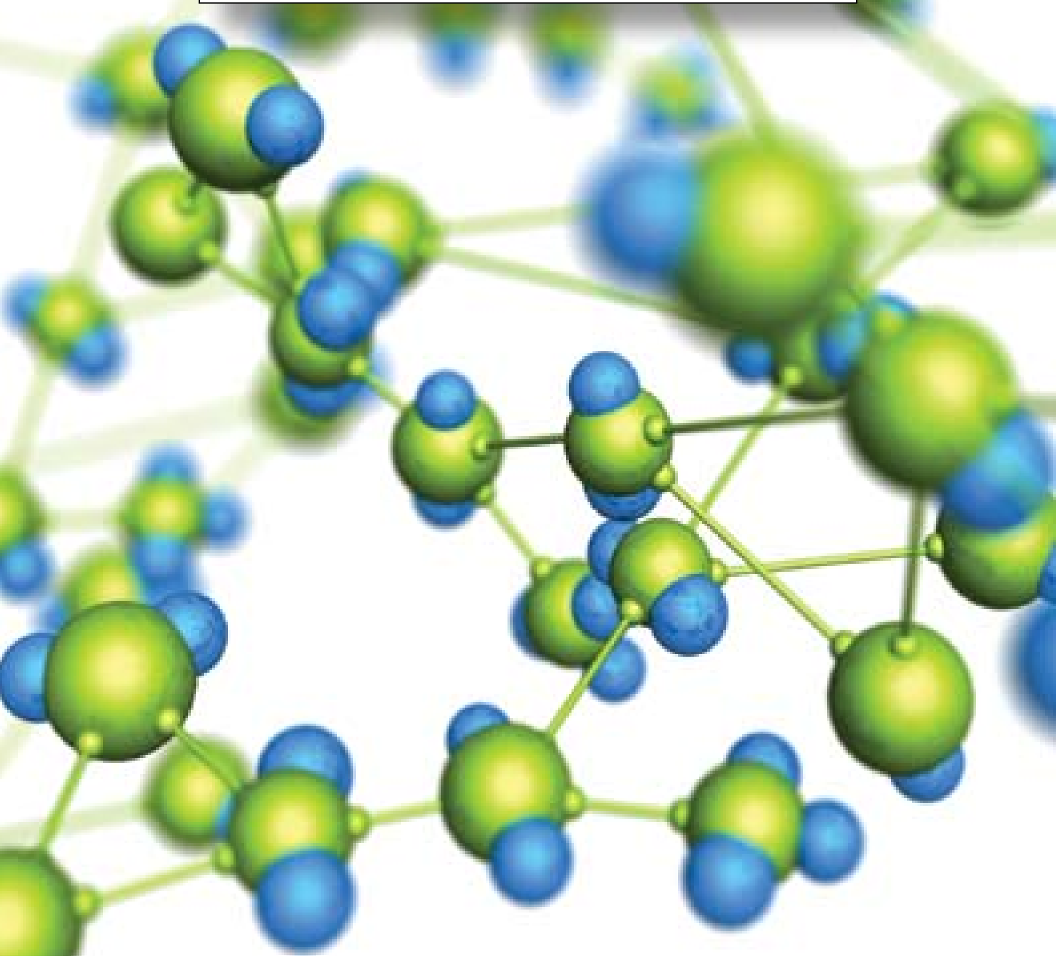
Science Education:

Linking Science with Society



A Symposium celebrating science teaching and learning with **Cecily Cannan Selby**, her students and colleagues at New York University

April 29, 2009

SYMPOSIUM PARTICIPANTS

Cecily Cannan Selby, Ph.D. M.I.T., scientist and science educator, is former professor of Science Education and chair of the Department of Science, Mathematics and Statistics Education at the Steinhardt School of NYU, and Trustee Emerita of the New York Hall of Science.

PANEL ONE

Pamela Fraser-Abder, Ph.D. Penn State Univ., is associate professor of Science Education at the Steinhardt School of Culture, Education, and Human Development at NYU where she directs programs preparing science teachers for master's degrees and New York State certification.

Janice Koch, Ph.D. NYU, author of science teaching texts, retired in 2009 as professor of Science Education at Hofstra University, where she directed IDEAS (Institute for the Development of Education in the Advanced Sciences). She now consults on school and college science and teacher education.

Paul Jablon, Ph.D. NYU, has directed science education at Brooklyn College, served on the faculty of the University of Massachusetts and is now associate professor at Lesley University's College of Education.

Julia Rankin Morandi, Ph.D. U. Conn., former director of Science K-12 for the New York City Department of Education, now lives and works in California where she is president of The Science Collaborative Inc., and coordinates the California Science Project Teacher Retention Initiative and educational partnerships in Los Angeles.

PANEL TWO

Marcia Rudy, Ph.D. NYU, is president of the Board of Art & Science Collaborations, Inc., and a consultant to museums and organizations on science, science/art/technology programs, exhibitions, and special projects.

Maura Flannery, Ph.D. NYU, is professor of Biology and director of the Center for Teaching and Learning at St. John's University.

Margaret Honey, Ph.D. Columbia University, is the president and CEO of the New York Hall of Science.

Joe Witte, a TV weather forecaster for more than 30 years, mostly as chief meteorologist for NBC's network in New York City, is currently working on his Ph.D. thesis on informal science communication using collaborations with the American Meteorological Society and other organizations.

Edited and produced by Rich Kelley
Designed by Spencer Brinker

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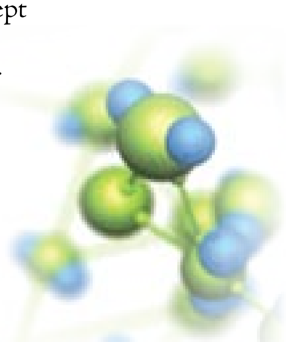
Why this symposium?

This symposium was born of Cecily Selby's wish to illuminate the skills, talents, creativity, and successes of science educators she has known and worked with. The title was chosen to reflect the role of science teachers, and all those communicating science to the public, as custodians of our population's scientific literacy *and* of our pipeline of future scientists, engineers, and physicians. The symposium honors science educators working in Pre-K through 12 and college/university classrooms, and in the media, the arts, museums, and after-school programs. All are helping to provide both the science and the public understanding of science so essential to a modern "open" democracy.

Science teachers have long been expected to prepare future science professionals, but it is only since the 1983 National Science Board landmark report on U.S. science education that their mandate has included ***all*** citizens. This report, *Educating Americans for the 21st Century: A plan of action for improving mathematics, science and technology education for all American elementary and secondary students: A report to the American people and the National Science Board*, was co-chaired by William T. Coleman and Cecily Cannan Selby. Notably, they wrote:

> *"The position of mathematics, science, and technology, historically at the periphery of learning for all but a few American students, must shift to center stage for all."*

And they said that science learning is accessible to all: "The Commission has seen convincing evidence that all students (except those with insurmountable learning disabilities) can develop a useful understanding of mathematics, science, and technology if these subjects are appropriately introduced and skillfully taught at the elementary and secondary school levels." Local, national, and international reports quickly followed establishing a new worldwide commitment to scientific literacy for all.



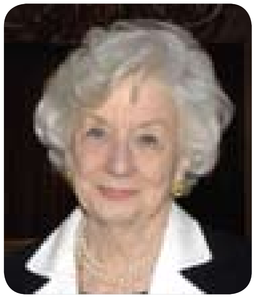
To help reach this monumental new objective, the Coleman/Selby report recommended strategically increasing attention to **informal (out-of-school) education**. "Much that affects the quality of formal education occurs outside the classroom and beyond the control of the school. . . . such experiences are particularly helpful for the sciences and technology." These words prompted an escalation of quantity and quality of out-of-school science educators over the past 25 years. "The **promise of new information technologies**" was also highlighted for increased funding.

The highest priority was accorded to the most expensive recommendation: vastly increased resources for pre-service and continuing teacher education. The report recognized "**the teacher as the key to education**." These recommendations for action by the governing body of the National Science Foundation (NSF) were quickly followed by the dedication of new material, human, and financial resources to achieve them. In the years since, as the symposium speakers testified, the practice of scientific inquiry and "hands on" strategies has increased student interest and achievement. And the dynamic and interactive interfaces that fast-developing information technologies have provided during these years have enriched teaching and learning. Extensive new investment in museums, media, and other "out of school" informal educational resources are now engaging a much larger and more diverse population in science.

But, as with all broad objectives, pre-existing constraints resist change. Economic and cultural disadvantages limit engagement

Note: Although the term "science" is used throughout, most references are equally relevant to STEM (science, technology, engineering, and mathematics.)

in science for much of our school population. Well-publicized deficiencies in student math and science testing illustrate the particular difficulties faced by U.S. science educators in reaching our markedly heterogeneous school population. Teacher recruitment, education, and retention remain primary constraints. Teacher shortages are most acute in mathematics and physical sciences, in high poverty areas, and are exacerbated by large numbers of teachers leaving before retirement age (NSF Science Indicators 2008).



About Cecily Selby

When Cecily Selby joined New York University as professor of Science Education in 1984, she brought with her experiences as a research biophysicist, medical school instructor, school principal, and director of non-profit and corporate enterprises. Born and bred in a family and community of scientists and educators, she had long been dedicated to linking science and society. At NYU, she taught graduate courses for teachers on "Science and Human Values," "Science in Historical Perspective," and "The Scientific Enterprise," courses for which NYU was notable. She also brought with her a deeply felt professional concern about popular misperceptions of what science is and what scientists do. After moving her work from science research laboratories to science teaching classrooms (K-16) and educational and corporate executive offices, she found outdated and misinformed conceptions of the "nature" of science holding back student and public engagement with science. Dr. Selby thereafter focused her work on illuminating why these errors persist and what can be done to change them.

Symposium speakers shared with the audience their engagement with and love of the sciences, and discovered a shared finding: the value added to students' learning when teaching science includes linkages to other subjects and professionals, and to families and communities.

Teachers as science professionals

Paul Jablon

One sentence from the 1983 NSB Report stands out for **Paul Jablon**, "College science faculty should be teaching courses the way we expect precollege teachers to teach." "That was a radical statement for the time," remarked Jablon, and he was determined to put it into practice. In 1990 he left 20 years of public school teaching, earned a Ph.D. at NYU with Cecily Selby, and then assumed responsibility for the elementary science teaching program at Brooklyn College. He initiated a unique collaboration between the college's senior science and education faculty. Both faculties worked together to replace the lecture and cookbook-lab science courses required for elementary science majors with courses that provided an innovative introduction to the "nature" of science: courses in which students designed experiments in a laboratory setting and discussed their findings with each other and the professor. In this way future teachers were introduced to a higher order of scientific thinking.

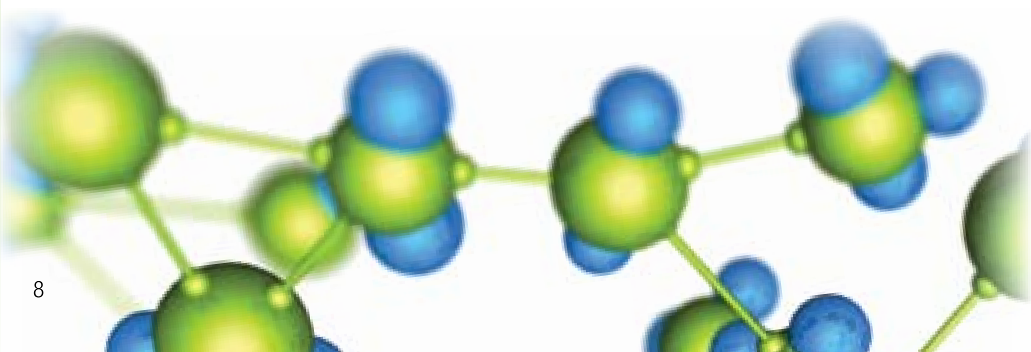
The effect was profound. Of the 96% of the elementary school teachers who before had listed science as their least-liked subject, 80% felt they were competent to teach science when they left—and 30% said they were more confident in teaching science than in some of their other subjects. Students learn best when the teacher conveys confidence and enthusiasm about the subject.

Paul Jablon also emphasized how ongoing professional development is essential to retain teachers. Settings matter too. In a suburban district the superintendent and the science coordinators and teachers are likely to stay for a long time. By contrast, in urban areas superintendents, principals, and science teachers turn over in great numbers and an organically self-sustaining program of teacher support is needed—a program where, for instance, this year's trainees become next year's trainers.


Janice Koch

Drawing from her experience, **Janice Koch** recommended a similar approach to teacher education. The author of several inspiring books providing stories for teachers to use in teaching science,* Dr. Koch has spent most of her career providing professional development for elementary and middle school teachers. Her teaching and writing focus on enabling students to "test their own ideas, to examine their own evidence, and then to explore their own conclusions." To accomplish this, teachers must "find ways to help science teachers become comfortable testing *their own* ideas, examining evidence, and explaining *their own* conclusions." She calls this "locating their scientific selves."

* Koch, Janice, *Science Stories: Science Methods for Elementary and Middle SchoolTeachers, Fourth Edition* (Wadsworth, 2009)
Koch, Janice, *So You Want to Be a Teacher?: Teaching and Learning in the 21st Century* (Wadsworth, 2007)




Julia Rankin Morandi

Julia Rankin Morandi reinforced this point. Teachers are as thrilled by the "aha" moment of discovery when their students "get it" as scientists are with a scientific discovery. Thus, "we need to treat them like science professionals" and "include them in the scientific community, not put them off in their own little worlds." Science teachers need opportunities to work with scientists and science professionals, and be recognized as part of the research community. "Young people are afraid to get into the teaching profession because they think they're not going to be scientists any more."

Rankin Morandi believes that teachers should also be active researchers of their own teaching practices. They should work in unison with science education faculty to develop strong research questions that impact upon teaching and learning.

Teacher education programs thrive when there is interaction between different teachers and different community resources.

The Urban Advantage, a NYC program Rankin Morandi helped develop, provides "hands on" instruction for middle school teachers in several informal science institutions in New York City (e.g., the American Museum of Natural History and NY Hall of Science). Scientists from these institutions work closely with teachers to improve their understanding of the research process. Teachers then turnkey this knowledge to help their students develop science research projects of their own.

Linking young students with undergraduate students also enriches teaching. In Dr. Rankin Morandi's work for the Partnership for Teacher Excellence with NYU and CUNY, undergraduate science students worked alongside teachers in middle and high school science classrooms. They clarified their own understanding by having to make it clear to other younger students. The program also brought scientists from the various college campuses together to align their teachings to improve student learning across the city.

Linking science professionals to professional communities

Dr. Rankin Morandi now works in California with Professional Learning Communities (PLCs)—-dynamic networks of K-12 teachers and university professors. She described her work with five teacher-directed K-12 networks and nine university-based PLCs developed by college professors, primarily to help with teacher retention by enabling middle and high school teachers to feel part of a professional learning community. Jablon has also developed teacher/college professor coalitions with great success. As he said,

> *"It's this matrix of things that has to be done—it can't just be this one program here and one program there. It needs to be this whole set of programs that's self-sustaining over a period of time."*


Pamela Fraser-Abder

Studying teacher retention, **Pamela Fraser-Abder** and her graduate students were able to document that the retention rate for NYU-trained teachers is a high 85%! Data from a just-completed focus group reveals that NYU-trained teachers keep teaching because 1) they feel confident, know the content, and are comfortable teaching it. And 2) they feel involved with the community. The graduate school program builds on their desire to be with students and encourages them to develop an in-depth understanding of their students' culture. When the teacher stays, the students are more likely to stay in the science pipeline—and stay excited about science. Retention of science teachers is the first step to retention of students!

Linking classroom teaching to families and communities

"Teaching in New York City is like being in the eye of a hurricane," says Dr. Fraser-Abder. What's happening in the street and in the home can enter and affect the classroom. She emphasized the positive influence of parental involvement in sustaining the interests of adolescents in school. While it is a tremendous help to teachers when they get parents involved, teachers must recognize constraints on parental involvement. If parents have to do four or five jobs to keep their lives together, they're not going to be able to be part of the school system. Teachers must then find other ways to accommodate student needs, and not blame students if their parents do not show up at PTA meetings.

Dr. Fraser-Abder noted other issues affecting the climate of the science classroom:

1) **Parental expectations**: Student attitudes about the science of chemistry and biology are, of course, vitally impacted by how they and/or their parents envision their future career. Will it be cosmetic chemistry, nursing, or hairdressing? Will science be an integral part of their future career?
2) **The impact of the guidance counselor**: Do guidance counselors feel that all students have a right to science? What courses should they take? Are these courses preparing them for further study in science?
3) **The importance of role models**: As teachers, do we expose our students to role models? Do we provide opportunities for our students to meet and work with scientists so that they begin to see themselves as scientists and not only as basketball players or rock stars?

Teaching and learning involve personal and cultural perspectives

"In New York City students are very upfront: they talk with their feet. If they're not engaged by what you're doing, they leave," Paul Jablon explained, drawing on his ten years teaching in the city's public school system. "Recognizing in my earliest attempts at teaching science that I was not engaging students, I learned that I was boring; the subject was boring. I was not meeting my student's needs. Studying psychology, I recognized that the needs identified 60 years ago by Abraham Maslow—the need for self-esteem, the need to demonstrate competence, and to be accepted by a group—were not being met. What was happening in the science program at that time was not satisfying these needs for a good portion of our students," Jablon said.

Working intensively over a ten-year period, while he took a leave from his Ph.D. studies, Jablon and his faculty developed programs that integrated language arts, social science, and science. They also introduced a unique new idea: allowing students to role play, on a daily basis, what Jablon calls "analogous interrelationships," the relationships students are most concerned about: with their parents, their peers. "These are the same relationships we want them studying in literature, in social studies. Once their Maslowian needs are met, students are willing to engage seriously with the science concepts that can help them in these relationships."

"Positive relationships with other students can't happen alone in a science classroom—but it can happen if, instead of artificially separating the various subjects we teach, we create a synergy between them. We have observed that when this happens, students often go out into the community and communicate their understanding to others."

Positive outcomes: After making these changes the results were impressive, as Jablon documented in his NYU Ph.D. dissertation with Cecily Selby. Students who before were not passing science classes, were not even coming to science classes—98% of them graduated with a Regents scholarship. Jablon now works with teachers in middle schools and high schools throughout New England to create programs (originally called "Bongo") like this that provide another portal of entry for students who otherwise would be deprived of the value that scientific literacy and job preparation can add to their lives.

Science teachers as models—fighting gender stereotypes

Dr. Koch credits Dr. Selby with encouraging her to develop her "gender agenda." "I wanted to model being female and being fiercely passionate about science," she said. Entering college at the age of 16 in 1962, Dr. Koch faced some resistance to her choices. "My grandmother tried to convince my mother that I really shouldn't major in biology because no one would marry me." Despite much progress since then, issues behind gender stereotypes continue to loom large. Koch cited one example: In 1999 more than half the entering class in one medical school were women, but a male friend of hers observed that "Well, you know they're just going to faint at the first sight of blood." Dr. Koch asked him how old he was. He was 22. "Then they have had at least a decade of more experience with blood than you," she informed him.

Sanaz Farhangi, a doctoral student, and John Frisoli, a masters student—both in science education at NYU Steinhardt—presenting their new website for science educators.

Making connections—everyday decisions and the news

Dr. Koch underscored that it is common for women to deny authentic experiences in their own lives as they engage with the abstractions of arcane subjects. It was Dr. Selby who taught her, when she was a doctoral student at NYU, to make connections, and how making decisions that involve scientific processes and/or products can affect the quality of our lives—daily. Through her work Dr. Koch now encourages women to become not just scientists, but citizen-scientists. This also stimulates the participation of those from groups now under-represented in science.

How can we best answer President Obama's charge "to think about new and creative ways to engage young people in science and engineering?"

Dr. Koch cited one practice she adopted from her experiences in Dr. Selby's classes: having students examine and discuss the Science Times section of *The New York Times* every week. She follows Selby's gospel that to engage students in science, elementary teachers must engage themselves in pursuing the "nature" of science—what makes something "science." Immersion in scientific inquiry, Koch says, should start in kindergarten—developing science as a "stable and staple subject" throughout schooling. She regrets that the testing culture of No Child Left Behind pushed science to a backseat behind the more testable subjects of mathematics and language arts. She hopes that the Obama administration will move us toward a future in which science is not just testable facts but a portal through which students can also approach language arts and mathematics in elementary and middle school grades.

Linking with Big Ideas

The explosion of data in the cognitive sciences over the past generation has had a transforming impact on science teaching. "We now know so much more about how people learn," says Koch, "and we know it's absolutely essential to make the connections between our lived experience and the big ideas and concepts in science that we want these precollege students to hold as enduring understandings." A page on the Steinhardt website (see Resources) lists some of these Big Ideas: the difference between living and nonliving. Understanding what forces are at work when you ride a bicycle. Understanding how the rotation of the earth and its revolution around the sun causes day and night and seasons.

Challenging how science is taught

The science curriculum does not need to be taught the way it always has, according to Dr. Koch. "We can challenge the sequence with which biology, chemistry, physics, and earth science are being offered. We can interrogate a physics-first program and ask ourselves why that would have merit." The legacy of "credits" most colleges still follow today dates back to the Committee of Ten of the 1890s. Might there not be new ways to approach the teaching of physical, life, and earth sciences?

Dr. Preeti Gupta, SVP for Science Education, NYSCI, and Frank Signorello, doctoral student in science education at NYU and VP of Professional Development, NYSCI, demonstrate DNA extraction from saliva. Artist Ross Lewis is one of the observers.

The symposium's second panel went "beyond the classroom" to explore informal resources. Museums, art galleries, nonscientific publications, software, television—they are all making dramatic breakthroughs in bringing science to the public in very innovative and effective ways.

While talking about classroom teaching, Dr. Fraser-Abder reminded us that "students spend a lot more time outside the classroom than they do inside." Before coming to NYU she had worked extensively on professional development for UNESCO and the UN with science teacher educators from the Caribbean, Latin America, Asia, Africa, and Europe. This work led her to appreciate the educational value of out-of-school resources like science playgrounds and traveling hands-on museums.

When Fraser-Abder arrived in New York, she was surprised to find few links between informal resources and universities, and so she initiated a graduate course at NYU, "Using New York City's Non-Formal Resources to Teach Science," which takes graduate students to museums, zoos, parks, and other non-formal institutions to investigate how these sites could be used in their science teaching.

Linking art and science

Marcia Rudy

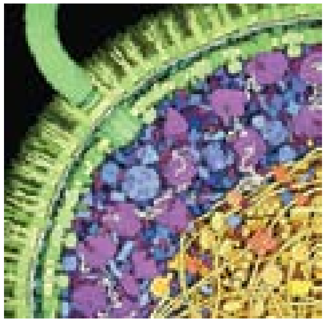
In a visually dazzling presentation **Marcia Rudy** illuminated links between aesthetic and scientific inquiry, between asking and answering questions artistically and scientifically. Throughout the ages great scientists have often used art as a dramatic and effective way to communicate the meaning of their work. Think of Darwin's drawings of plants and animals. Bohr's drawing of the model of the atom. Galileo's phases of the moon.

Children's behavior illuminates a close connection between exploration in art and science. They often take a crayon to try to draw what they see: A rock. The sun. The moon. They want to capture the size, shape, and color of their experiences, and to touch what they are learning about. Many contemporary science museums use this instinct to awaken scientific inquiry through aesthetic inquiry.

Linking art and science can produce the kind of "aha" experience that can live in memory for years—and even shape life choices.

For more than 25 years Marcia Rudy worked at the New York Hall of Science in Queens (NYSCI), overseeing public programs and special events. Under her leadership, the Hall was very much a part of the worldwide movement to revolutionize how museums present science to the public. Inspired by the work of the scientist/designers at San Francisco's Exploratorium, Dr. Rudy initiated several catalyzing permanent and traveling exhibits, the most effective ones being both visually striking and tactile.

In 1996 Art & Science Collaborations, Inc. (ASCI) held a competition for an exhibit for the NYSCI's entrance rotunda. Ross Lewis's "Roto-Sphere" (page 19) stood out because it was both playful and interactive. When two motor-driven intersecting rings reach the top of a loop, the motor stops, gravity takes over, and the rings spin down, gaining momentum until joining



Cross section of Escherichia coli, *by David S. Goodsell, the Scripps Research Institute*

together to create the illusion of a solid sphere—the "aha" experience that results prompts questions about force and gravity from young and old.

By using the same technological tools used by scientists—telescopes, microscopes, electron microscopes—artists are now able to explore new worlds and create striking, other worldly visualizations, images that command you to look closely and ask questions. Dr. Rudy shared numerous striking images to illustrate these technologies: one produced by David Goodsell, a molecular biologist and artist, combines hand-drawn and computer graphic illustration to explore macromolecular size, shape, and distribution, Another artist used a scanning electron microscope to reveal the scales on a butterfly's wing, the hair of a tarantula, and the tiny hooks and loops in a patch of Velcro. Competitions sponsored by corporations (Nikon, Olympus) and universities (Princeton University, University of Colorado) and ACSI now provide a bonanza of scientific visualizations —created by people from all walks of life.

The organization which Dr. Rudy has been involved with for many years, Art and Science Collaborations, Inc. brings artists and scientists together with stunning results. An acoustic engineer has turned whale and bird songs into mandalas. A medical technician creates bio totems using MRI data from human embryos. Some scientist/artists use their art to press causes they care about, like AIDS awareness or environmentalism. Scientists who are not artists have commissioned artists for projects that illustrate and amplify their work. In 2007 Nobel laureate Rod MacKinnon commissioned sculptor Julian Voss-Andreae to create a work, "Birth of an Idea," inspired by MacKinnon's model of how a class of proteins generates nerve impulses.

Linkages between science and art continue to thrive. They facilitate our understanding of how things work; they engage us and get us to interact with our environment; they help us aesthetically appreciate the world around us; and they can inspire us to create something ourselves. Courses now offered at a variety of institutions for teachers and the public range from teaching how artists use color and light to learning the physics of the spectrum to exploring how best to preserve works of art.

*Ross Lewis, **Roto-Sphere,** New York Hall of Science*

*Klaus Bolte, **Chrysolina fastuosa** (Micro leaf beetle) on a pin head (40x); Photo courtesy of Nikon Small World*

*Julian Voss-Andreae, **Birth of an Idea**, 2007 Steel, glass, and wood; Photo: Dan Kvitkaadd*

Linking science with crafts: more "aha" experiences

Maura Flannery

When **Maura Flannery** wanted to explore the connections between aesthetics and science as her dissertation topic for a doctorate in science education at New York University, she was delighted to find a kindred spirit in her advisor, Cecily Selby. "I couldn't believe someone could be interested in the same things." Teaching nonscience majors at St. John's University, she discovered that by exploring relationships between art and science she could help her students engage with science by connecting it to things they know.

For her symposium presentation Dr. Flannery focused on one section of her interests: linking science with crafts, a connection taking many forms. Craft artists can achieve their own "aha" moments when they devise striking new creations from things found in nature—or when they use their craft to interrogate a scientific subject.

Dr. Flannery's research and publications include many not considered scientific, but still yielding new insight into our human species. She has long been fascinated with biophilia, which argues that humans have an innate desire to relate to other species. "Since humans no longer have direct contact with most living organisms, we cannot physically satisfy this desire any more. Instead we decorate our houses with animals and wear them on our clothes."

Flannery illustrated her talk with stunning examples of jewelry incorporating found objects. When one jeweler, Jan Yager, embossed, pressed and cast local wild plants into her jewelry, she discovered that what she had collected were all invasive species. Yager then decided to weave them into a tiara to celebrate the most invasive species of all!

Karen Norberg: ***#1 (knitted brain)***

Jan Yager: ***Invasive Species Tiara****;*
Photo: Ian Thomas, V&A Photo Library

Dr. Flannery credits Dr. Selby with introducing her to several historical writers who illuminate how artisans of other eras contributed to the development of modern science. This fascination with crafts led Flannery to start quilting herself, thereby discovering numerous artists who incorporate biological materials into their work.

Cornell mathematicians David Henderson and Daina Taimina had been frustrated for years trying to create paper models of hyperbolic curves. It was only in 1997 when Taimina tried to crochet these curves that she made a major breakthrough and succeeded in creating the first successful physical model of the hyperbolic plane. A workshop for NYC secondary mathematics teachers was recently held in NYC introducing mathematics teachers to crocheting as a student-friendly approach to teaching 3-dimensional mathematics. It was fitting that Dr. Flannery ended her talk with a project that involves women on three continents quilting a coral reef—it relates to science, to craft, and to feminism. "What more do you want?" asked Flannery.

Science & Technology: uncovering gender stereotypes and engaging young minds

> *"If technology is such a pervasively human endeavor, how did it acquire the "macho" flavor that now pervades descriptions of it in schoolbooks and the media?"*
>
> *— Cecily Cannan Selby,* Phi Delta Kappan, *May 1993*

Margaret Honey

Little did Cecily Selby know when she included this quote in her 1993 paper that it would lead to a whole body of research that **Margaret Honey** and her colleagues pursued for some eight years. Their research team interviewed accomplished technologists, men and women, and assigned them a task—design a version of the technology they currently work with but improve it for the future. Common traits emerged across the many different answers. Women described technology objects that were about connecting the different dimensions of their lives—-often taking the form of jewelry, in forms strikingly similar to those studied by Maura Flannery. Men imagined very different kinds of devices, many suggesting odd fantasies. Several envisioned direct brain-to-machine links. You plug them in and instantly you know everything anyone ever knew!

Uncovering gender stereotypes. In the same study Dr. Honey and her colleagues asked children to draw technologies that would take on different challenges. Again the responses varied. One boy created the "amazing hover car" with a triangular windshield, moon seats, twelve-valve-nine-caliber booster rockets with hidden turbo jets, a snack bar, and a TV. Girls tended to imagine different kinds of devices, like a seasonal chore doer (page 24). The device would be smart and would sense the task it needed to perform: when leaves are falling out pops a rake, when snow is falling out pops a shovel, when it's raining out pops an umbrella.

What did the researchers make of these answers? The masculine voice had faith that problems created by technology can also be solved by it. The feminine voice, on the other hand, was more about making do, more concerned with the consequences of creating technology and how to integrate it into our lives. The reality is that neither voice is sufficient in itself. "What we need," concluded Honey, "is both voices and the blending of both voices and objectives."

Technology is not always about speeding things up. What struck Dr. Honey, in listening to the other panelists, was how many emphasized how good pedagogy slowed things down so that students could delve deep, so the science could be relevant and the inquiry good and sustained. "Those are not the sort of values that you typically associate with technology," said Honey. Technology is supposed to speed things up. "Yet it's exactly the opposite."

> *"When we talk about good judicious uses of technology for educational purposes what we want to think about is what will slow things down and deepen the learning process."*

"What's surprising," Honey went on to say, "is how not pervasive really good technology is." One of the pieces of software she likes is *The River City Project*, a multi-user virtual environment (MUVE) to develop scientific inquiry and 21st century skills. It was designed for middle grades science teachers by Chris Dede and his team at Harvard. The graphical environment presents a world you enter which has a chat window and a work space where you can keep track of your progress. River City's mayor announces a task and the players have to collect data to solve a series of problems. Dr. Honey considers it "a very thoughtful, judicious use of technology."

Dr. Honey offered a video clip from the television show, *The Voyage of the Mimi*, as an example of some "old but really good stuff. I still think it was one of the best ways to engage children in science and mathematics." It was developed at the Bank Street College of Education in the 1980s. As an example of how good provocative materials can motivate a student she related an experience she had while visiting an East Harlem school. One student there had been so inspired by a scene in the video in which an artifact was recovered from the ocean floor that he tried to recreate it in his bathtub using a brick, baggies, and a straw.

As another example of good educational technology Dr. Honey described some student testing assessments developed in the UK. They are now being used by mothers in Pacific Rim countries who want to give their kids a leg up through self-teaching! Honey believes that these assessments succeed because they are well designed for self-teaching—they make students' thinking visible and help them reflect on their own thinking.

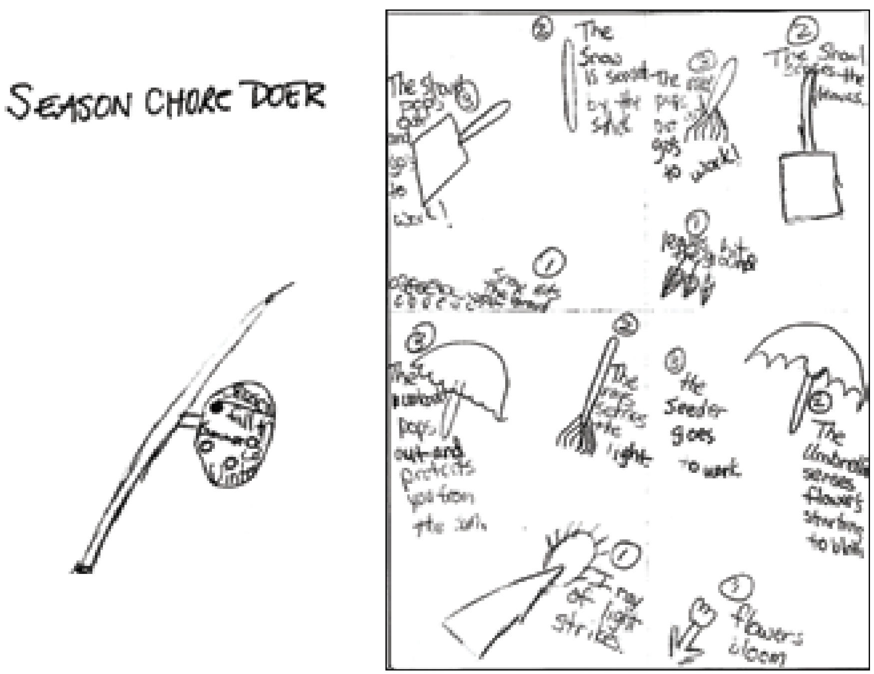


Illustration courtesy of Dorothy Bennett & Cornelia Brunner, EDC Center for Children and Technology

Science & TV: empowering weathercasters for public science literacy

Joe Witte has worked as both a national and local television weathercaster for more than 30 years. But his interests have always extended beyond the weather and in recent years he has been exploring how weathercasters can play a larger role in communicating science to the public. And he has some very good research to back up his objectives. According to the 2006 NSF report to Congress, *Indicators of Science and Technology*, "Television is still the main source of information about Science &Technology, but the Internet is a strong competitor." Newspapers and the Web fall short when compared to TV as a major source of science information. While network TV in the 90s was a major source of S&T information, it's not as much now. Local TV is not the only source but it is a primary source of S&T news. The Web is the fastest growing new source, but it is usually used to search for something specific. Curiosity must be sparked. The Web is active. Most of the public get their information about science by chance when a science story occurs on a general news show.

The Pew Research Center's Project for Excellence in Journalism answered the question "What Gets Covered" as follows: Crime and bizarre events get the most coverage with science and technology at the very bottom with the least.

This is a democratic dilemma, argues Witte. "Can citizens learn what they need to know? Who will the public listen to?" The NSF Report found the data consistent when they asked survey respondents whose credibility they trusted about a series of S&T topics. Politicians and religious leaders ranked at the bottom, scientists at the top, with television just above print media. What if we could combine the knowledge and credibility of the scientists with

Joe Witte on TV

the visibility and credibility of broadcast media? This is where, according to Joe Witte, we can leverage the unique value of the local weathercaster.

Of the 2000 local weathercasters, more than 800 have a college degree in meteorology or another science. In most newsrooms the weathercaster is the only person with a science degree.

Considering the amount of airtime local stations devote to weather, the weathercaster could be actively serving as gatekeeper for local science stories.

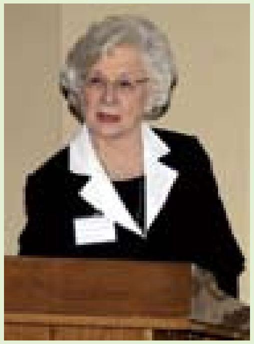
What do they need to do so? Content. Over the past few years Joe Witte has been working with other weathercasters to provide just that. With significant help from several foundations, Witte and his team have created 12 video science segments on water quality. Responses from early testing are positive: "Content and script are great." "Love having them." More information about this program, Earth Gauge, and the American Meteorology Station Scientist project can be found at:

http://www.ametsoc.org/stationscientist/earthgauge.html

Joe Witte plans to expand the Earth Gauge project while also looking into whether other media—taxicab and gas station televisions, billboards, corporate advertising, pre-rolls on YouTube videos—could also be leveraged as vehicles for communicating science.

NASA visualization of the cold water trail left by Hurricane Katrina, August 23 - August 30, 2005

Science education for a competent, confident, and democratic society



Cecily Selby

We take it as commonplace that science's processes and products are woven seamlessly into our lives and culture. Yet for many people the reverse case—the idea that our lives and culture can and should be seamlessly integrated into science teaching and learning— is very new and provocative. Not so for the speakers at this symposium. As successful science educators, they are among those described by Pamela Fraser-Abder as "custodians" of the scientific literacy of our society and gatekeepers of its pipeline of scientists, engineers, and physicians. To create the warp and woof of science education essential to a modern, "open," and democratic society, they reach beyond the classroom to where people live and work. They link science and society in what and how they teach, and, as teacher educators, they teach others to teach.

I have long argued that public engagement with science is held back by the familiar "two cultures" gap between the sciences on one hand, and the arts and humanities on the other.

This "gap" is maintained by outdated and misinformed public perceptions that the practice of science must be impersonal, abstruse and inaccessible—and divorced from the arts and humanities. In reporting on their "best practices," today's speakers vividly refute this perception, melding, as they do, all modes of human inquiry in teaching science as a personal, creative, and human inquiry.

But, as they close one cultural gap, they find another, notable in our markedly heterogeneous school population: the gap of access—the gap between the accessibility of science to students from families and communities that are ready to engage in science and those from places that are not. Socioeconomic deprivation often, *but certainly not always*, characterizes places where science is "not spoken." Many of the successful practices described by today's speakers reach into these places—directly and indirectly. Joe Witte's work, using TV weather reports to broadcast science literacy, is a stunning example of such outreach, but so much more can be done. Commercial and promotional advertising, for instance, offer many untouched possibilities.

The title of my closing remarks claims that science education helps build a competent, confident, and democratic society. All speakers agree. Asking and answering questions scientifically, and finding one's "scientific self," as Janice Koch describes, promote confidence and competence—particularly because science is supposed to be so difficult! Self-confidence and competence can also come from building things that work, as Margaret Honey illustrated, and exploring personal relationships through science, as in Paul Jablon's teaching.

And is not the ability to distinguish between scientific and nonscientific evidence* essential for every citizen in a democratic society? For this point I cite my favorite quotation—from the South African leader, Mamphela Ramphele, when she was Chancellor of the University of South Africa. Speaking in 1998 at an AAAS annual meeting in Washington D.C. on the topic of science for the developing world, she said, "*With its emphasis on evidence and honesty, science enables us to call the bluff of those who would lie to us.*" Calling someone's bluff certainly boosts self-confidence!

As Julia Rankin Morandi emphasized through her work with Professional Learning Communities, and as others noted in their work on promoting science teachers as science professionals, teachers also need self-confidence and competence! Linking science with society was probably missing in their early science education, so teacher educators, as Paul Jablon highlighted,

* See "What Makes It Science? A Modern Look at Scientific Inquiry," Selby, C.C., 2006, *Journal of College Science Teaching* (July/August).

must now model the science/society and "hands on" inquiry links needed to engage most students. Marcia Rudy and Maura Flannery offered numerous striking illustrations of the profound relationship between aesthetic and scientific inquiry.

This symposium provides ample evidence that science needs and deserves equal opportunity with the arts and humanities to advance personal and societal development in the cultural mainstream. But current cries from political and business leaders for more and better science education all seem to end up piled on the backs of science teachers and their classrooms. With so many great examples of informal science education now present in many societies, why make scientific literacy entirely dependent upon a few hours a week with a science teacher? Why not hold all communicators of science, all science educators, responsible and accountable for the scientific leadership and literacy we seek? Why do we not figure out what can best be communicated and understood in classrooms, and what best in museums, on TV, in different media?

When citing "good teachers" as the sine qua non of a STEM literate society, as so many do, why not include supportive communities, teacher education institutions, media, and other resources?

I dream of a school where children would explore all modes of human inquiry concurrently. In early grades, they could discuss the questions an artist, a historian, a philosopher, or a scientist ask about a tree—how each of them would seek answers, and how these answers would be used. They would explore "Big Ideas" like "time" or "force" or "humanity" across all academic disciplines. Evaluation of student achievement would emphasize knowledge and skills related to health and the environment—with relevant chemistry, biology, physics, mathematics, and technology included.

Being able to distinguish between scientific and non-scientific evidence would be central to all teaching. And college admission practices would allow high schools to teach science that is appropriate for, and relevant to, the age involved. High school adolescents would have time to study the world within us (anatomy and physiology) and the world outside (environmental sciences) rather than be forced to concentrate on topics required as preparation for college chemistry.

Today's interdisciplinary activity at the frontiers of science would also argue against a continued "building block" approach to curriculum—as Janice Koch notes. My bias against this practice is born of my admission to graduate study in biology at MIT without any previous courses in biology in school or college—and by my initiating faculty-wide integrated curriculum development at the North Carolina School of Science and Mathematics.

I close with a few words about teacher education, about continuing professional development for teachers. I accepted the invitation to join NYU's Steinhardt School faculty to work on teacher education after co-chairing the National Science Board 1983 report on K-12 Mathematics, Science and Technology Education. Crossing the country to recommend this report's recommendations about teacher education, I discovered another disastrous misperception: that *good science students and good teachers are born not made*. I found this belief responsible for the appalling failure of most school boards to provide opportunities and funds for their teachers to continue professional development—to attend national professional meetings and join refreshment workshops—the lifeblood of continuing teacher development and status.

The dream of today's science educators is of communities within which science teachers, scientists, and all educators interact and bring a useful understanding of all modes of human inquiry, and their products—literature, music, democracy, electronics, medicine, Newton's Laws—to everyone.

If science instruction can be understood and promoted as sharing, with the arts and humanities, the goal of advancing personal and professional development, the outcome will be more confident and competent citizens, a larger pipeline of students prepared for advanced science study, and a healthier and "open" democratic society.

Reports on Education (in chronological order)

1. *Educating Americans for the 21st Century: A plan of action for improving mathematics, science and technology education for all American elementary and secondary students: A report to the American people and the National Science Board*, Science and Technology National Science Board Commission on Precollege Education in Mathematics. Published by The National Science Foundation (1983).

2. *Project 2000: Scientific and Technological Literacy for All* (UNESCO, 1993) See http://www.unesco.org/education/educprog/ste/projects/2000/origins1.htm (panelist Pamela Fraser-Abder consulted on this report)

3. *National Science Education Standards* by The National Committee on Science Education Standards and Assessment, National Research Council (1996) Published by National Academies Press Available for purchase or free download as a PDF at http://www.nap.edu/catalog.php?record_id=4962

4. *No Child Left Behind* (2001) See http://www.ed.gov/nclb/landing.jhtml

5. Selby, C. C. (May 2006) The Missing Person in Science: Inquiry Begins with I. *New York Academy of Sciences Update* 10-13.

6. Selby, C. C. (July 2006) Does Bias in Science Hold Women Back? The *FASEB* Journal 20: 1284-1287 http://www.fasebj.org/cgi/content/full/20/9/1284

7. Selby, C. C. (July/August 2006) What Makes It Science: A Modern Look at Scientific Inquiry. *Journal of College Science Teaching* 35: 8-11 http://www.nsta.org/store/product_detail.aspx?id=10.2505/4/jcst06_035_07_8

8. *National Action Plan for Addressing the Critical Needs of the U.S. Science, Technology, Engineering, and Mathematics Education System*, National Science Board, October 30, 2007 downloadable as a PDF at http://www.nsf.gov/nsb/documents/2007/stem_action.pdf

9. *Science and Engineering Indicators* – biennial report to Congress (updated February, 2008) Free PDF download at http://nsf.gov/statistics/seind/

10. *The State of the News Media 2009: Annual Report on American Journalism*, Pew Research Center's Project for Excellence in Journalism – free report online at http://www.stateofthemedia.org/2009/index.htm

Web links

- Symposium website http://steinhardt.nyu.edu/steinhardt/alumni/selby/
- Steinhardt School of Culture, Education, and Human Development at New York University http://steinhardt.nyu.edu/
- President Obama's address to The National Academy of Sciences (April 27, 2009) http://www.nationalacademies.org/morenews/20090428.html
- The New York Hall of Science www.nysci.org
- "Big Ideas" in Education http://steinhardt.nyu.edu/teachlearn/science/resources/ideas
- The Urban Advantage http://www.urbanadvantagenyc.org/home.aspx
- Art and Science Collaborations, Inc. http://www.asci.org/
- American Meteorological Society http://www.ametsoc.org/amscert/index.html
- Earth Gauge http://www.earthgauge.net/ and also at the American Meteorology Station Scientist http://www.ametsoc.org/stationscientist/earthgauge.html

Links to some of the works cited by Panel Two panelists

Marcia Rudy

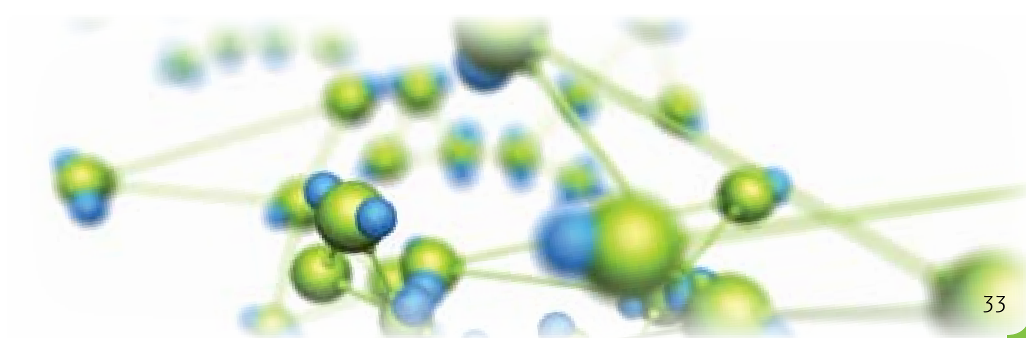
- "Professor Pulfrich's Universe" by Gerald Marks http://www.pulltime3d.com/index.html
- "Roto-Sphere" by Ross Lewis http://www.rosslewisartist.com/index.html
- "Ropes and Pulleys" by Kyle Dries http://www.youtube.com/watch?v=eeeDvReDShA
- "Mandalas" by Mark Fischer http://aguasonic.com/Art/
- Eva Lee's "Discrete Terrain" http://www.vimeo.com/4399448
- "Tree Mountain" by Agnes Denes http://www.bravinlee.com/artists/denes/denes.html
- Works about plasma fusion and art by Todd Siler www.toddsilerart.com
- Julian-Voss Andreae, "Birth of an Idea" http://www.julianvossandreae.com/work

Maura Flannery

- *Metalsmith Magazine* http://www.snagmetalsmith.org/.docs/pg/10050
- Jan Yager, "Invasive Species Tiara" http://www.vam.ac.uk/collections/fashion/object_stories/tiara/index.html
- David Freda, "Tomato Worm Caterpillar Brooch" (http://home.att.net/~dfreda/wsb/html/view.cgi-photo.html--SiteID-474595.html
- Laura Splan (http://www.laurasplan.com/)
- Psychiatrist Karen Norberg, "#1" (knitted brain) (http://imaginaryfriends.typepad.com/neuroscienceart/2006/09/karen_norberg_1.html.)
- Radical Lace & Subversive Knitting (http://www.madmuseum.org/SEE/traveling%20exhibitions/RadicalLaceSubversiveKnitting.aspx)
- Christine and Margaret Wertheim http://www.ted.com/talks/margaret_wertheim_crochets_the_coral_reef.html

Margaret Honey

- *The River City Project* (http://muve.gse.harvard.edu/rivercityproject/index.html),
- *The Voyages of the Mimi* http://www.bankstreetcorner.com/voyages_of_mimi.shtml (the clip played in Margaret Honey's presentation can be found at http://steinhardt.nyu.edu/e/i/alumni/selby/03_technology_and_gender.mp4)



Science Education:
Linking Science with Society

A Symposium celebrating science teaching and learning with Cecily Cannan Selby, her students and colleagues

On April 29, 2009, colleagues and students of scientist and educator Cecily Selby gathered at a symposium to honor her legacy by highlighting the important breakthroughs science educators have made—in school and out of school—and to celebrate their passion for the sciences and their successes in communicating that passion to others. These thoughtful leaders, mostly NYU alumni, shared best practices in presenting science in artistic, technological, environmental, meteorological, community, and personal contexts. Their common objective: to open sci-tech literacy and access to jobs and careers in science to all.

"The dream of today's science educators is of communities within which science teachers, scientists, and all educators interact and bring a useful understanding of all modes of human inquiry, and their products—literature, music, democracy, electronics, medicine, Newton's Laws—to everyone. If science instruction can be understood and promoted as sharing, with the arts and humanities, the goal of advancing personal and professional development, the outcome will be more confident and competent citizens, a larger pipeline of students prepared for advanced science study, and a healthier and 'open' democratic society."

—Cecily Selby