Boxer [2], the executive director for Environment America [3], the president of Clean Air Watch [3], the CEO of the National Wildlife Federation [1], and Al Gore [4]. McCarthy has a strong track record with regulating pollution, and she also has a "strong working relationship with members of the business community" [5]. She also served under Mitt Romney when he was Governor of Massachusetts, so she has a history of being bipartisan and maintaining her commitment to the environment [3]. At this critical time for the environment, it is essential that Federal leadership take action on regulating pollution and carbon emissions. Gina McCarthy worked in environmental regulation in Massachusetts for more than 25 years before her last 5 years with the EPA [2], making her an excellent choice to lead the EPA. And as Smith students, we cannot help but support a strong woman from Massachusetts who cares about sustainability to lead the EPA, and the country, towards a greener future.

9.2.1 Citations


10 Geology

10.1 Optical Refractometry: Characterizing Minerals using Light by Wanda Feng

"Man is not wholly lost nor wholly changed. Disgraced he may be, yet is not dethroned, and keeps the rags of lordship once he owned: Man, Sub-creator, the refracted light through whom is splintered from a single White to many hues, and endlessly combined in living shapes that move from mind to mind.” –J.R.R. Tolkien

If you have ever seen a rainbow, you have seen refraction at work. Refraction is the bending of light when it travels through different materials. In the case of the rainbow, light passes through water vapor and splinters from the single white to many hues that Tolkien so elegantly describes. This splintering may be related to the speed the light travels through the water, a property known as the refractive index. Known refractive indices can then be used to identify substances, like minerals.

Minerals are naturally occurring substances that compose the rocks in our environment. These are defined by chemical composition and have different properties as a result. For example, quartz is composed of silicon dioxide and is generally colorless and relatively hard. When a rock is cut and ground to 30-micrometers, a "thin section", mineral properties can be studied under a microscope. An example is shown in Figure 6.

![Figure 6: A thin section of a sample of granite with four minerals labeled.](image)

Refractive indices for minerals have been long studied and used for identification. Traditionally, this is done by comparing the mineral, in powdered form, to oils with known indices under a
microscope. In the 19th century however, an optical refractometer instrument was conceptualized to find refractive indices accurately and precisely. A beam of light is essentially directed to a glass hemisphere with mirrors. When mineral thin section is placed onto the flat plane of the hemisphere, light rays may either pass through the mineral or reach a certain critical angle and are then reflected. The reflected ray then falls onto a scale and the refractive index can be determined.

John Brady and Doreen Weinberger have assembled an optical refractometer at Smith College (background). Accurate refractive indices have not yet been measured due to interference by the superposition of light waves. The purpose of this project is to measure the refractive indices of mineral crystals. When the same minerals are analyzed with the scanning electron microscope (SEM), then the relation between refractive indices and chemical composition may be determined.

10.2 In New Zealand: Frontiers Abroad and University of Canterbury Tales by Sarah Brisson, Paula Brgi, and Camille Dwyer

Sarah Brisson, Paula Brgi, and Camille Dwyer are all class of 2014 geosciences majors at Smith College who independently decided to attend a rigorous field camp set in the geologic paradise of New Zealand.

We spent five weeks traveling the North and South Islands completing physically and mentally challenging course work. We rose early, spent an average of nine hours a day in the field, and in the evenings completed exercises and finalized maps. Rock outcrops ranged from roadcuts to steep mountaintops. We worked in all kinds of weather and we always carried everything - lunchbox, "high vis" vest, 3 liters of water, hat, sunscreen, rain gear, field notebook, rock hammer, hand lens, compass, knife, toilet paper, map and map board, and camera, to name a few. One of our field camp mottos became "always bring everything."

At each outcrop we would "STC" the rocks (describe their structure, texture, and composition) and "S that D" (measure strike and dip), a method of determining the inclination of a rock bed.

For our first week we went to the Castle Hill region, located in the center of the South Island, where we focused on an intensive large-scale mapping exercise whilst learning how to juggle our extensive gear, chasing sheep, and braving 80 mph winds. Our next destination was Westport, where we studied the rocks and processes associated with the early formation of New Zealand. We learned the true value of our water-proof notebooks, how to jump-start cars, and took in the incredible views of the coast plunging into the Tasman Sea.

After Westport we took a break from field camp and spent two days in Abel Tasman National Park hiking and sunbathing, but then were quickly whisked away to the North Island to begin our studies in volcanology. We camped on the flanks of Mt. Ruapehu, an active volcano, while we mapped the lava flows of Mt. Ngauruhoe (Mt. Doom in the Lord of the Rings movies) and participated in a 6-hour hazard management exercise involving a volcanic eruption simulation.

We spent the fourth week of field camp in the central region of the North Island near Rotorua, studying geothermal systems and the largest super eruptions in recent geological history. After long days in the field we often visited geothermal pools, and even rafted down a 27ft waterfall!

The final week was set close to our soon-to-be home for the semester, Banks Peninsula. We participated in Waitangi Day, a celebration of a treaty signed between the Maori and Europeans, and rode a Maori canoe, called a waka. This week was different from the rest of field camp. Rather than being led around and taught by professors, we formed teams, chose research locations, and collected data for our semester-long research project. Our field site was East Okains Bay. One morning we travelled by boat, since some of our field area was inaccessible by foot. Of course we sampled rocks and mapped, but we also avoided angry seals by clapping at them, and were rescued
When our five-week adventure finished, we returned to Christchurch and the University of Canterbury. In the upcoming semester we will follow up on the data collected at Banks Peninsula, but to different research aims and ends. Sarah Brisson will tackle the puzzle of connecting lava flows and extrusive eruptions from million year old volcanic vents. Paula Brgis project relates to the distribution and eruption history of parasitic vents - vents on the flanks of a volcano - and how this pertains to hazard prediction and management of Mt. Etna, Italy. Sarah and Paula are also creating a website to teach the public about the geological significance of Banks Peninsula. Camille Dwyer is researching how the Maori, the indigenous people of N.Z, use their heritage and oral tradition to interpret the geological landscape of Banks Peninsula. She is also helping a working group in the formation of New Zealands first Geopark.

If you are interested in learning more about field camp, feel free to e-mail us or find us in the Cave next semester while we are doing our theses.

Figure 7: Paula Brgi and her leather-skinned hat overlook Castle Hill Basin.

Figure 8: Sarah Brisson holds her map board at our beautiful field site, East Okains Bay in Banks Peninsula.
One of the tragic results of interactions between and among natural disasters and the structure of societies they affect is that catastrophes often occur in pairs. Natural disasters frequently lead to other tragedies, sometimes natural, but most other times caused by inadequate or insufficient societal response. The earthquake of magnitude 7.7 that hit Pakistan on September 24th, 2013, as well as an aftershock earthquake on September 28th, led to significant civil damage. These earthquakes were due to a strike-slip movement just below the Earth’s crust.

Many of the earthquakes that occur in Pakistan happen near the Eurasian, Arabian, and Indian plate boundaries, as was the case for this earthquake that hit 43 miles north of Awaran in the Balochistan province of Pakistan on September 24, 2013. The underlying reason of earthquakes in this region is that while the movement of India into Asia is nearly perpendicular to the Himalayan Mountains, it is oblique convergent for Pakistan. For earthquakes with thrust, strike-slip, and sometimes normal faulting techniques, this area is very complicated. The plate tectonics of southern and central Pakistan are relatively complex given that this is the area where the Indian Plate slides north towards the Eurasian Plate and the Arabian Plate sinks north under the Eurasian Plate into western Pakistan. This usually causes a north-south to a northeast-southwest strike slip motion at the latitude of the earthquake (Magnitude 7.7 Earthquake).

The earthquake on September 24th originated just below the Earth's crust due to a left-lateral strike slip movement (Magnitude 7.7 Earthquake). At the epicenter, the intensity on the Modified Mercalli Intensity (MMI) Scale was IX, with severe damage and shaking (M7.7- 61km NNE). It is estimated by the USGS that 18,000 people encountered violent shaking and 30,000 people were exposed to severe shaking (Magnitude 7.7 Earthquake). The tremors of the earthquake lasted two minutes and were felt as far as 700 miles away in New Delhi, India and Abu Dhabi, UAE (M7.7- 61km NNE).

Four days after the September 24th earthquake, a second earthquake of 6.8 magnitude hit less than 20 miles away from the epicenter of the first earthquake (Chappell, 2013). The USGS reported this earthquake as an aftershock since both earthquakes occurred with similar means of faulting and were very close in area. Similar to the first earthquake, the mechanism and position of this second earthquake were consistent with the rupture in the Eurasian plate. Furthermore, the earthquake on September 28th also struck due to an oblique strike-slip motion just below the
Earths crust. Close to the epicenter of the second earthquake on September 28th, approximately 9,000 people experienced severe shaking with the intensity recorded as VIII on the MMI Scale in this area (M6.8- 85km NNE).

Following these back-to-back earthquakes, it was estimated that more than 500 people had died and more than 185,000 had been affected (New Earthquake Strikes). The communication system had also been damaged, thus hampering the ability to report status from the most affected areas and complicating rescue operations. Due to the destruction of roads and buildings, as well as the continuous battle between the government and rebels, it was difficult for aid agencies personnel to reach the impacted region. (Chappell, 2013).

The preceding paragraphs show that a natural disaster can lead to other natural disasters, as well as cause significant humanitarian crises. Both the earthquakes on September 24 and 28 struck just below the Earths crust due to a strike slip motion, with the epicenter of the aftershock hitting less than 20 miles away from the original earthquake. In total, more than 350 people were killed and thousands were left homeless. The earthquake on September 24 and the subsequent humanitarian crisis repeat the pattern seen in many other places. It is hoped that by studying the interactions between two linked issues, response to future tragedies can be improved.

10.3.1 Citations


11 Mathematics and Statistics

11.1 Professor Spotlight: Nessy Tania by Helen He

Although she is the youngest female professor in the Smith College Math department, Professor Nessy Tania possesses an abundance of experience in mathematical research, especially within bio-mathematics. Recently, one of the research projects Tania has worked on studies the nervous systems, specifically how glial cells divide and proliferate as the brain develops.

Tania started the project along with Michael Barresi, a fellow Smith professor in the Biological Sciences. How did they begin to tackle this area of research? Well, one of the foremost steps of doing research is to start with something as basic and simple as possible, and then build on it. For example, imagine doing research on human glial cells. This is frustrating because it takes a full nine months for the cells to mature and function in the brain! That's way too long for a single experiment. Contrast this with zebrafish: it only takes a day for one single glial cell of zebrafish to grow into a fully functional nervous system. And what's more, zebrafish are small and easy to breed in capacity in a small space. Their embryos are also optically transparent, which makes them very easy to observe under microscopes. In fact, check out this cool video to watch the development of a zebrafish embryo: http://sophia.smith.edu/~mbarresi/lab/videos/zebrafishb.mov! When it comes to building models, Tania thinks that it is always important to start with something simple and then refine it. For this research, she first considered several questions while building a model for stem cell division in zebrafish. How long does it take a single glial stem cell to mature? Suppose the rate of cell division is constant, what is the expected time for a single cell to complete division? How does this rate affect the number of cells in experiments? Her collaborator, Professor Barresi, has been studying a special class of mutant cells that could not successfully complete cell division, and observed how the accumulation of these cells affects the division process of other cells. After carefully improving the model and repeating experiments, Tania and Barresi concluded that there might exist a communication between glial cells, such that the cells slowdown in reproducing when they are "piling up".

Professor Tania has done a lot of meaningful research in the bio-mathematics field. But how did she choose her path of becoming a bio-mathematician? As Tania recalled, she originally started as a biology major. When she recalls her experience experimenting on fruit flies, she laughs, "I counted too slowly, and the fruit flies had all died by the time I finished counting! I just couldn't count!" In her junior year, she found out about a bio-math training program on blood-flow modeling: "I have never heard of bio-math before, but it looked interesting and I decided to try it out." From then on, Tania has become highly involved in the field of bio-mathematics.

On being a female professor in a male dominated field, Tania feels that she has been fortunate and has received much support from Smith, her collaborators, and the science field in general. It is very impressive that Tania is simultaneously working on quite a few different projects and research. So what advice does she have for students aspiring to work in the STEM fields? Tania explains, "It is important that you keep your eyes open and get exposed." She herself has made a great effort to talk to different people and attend seminars. "And don't get intimidated even if you don't know much about the subject," she added, "I often don't know much about the subjects of my biology research either, and I have been self-studying for them most of the time."

It is clear that even though Professor Tania didn't start in the bio-mathematics path, she has demonstrated her capability and achievements by combining her skills to work with interdisciplinary fields, and by constantly seeking new knowledge. These distinct qualities prove that Professor Nessy Tania is one of the many outstanding women in math, and they also make her a stronger bio-mathematician.
11.2   Student Spotlight: Kate Aloisio ’13 by Sara Stoudt

Kate Aloisio is a senior Mathematics major and Psychology minor who is currently working on her
statistics thesis to be presented in April. She is working with data concerning eating disorders in
children from the Avon Longitudinal Study of Parents and Children. Longitudinal studies collect
data on the same subjects over time, and the particular data that Aloisio is working with includes
multiple reports from questionnaires answered by both parent and child on each child’s eating
behaviors.

With observations collected from two sources, the parents and the child, over a long period of
time, incomplete data sets become much more common. For example, willingness to participate
can dwindle over time and consent may change as the study continues. Since there are multiple
reporters, there can also be discrepancies between the answers from the child and parent. With all
of these problems, you may wonder why Avon even bothered with the study. When using real world
data, you quickly realize that it is not as "pretty" as the data sets you get in your statistics classes.
Aloisio is not deterred by this setback. In her thesis, she aims to assess inter-rater reliability (how
much different raters agree with each other) between the multiple reports of child eating behaviors.
This analysis can help determine if the scale on the questionnaires is appropriate for measuring
eating behavior in children. In order to get these results, she must deal with other obstacles as well.

Incomplete data sets are a considerable problem for statisticians. If samples were removed from
a study due to a missing entry, there would be a significantly lower number of samples in the study.
Statistical methods require a relatively large sample size in order to meet certain assumptions
built into the models. Aloisio addresses this issue by exploring multiple imputation. This method
assumes that the holes in the data sets are random, and that there is no trend in the missing data
that is correlated to another variable measured in the study or lurking. It then attempts to fill in
the missing data in a way that follows the trends in the non-missing data. Aloisio pairs multiple
imputation with generalized estimating equations to analyze the data from the longitudinal study.
These generalized equations work better when there is an unmeasured dependence between the
outcomes of different subjects. Covariance measures how much two random variables in a study
change together. In a simple model, the change in one variable should be independent of the
change in another variable. However, the generalized equations are a more sophisticated tool that
can estimate the average response over a population when relationships between variables are less
clear.

By combining many techniques to tackle problems that come up in statistical analysis, Aloisio
is able to make sense of real-world data and combine her interests in mathematics, statistics, and
psychology.

11.3   Emmy Noether and the Obscurity of Women in Mathematics
by Shreeya Rajanarayanan

After Emmy Noether’s death in 1935, Albert Einstein mentioned in a letter to the New York Times
that she ”was the most significant, creative mathematical genius thus far produced since the higher
education of women began” [1]. Yet, the contributions of Noether have gone largely unrecognized
and Noether remains mostly unknown outside the realms of mathematics and physics. Amalie
Emmy Noether was born on March 23, 1882 in Erlangen, Germany. Her father, Max Noether, was
a mathematician who specialized in algebraic geometry. Emmy Noether studied mathematics at
the University of Erlangen, where she later worked free of pay for several years, since women were
rarely given paid positions at the time. Later, she joined the University of Gottingen mathematics
department after catching the attention of David Hilbert and Felix Klein, respectively known for their theory of Hilbert spaces and Klein bottles. While at the University of Gottingen, she focused on mathematical invariance. Mathematical invariance is a property, which states that an object remains unchanged after undergoing some type of transformation. After Einstein published his theory of general relativity, Emmy Noether applied her understanding of mathematical invariance to the theory, which led to the creation of Noether’s theorem [2]. In his theory of general relativity, Einstein concludes that large objects cause a distortion in space-time, which we feel as gravity [3].

Noether’s theorem states that the mass and energy in the universe is conserved under certain transformations that preserve symmetry. An important relationship that emerged from the founding of the theorem is the link between time and energy. In other words, the time at which a ball is thrown in the air does not affect the trajectory of the ball (there is a symmetry of time), which ultimately indicates that energy must be conserved [4]. Noether also made significant contributions to several other branches of mathematics, including ring theory and group theory.

While Newton and Einstein have become household names, Noether has failed to do so. Most of the obstacles Noether faced were due to the fact that Noether was a female in the male-dominated field of mathematics. She was not allowed to receive a formal bachelors degree in mathematics from the University of Erlangen, as the University did not award degrees to women. Hilbert and Klein attempted to get Noether an associate professorship at the University of Gottingen, but she was not granted the position because she was female. She was instead only granted a position as a guest lecturer and Noether was forced to lecture under Hilbert’s name. Noether also had to publish several of her papers under a male name, which meant that she was not properly credited for all of her work [4].

Emmy’s story of toiling in obscurity is typical for women in the fields of mathematics and the sciences. In 1967, Jocelyn Bell Burnell and Antony Hewish discovered pulsar stars, yet Jocelyn did not receive a Nobel Prize for the discovery while Antony Hewish did [5]. In fact, women are still struggling to receive equal recognition and representation in STEM fields, though the situation has improved significantly since Noether’s time. Though 50.4% of doctoral degrees were awarded to women in 2008-2009, only 33% of doctoral degrees in the physical and earth sciences and 27% of all doctoral degrees awarded in mathematics and computer science were awarded to women. Statistics do suggest a positive outlook. From 1998 to 2009, there has been an upward trend in the percentage of women receiving graduate degrees in STEM fields. Between these years, the percentage of graduate degrees awarded to women in math and computer science, physical and earth science, health sciences, and engineering grew annually by an average of 7.0%, 4.7%, 14.0%, and 6.0% respectively [6]. Hopefully this is an indication of a brighter future for women in STEM fields.

11.3.1 Citations


12 Neuroscience

12.1 Opinion: Don’t Put All of Your Eggs in One Basket (Take some time to explore different paths!) by Alexis Ziemba

In 2012, I graduated from Smith far more confused about what path I wanted to pursue than when I had started. Now what!?!? I majored in neuroscience with the intention of becoming a neurologist, but my interest in basic science and research grew during my undergraduate career.

Smith’s science courses and my research in Adam Hall’s lab fueled my interest in pharmacology and general anesthetics. This motivated me to take a lab technician position at Massachusetts General Hospital this past fall, involving the study of binding sites of various anesthetics. Working in a small lab, I have a great deal of autonomy, carrying out my experiments from start to finish. The environment is much different than Smith, being co-ed and having no undergraduates. In a department where there are not yet any female principal investigators, there is certainly great motivation to excel in the field.

The lab’s main objective is to identify specific amino acids that anesthetics interact with on various subtypes of the GABA receptor, a known target. To achieve this, we selectively mutate hypothesized amino acids into cysteine, a thiol-containing amino acid. This enables covalent modification by reagents that irreversibly react with the thiol. The effects of the modification are then quantified using electrophysiological techniques that involve measuring chloride currents that pass through the GABA receptors. Through observing whether anesthetics enhance or inhibit these currents, we are able to learn more about the efficacy of anesthetics and which binding sites are the most crucial. This project is very exciting because it could result in long-term anesthetic modifications that enable better selectivity, which could render the anesthetics safer and more effective.

Since I work at a larger institution, I am able to participate in other activities, including a Youth Scholars program that involves mentoring high school students who are interested in STEM fields. One of my roles is to assist them as they research a problem for a hospital department. My group is investigating why elderly patients are not taking advantage of free programming that the hospital offers. I also have time for other things I enjoy, including chemistry tutoring, ice skating, and cooking!

I will be honest in saying that I am now even more confused about what I want to do than when I graduated, but I suppose that gives me another chance to try things outside of research and medicine. Although I really enjoyed all of my neuroscience-related experiences, I wish I had also sought other internships and opportunities while I was in college. I highly recommend that all Smith students seek at least one opportunity outside of their realm and that they stay as open-minded as possible on the road that lies ahead.

12.2 Does Marijuana Permanently Hinder a Youths Cognitive Abilities? by Naina Zaman

Cannabis sativa, more commonly known as marijuana, is a popular psychoactive drug available today in the illegal drug trade, with users ranging from young adolescents to the elderly. Known as a friendly, non-addictive drug and used by many in popular culture, marijuana is commonly held to high prestige as a drug with minimal side effects. However, research conducted does not often investigate the effects on children who start using marijuana from a very young age.

According to the National Institute on Drug Abuse (NIDA), marijuana has acute effects after the "high" that occurs, especially for young users under the age of thirteen. It has major implications
against learning and memory development by essentially changing the structure and function of some parts of the brain. The "high" that arises from marijuana use is from the oily resin found the leaves of the cannabis plant, namely tetrahydrocannabinol (THC). This drug mimics some of the brain's neurotransmitters so the brain cannot distinguish the cannabinoids produced from marijuana from our internal neurochemistry. The brain is thrown off its chemical balance, and the feeling of being "high," a feeling of intoxication, is felt by the user [2].

The NIDA/NIH recently conducted a study where users who began using marijuana in adolescence were revealed to have a notable deficit in the learning and memory formation areas of the brain. This study showed that people who began smoking marijuana heavily in their teens lost eight IQ points between the ages 13 - 38. The loss of these cognitive abilities was never restored as they reached adulthood. In comparison, people who started to use marijuana as adults did not show any significant IQ drop [3].

This phenomenon is better understood by the fact that the brain continues to undergo important development until the age of 25. At puberty, the brain undergoes a sudden growth of new connections among its 50-100 billion nerve cells that results in a greater level of comprehension of knowledge. This growth period also helps guide the development of the rest of the brain. However, through heavy use of marijuana during the prime neural reorganization, brain development can be altered. Nerve tracts within the brain are dictated by our natural cannabinoids, and as a result, exposure to excessive stimulation can alter development of essential chemicals in the brain such as endorphin, gamma-aminobutyric acid (GABA), and serotonin. As a result, through marijuana use, excessive cannabinoid stimulation during critical periods have profound impacts on brain development [4].

Cannabinoid chemistry has shown to excel and introduce development of other brain structures besides those related to growth. As most growth occurs in the cortex of the brain, nature has a way of thinning the cortex and strengthening connections that contribute to learning, known as a pruning process. Specifically, the National Center for Toxicology Research showed that THC affects the normal pruning process, for example, decreasing the hippocampus, a structure critical for learning, enlarging the cerebellum, and enabling asymmetrical increase in structures related to growth [5].

Also, at such a young age users are easily influenced, so marijuana has the ability to become addictive. It has been shown through animal studies that THC withdrawal symptoms are possible. Similar clinical reports in humans have shown these withdrawal symptoms within the first week. Symptoms include anger, aggression, extreme weight loss or gain, anxiety, and sleep difficulties. Research has also shown that 9% of people who begin smoking marijuana over the age of 18 are dependent on the drug, often expressing withdrawal symptoms, and this number is tripled for users under 18. As a result, cognitive abilities become altered as these users constantly crave marijuana [6].

Emotions are strongly linked to the amygdala, a region in the brain important for memory processing. Cannabinoid receptors in the amygdala increase the activity patterns of neurons in the prefrontal cortex. Essentially, the prefrontal cortex controls how the brain perceives emotional significance of incoming sensory information and the strength of memories associated with such. Research has shown that marijuana use from a young age, due to the abnormalities in the amygdala and prefrontal cortex, can result in schizophrenia. The effects of emotional processing can lead to psychotic side effects such as heavy paranoia [7].

Although most children and adolescents who use marijuana do not become dependent, those who use marijuana more than once a week have a higher chance of becoming dependent and addicted to the substance, expressing withdrawal symptoms later in life. Beyond the state of euphoria felt
during the high, feelings, thoughts, and physical changes are all altered. The effects of marijuana use from a young age have shown effects on brain development for adolescents as they grow older, and if marijuana is ever legalized, it should be regulated in a way that young users cannot use it regularly.

12.2.1 Citations


13 Psychology

13.1 The Presence of Female Experts and Peers Strengthens Confidence and Participation of Female Students in STEM Fields by Samantha Floyd

A new series of studies from University of Massachusetts, Amherst suggests that female students' confidence and persistence in math and science is significantly affected by contact with professors, teachers, and fellow students of the same gender. Dr. Nilanjana Dasgupta, (Smith '92), recipient of an NSF CAREER grant and multiple other NSF grants and research honors, has devoted her work to exploring the ways in which implicit (unconscious) stereotypes about academic disciplines and professions shape the next generation of young people's behavior and decisions to pursue or stay away from specific fields such as science, technology, engineering, and mathematics (STEM). Specifically, Dasgupta’s research has explored the impact of exposure to same-gender experts and peers on the next generation of young girls and women’s interest in the fields of science and mathematics. In a series of longitudinal field studies and lab experiments she explored how the presence (or absence) female professors and teachers in class, or exposure (or no exposure) to female scientists and engineers in the media influence girls and young women’s implicit attitudes toward STEM, identification with STEM, confidence, and career aspirations. This is likely to have implications for the likelihood of women pursuing careers in these fields.

Some of these studies were conducted with middle school children; others were conducted using college students in calculus and engineering. One longitudinal study conducted in a calculus class showed that female college students had stronger implicit positive attitudes toward math, identified more strongly with math, felt more confident about their math ability, and felt a greater sense of identification with their professor when their professors and TAs in calculus were female rather than male. Male students’ attitudes and identification with mathematics stayed stable regardless of their professor’s gender. It is important to note that even though women’s confidence in their calculus ability increased when their professor was female and decreased when their professor was male, their actual grade in calculus was consistently higher than that of male students across all sections of calculus regardless of the gender of their professor. Clearly, these female students had strong ability and skills in calculus; what was more fragile and variable was their confidence. Younger students in middle school showed similar results. Another study showed that media exposure to successful female engineers and scientists had similar benefits on female students’ confidence and aspirations in STEM as did classroom contact with female professors and teachers. A final study showed that exposure to female peers in STEM fields also has important benefits for young women entering the field. Specifically, in a study on team performance in engineering, female college students in engineering were less anxious, more eager, and participated more actively when they were assigned to work in engineering teams that had more female peers relative to male peers.

It is important to note that this research points to a variety of larger messages. It suggests that more female professors having direct contact with students is beneficial for the recruitment and retention of young women in science, technology, engineering, and math. Similarly, having more media exposure to successful females with careers in STEM fields is also important to generate the next generation of female scientists, engineers, and technology innovators and entrepreneurs. These data provide us with strong statistical evidence that women exposed to experts or authority figures of the same gender are significantly more likely to feel confident about their participation in those fields, both in a classroom context as well as their long-term career aspirations.
13.1.1 Citations
