Council on Science and Technology

Princeton University

2010-2011 Annual Report

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I. CST Initiative

The bulk of the Council on Science and Technology's work this year focused on implementation of the new undergraduate science and technology distribution requirement that was passed by the faculty in May of 2010. Toward that end, we gathered and began evaluating syllabi from all of the current and proposed ST courses for non majors. We began to explicitly determine what the requirements will be for the Signature Laboratory courses and for the Societal Non-Laboratory courses. Most importantly in this realm, we hired the first of three Professional Specialists. Dr. Carolyn Sealfon joined us in June 2011 and she has rapidly taken a leadership role in transforming the ideas in the Council initiative into realistic subject matter for courses. She has developed assessment tools and tests to give to incoming freshman to document their entering quantitative skills and attitudes about science, math, and technology. She has developed a rubric defining the essential skills that must become elements of all ST courses. She is currently designing a set of creative yet concrete suggestions for how faculty throughout the University can incorporate these

elements into their courses. Dr. Sealfon, who is trained in Physics, is also working with Professor Paul Steinhardt to revitalize the Physics for non-majors course. Our goal here is two-fold: First, this course will become the model for how faculty can revamp existing courses to incorporate all of the new ST elements. Second, this course re-design will showcase how faculty can exploit the skills of the Professional Specialists in course development. The Council is currently working with Professor Lars Hedin to identify and hire a second Professional Specialist with a background in pedagogy and environmental sciences. This person will begin by playing a major role in developing the new ENV courses. Finally, Dr. Sealfon is housed in the McGraw Center for Teaching and Learning and she is collaborating with our colleagues there.

II. STC Postdoctoral Teaching Fellowships

After thirteen successful years, the Council's Postdoctoral Teaching Fellows Program is coming to an end, in order to allow the Council to fully focus its intellectual and financial resources on the new science and technology initiative, as well as the professional specialist program . This year, the Council had only five postdoctoral teaching fellows in various science and engineering departments across campus.

Jaime Palter (Geosciences) left mid-year to accept a faculty position at McGill University. Greg Novak left at the end of this year to accept a postdoctoral position at the Observatoire de Paris in France. Lisa Manning also left at the end of this year to accept a faculty position at Syracuse University. Corinna Riginos and Lalitha Sankar will continue to be employed by Princeton as Postdoctoral Research Associates in the departments of ecological and evolutionary biology and electrical engineering, respectively.

A brief summary of the Fellows' activities during this past year is provided below.

Dr. M. Lisa Manning investigated collective motion in disordered, non-equilibrium materials including disordered solids and biological tissues. In collaboration with Dr. Eva-Maria Schoetz (Lewis-Sigler fellow, Genomics), she developed a minimal model for surface tension in biological tissues based on the structure of individual cells, which has been

experimentally verified (Manning et al PNAS 2010). In collaboration with Dr. Andrea Liu (University of Pennsylvania) she developed a method for identifying structural defects in disordered solids, which allows a deeper understanding of the onset of failure in these ubiquitous materials (Manning and Liu, Phys. Rev. Lett. 2011), and with experimental collaborators she verified the existence of these defects in glassy colloids (Ke Chen, M. Manning et al, Phys. Rev. Lett. 2011) Other projects included understanding the mechanical properties of nuclei in the early development of fruit flies (with Dr. Thomas Gregor, Princeton) and developing continuum models for deformation in bulk metallic glasses (with Dr. Mikko Haataja, Princeton).

On the teaching front, she has accepted a faculty position at Syracuse University, where she will teach an advanced class on condensed matter physics. Based on her teaching proposal for the Council, she also plans to develop an undergraduate course on statistical mechanics, appropriate for students in both engineering and natural sciences. The goal of such a course would be to provide students with a "universal prism" through which they could analyze and understand collective phenomena across a multitude of disciplines.

Dr. Gregory Novak worked with Professor Jeremiah Ostriker and Dr. Renyue Cen, studying the effects of massive black holes on the galaxies they inhabit. The sizes of massive black holes at the centers of galaxies are known to be closely linked to the properties of their host galaxies, but the nature of the interaction between the two remains poorly understood. With Professor Ostriker, Novak explored the connection between intense radiation from massive black holes on small length scales and the dynamics of gas in the galaxy on large length scales. Novak and Cen worked on understanding the effect of magnetic fields produced by black hole accretion on the observable properties of clusters of galaxies.

Together with Professors Anatoly Spitkovsky and Christopher Chyba, Novak co-taught Astronomy 203, an introductory course for non-majors with ca. 120 students, his first experience with a really large audience. Greg's lectures were much appreciated; in fact, one of the auditors of the class invited him to speak at the Present Day Club in Princeton.

Dr. Jaime Palter continued working in Jorge Sarmiento's group on problems at the intersection of physical oceanography, biogeochemistry and climate. Her recent work explored how the ocean's overturning circulation (sometimes called the great ocean conveyor belt) supplies nutrients to marine algae at the ocean's surface. Another project aimed to understand

why nitrogen fixation does not become a self-limiting process in a region lacking major fixed-nitrogen sinks. She also started work that aims to understand how changes in ocean overturning due to global warming may influence the rate at which the ocean can soak up carbon dioxide emitted to the atmosphere each year.

Last spring, with the help of several ambitious graduate students and a great lab manager, Jaime unrolled a new series of instructional laboratory exercises to accompany Professor Sarmiento's course, Ocean, Atmosphere and Climate. These labs explored the effect of rotation on fluid dynamics, simulating the weather patterns and oceanic currents we experience on Earth in a water-filled rotating tank. Finally, she had the great pleasure of supervising a Princeton undergraduate who worked as a summer intern exploring the impacts of North Pacific climate variability on nutrient distributions in the region.

Starting in January, Jaime has been working as an assistant professor at McGill University in Montreal, Canada and continues her research in physical oceanography and biogeochemistry. She taught Introduction to Oceanic Sciences in the spring to 60 enthusiastic undergraduates who benefited from her experiences in the Council's postdoctoral program.

Dr. Corinna Riginos conducted two large-scale experiments at the Princeton-affiliated Mpala Research Centre in Kenya, to test how large herbivore migrations (using cattle as surrogate wildebeest) might affect the plants and other wildlife in a Kenyan savanna system. Meanwhile, Corinna won a one-year seed grant on the theme of restoring degraded African rangelands to increase grass production (thus, food for wildlife and people's livestock) and carbon sequestration. Corinna has since been setting up a series of restoration experiments in Kenya and is hoping to continue this work with a 3 year follow-on grant.

In February, Corinna taught the first class of the Princeton EEB semester-long field course, introducing students to African savanna ecology and conservation.

Dr. Lalitha Sankar's research in her final year as a fellow focused on developing a theoretical model to quantify precisely the fundamental tradeoff between guaranteeing the safety of individual data (privacy) in electronic databases while still providing useful benefit (utility) to multiple legitimate information consumers. Information technology and electronic communications have been rapidly applied to every sphere of human activity, including commerce, medicine and social networking. The

concomitant emergence of large centralized searchable data repositories has made "leakage" of private information via data correlation (inadvertently or by malicious design) an important and urgent societal problem. Maintaining the usefulness of these data sources while providing necessary privacy guarantees is an important unsolved problem. To this end, Lalitha in collaboration with S. Raj Rajagopalan of HP Labs and Prof. H. Vincent Poor has used techniques from information theory to develop a unified framework to study the utility-privacy tradeoff, irrespective of the type of data source or method of perturbation. Specifically, she has applied rate-distortion theory to model data sources, develop application independent utility and privacy metrics, and develop a side-information-theoretic model and current approaches and the dominant theoretical framework in computer science. In addition to publishing three conference papers on the subject, for this work, Lalitha and her mentor Prof. H. Vincent Poor have received a three-year NSF Theoretical Foundations grant.

In the fall, Lalitha taught the Freshman Seminar Course FRS174 on the "Information Revolution: Insights into Technology, Language, and Biology'.

Two of the postdoctoral fellows attended conferences or symposia specific to their disciplines during this academic year.

III. STC Course Support Program

This year, support was provided for the enhancement of five existing courses that will meet the new objectives of the Council. They are as follows:

AST 201: Mapping the Universe
This specially designed course begins by discussing the cartographers' problem of mapping the curved surface of the Earth onto a flat plane, and compare different map projections and their properties. Projections for mapping the Moon, Mars, Jupiter, and the sky are considered. Other topics include mapping the solar system and galaxy, the Sloan Digital Sky Survey 3D map of the visible universe, the WMAP map of the cosmic microwave background, Einstein's mapping of space and time, and mapping the inside of the black hole. Finally, students explore the Gott-Juric Map of the Universe, showing everything from satellites in low Earth orbit to distant galaxies and quasars. The Council contributed to the funding of a "Magic Planet," a digital globe which will be used to show each of the planets and

large moons in the solar system, movies of the earth, displaying night and day as well as the seasons, and continental drift. Other phenomena that can be displayed on the Magic Planet include the weather on Jupiter, the Great Red Spot twirling (a 300-year-old storm), the nearest million galaxies and the WMAP map of the microwave background. Several faculty members in geosciences and in the geofluid dynamics lab, as well as those in the astrophysical sciences, have expressed interest in using this "magic planet" in various courses across campus, enabling students to visualize phenomena they cannot see otherwise.

ENV 201/202: Fundamentals of Environmental Studies

These core courses in the environmental sciences have been given support by the Council previously, in order to develop state-of-the-art laboratory sections and thus exposing large numbers of non-science students to scientific reasoning, experiments, methods, data analysis and interpretation. More recently, a novel "Living Laboratory model" was developed, which allowed students to practice hands-on research and problem-solving skills in environments and ecosystems in the local area surrounding Princeton. This year, the Council provided equipment and development funds to take the program to the next level by placing it in the context of real-world environmental needs and questions in partnership with local community agencies and stakeholders. Such a new "Real World Model" will allow students not only to conduct experimental research in local ecosystems, but to do so in the context of social and intellectual interactions that model the kind of interdisciplinary problems they will likely encounter in their future lives and careers.

FRS 167: Science and Technology for a Sustainable Energy Future

This brand-new seminar was developed for first-year students interested in examining how we use, generate, store and convert energy and in exploring alternative energy technologies. The course examines these technologies from the standpoint of the science underlying the different approaches through a combination of discussion, demonstrations, and hands-on experiments. This coming year, it will be offered for the second time as a freshman seminar, with the goal of scaling it up to reach a broader cross section of the undergraduate population by the following year. This will entail formalizing a curriculum and developing lectures and background material that is more complete in its scope. In addition, the laboratory aspects of the course will be augmented by including more detail on general

statistics, plotting/displaying scientific data, and other topics. The Council provided funding to improve the existing laboratory modules and develop new modules towards this transition.

MOL 101: From DNA to Human Complexity

This course was developed eight years ago, with the help of Council funding, to introduce students who are not science majors to the theory and practice of modern molecular biology. Topics covered include the basics of gene expression as well as many topics that are currently facing our society such as how genes affect development and behavior, genetically modified food, stem cell research, pathogenic bacteria, and forensic analysis. A central goal for the course is to stimulate student interest in science by developing laboratories that more closely resemble actual experiments carried out in research laboratories. The laboratory experiments are designed to allow students to perform experiments to both reinforce and improve their understanding of the scientific principles discussed during lectures and introduce them to the scientific method. The course has been successful by all measures, and as enrollment has grown, so has the need to expand the capacity of the lab portion of the course. The Council provided funds for the purchase of six additional microscope systems (microscopes and cameras).

NEU 101: The Neuroscience of Everyday Life

This is a relatively new course directed at nontechnical majors, which uses everyday life experience to illustrate the workings of the brain. The course spans neuroscience at all levels, including molecules, cells, systems, behavior and cognition. The course emphasizes principles of critical thinking about the brain and scientific evidence for responsible citizenship. It includes a laboratory component that is unusual in showcasing a wide variety of basic and advanced methods. Methods range from flies and optogenetics (controlling behavior with light) to EEG and fMRI (recording the students' own brain processes in making decisions and choices). As the course has become popular and enrollment has grown, the need for new microscopes designated to and customized for neuroscience-specific exercises has become evident. The Council supported the purchase of ten microscopes for the course.

IV. STC Visiting Lecturer Program

In alternate semesters, Council provides fte support for guest lecturers to teach one of the two highly rated standing STC courses.
Michael Lemonick regularly offers STC 349 "Science Journalism" (see description below).
Professor Allen Keller (of NYU) teaches STC 398 "Health and Human Rights in the World Community (see description below).
Furthermore, one cross-listed course, MOL 460/STC 460 "Diseases in Children: Causes, Costs, and Choices," is offered every spring.

STC 349: Science Journalism

Michael Lemonick, science writer and editor at Time magazine and author of "Echo of the Big Bang," "The Light at the Edge of the Universe" and "Other Worlds: The Search for Life in the Universe," has taught this very successful upper-level course nine times, with an overall rating of 4.8-5.0. This course has a limited enrollment of 15 and helps students, science majors and non-majors alike, to develop their skill at writing about science and technology for non-technical readers. Through class discussion, analysis of published writing and especially through extensive writing exercises, students learn to present complex information with both clarity and style.

STC398: Health and Human Rights in the World Community

Dr. Allen Keller has now taught STC 398 ten times. Dr. Keller, who is a physician associated with New York University School of Medicine and Bellevue Hospital, is an expert in the treatment of torture victims. His course, limited to an enrollment of 20, has always been highly successful, consistently earning an overall student evaluation of 4.7-4.9. The seminar examines the relationship between health and human rights. It provides an overview of human rights violations in the world today and an analysis of their health consequences. The seminar also evaluates the role of health professionals in caring for victims of human rights abuses, documenting the health consequences of human rights violations, and participating in human rights advocacy and education. Due to the strong interest in bioethics on

campus, Council has invited Dr. Keller to offer the course every other year now that the seminar has been incorporated into the permanent curriculum.

STC 460/MOL 460 Diseases in Children: Causes, Costs, and Choices

Professor Daniel Notterman teaches this extremely popular course in the spring. It includes a survey of normal childhood development and selected disorders from the perspectives of the physician and the scientist. Emphasis is placed on the complex relationship between genetic and acquired causes of disease, medical practice, social conditions, and cultural values. Patient visits are an integral component of the course.

V. Lunchtime Seminar Series

The lunchtime seminar series has always been an important activity of the Council. It serves to bring together graduate students, postdoctoral fellows and faculty who share an interest in pedagogical issues, particularly as concerns science teaching. Attendance is usually ca. 40-50, and although there is a core of regular attendees, new faces regularly appear.

This year, the Council sponsored one lunchtime seminar, carefully chosen to represent the model for the Council's new signature courses. Accordingly, on April 19, **Professors Sam Wang and Alan Gelperin**, from the Molecular Biology Department and Princeton Neuroscience Institute, delivered a presentation entitled "Neuroscience of Everyday Life." The course serves as a model for many reasons. The topics it addresses, ranging from autism to free will to "déjà vu" experiences are accessible and interesting to nonscientists. It also debunks commonly accepted myths, such as the idea that we use only 10% of our brains or that puzzles like Sudoku are the best way to keep aging brains young. Furthermore, the laboratory exercises are hands-on and have unusual technical breadth, including invertebrate action potential recording, optogenetic activation to manipulate fly behavior, counting of newly born neurons in adult rodent brains, EEG of decision making and a "free-will" task, and analysis of fMRI signals in language processing by lefthanders. Finally and most importantly, the course teaches about the scientific method and evidence-based decision-making. The presentation sparked much discussion and interest in other

similarly-minded courses on campus. The plan is to identify and present other such courses in next year's series.

VI. Evnin Lectures

The Evnin Lectures are sponsored annually by the Council, and funded through an endowment from **Anthony B. Evnin '62**. This year, the Council hosted one important, highly visible Evnin lecture during the spring semester. On March 2, **Professor Cynthia Breazeal**, Director of the Personal Robots Group from the MIT Media Lab, delivered a fascinating Public lecture entitled "Robots as Social Technology." This was very well attended and drew a larger audience of students than ever before.

VII. The Gregory T. Pope '80 Prize for Science Writing

The Gregory T. Pope '80 Prize for Science Writing was initiated eleven years ago by the class of 1980 in remembrance of a member of their class, Gregory T. Pope, a science writer and editor, who died at the age of 36 in May 1996. Starting in 1998, the prize has been awarded annually by the Council to the senior(s) who has/have demonstrated an outstanding ability to communicate scientific knowledge to a broad audience.

Nominations were solicited from faculty and students in the spring. Thirty two entries were received, ranging in style, length and topic. A committee consisting of School of Engineering staff writer **Chris Emery**, **Judith Friedman** from the Development office, science writer **Fred Guterl**, PPL Director of Communications **Kitta MacPherson**, PEI Communications & Outreach Manager **Carol Peters** and **Carol Prevost**, Associate Director of the Council, selected four winners this year. First prize was shared by **Lisa M. Tom'11** of the Anthropology Department for her submission "Flookie and the Fish" and **Daniel S. Growald'11** from the Department of Ecology and Evolutionary Biology for two related articles entitled "A Cup of Corn" and "The Problem of Green." Second prize was shared by **Yi Liao '11** of the Chemistry Department for her paper "Saving the World, One Cook at a Time" and **Sophie C. Jin '11** from the Woodrow Wilson School for "Connected by Complexity". Members of the Pope family and Carol Prevost participated in the awards ceremonies.

VIII. Women in Science Panel

The Council sponsored its annual panel discussion during Freshman Orientation Week to welcome incoming first-year women interested in pursuing studies in science, engineering or mathematics. The panelists included Professors **Sigrid Adriaenssens**, Civil and Environmental Engineering; **Rebecca Burdine**, Molecular Biology; **Abigail Doyle**, Chemistry; **Naomi Leonard**, Mechanical and Aerospace Engineering; and **Anna Wienhard**, Mathematics. The panel was well attended and very much appreciated by approximately 100 first-year women. The panelists spoke briefly about their career paths in science, what attracted them to the field and continues to impassion them, obstacles encountered and helpful pointers to overcome them, as well as job opportunities.

Membership, The Council on Science and Technology 2010-2011

Bonnie L. Bassler, Molecular Biology (Director)
Manjul Bhargava, Mathematics
D. Graham Burnett, History of Science (on leave)
Naomi E. Leonard, Mechanical and Aerospace Engineering
Sharad Malik, Electrical Engineering
James Richardson, Creative Writing
Paul J. Steinhardt, Physics
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Carol Porter, Director, McGraw Center for Teaching and Learning
Carol Prevost, Associate Director, Council on Science and Technology