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Hansen Speaks on Climate Change

"If we do not take steps to stabilize climate, it will be a case of intergenerational injustice," said James Hansen in opening his talk on "Halting Human-Made Climate Change: The Case for Young People and Nature" to the American Association of Physics Teachers in Omaha (NE) on 3 August after receiving their Klopsteg Memorial Lecture Award. The Director of the NASA Goddard Institute for Space Studies continued by saying that there is a severe gap between what is understood by scientists and what is known by the public, and he was there as part of his greater outreach to the public to make the points concerning climate change that he has been making to the scientific community for years.

Policy makers understand the problem, he went on, but they don't have the gumption to speak out about it, making it all the more important that he reach out to the public. The "enemy," he said, is inertia in the climate system which makes the climate system susceptible to irreversible tipping points – *e.g.,* degradation of ice sheets, extinction of species. Even surviving species will experience habitat change, he added, and some species might not be able to migrate fast enough. "Business as usual" would drive between 20% and 40% of currently existing species to extinction by 2100.

Although he was once content to leave communication about climate and climate change to others, Hansen said that he has stepped into this communication process because of the inaction he saw in the George W. Bush administration: the planet has already warmed by 0.8^{o}C, with more warming in the pipeline. If the effects of El Niño and La Niña are factored out, the increase in global temperature appears to be linear in time.

The basis of our understanding of climate, Hansen continued, is paleoclimate history, ongoing observations, and climate models. Between 35 and 65 million years ago global temperature was more than 5^{o}C warmer and sea level between 60 and 70 meters higher, all attributed to greater atmospheric concentration of carbon dioxide at the time. Then the concentration of atmospheric carbon dioxide changed at a rate of 0.0001 ppm per year, but now humans are changing it by 2 ppm per year.

Because of this, Arctic ice and the Greenland ice sheet are decreasing at increasing rates, though this rate increase is not as great for Antarctic ice, he said. The subtropical arid region is moving northward, and wildfires are destroying a greater area. Mountain glaciers are receding worldwide. Ocean acidification is endangering coral reefs. Avoiding catastrophic effects, he emphasized, requires capping atmospheric carbon dioxide concentration at 350 ppm (and, as this is being written, the NASA website shows the current value to be 391 ppm).

This means that we can't burn all our fossil fuels. Burning all our remaining oil and natural gas, Hansen said, would peak atmospheric carbon dioxide concentration at 425 ppm, if we stop burning coal and fuels from oil shale and tar sands. But, he lamented, as long as fossil fuels are the cheapest energy sources, we will continue to use them. They are cheap, he stated, because they don't pay for their environmental costs. Hansen suggested a fee equivalent to $1 for every gallon of gasoline at its point of production to be distributed to citizens to reduce their carbon footprint – which is something we're going to have to do anyway. He contrasted this with cap-and-trade schemes, which he said can never be implemented globally.

Regarding the now largest emitter of carbon dioxide in the world, Hansen noted that China has a lot to gain from carbon dioxide abatement, with 300 million people living near sea level and high air pollution. In fact, he credited China with recognizing the results of climate science and noted that it is making enormous investments in carbon-free energy, including 30 nuclear power plants. But he feels that the U.S. Congress is "oil and gas fired" and that

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Making the case for Science Outreach

It was the twenty-eighth of March, nineteen hundred seventy-nine. James Stith was *en route* to friends in Lancaster, PA, and noticed heavy traffic in the opposite direction. When stopping for gas, he learned of the accident at Three Mile Island, and when he reached his friend's house, he found that his friend was getting ready to leave, too. A conversation comparing the risks of staying near the dysfunctional reactor and the risks of traveling away led them to stay, but listening to accounts of the story from the news media gave Stith doubts. Given the disbelief the public was showing in the story, Stith began to wonder what the role of scientists should be in reaching out to the public.

More than thirty years later, Stith, now Vice President Emeritus of the American Institute of Physics, spoke to the American Association of Physics Teachers on 1 August 2011 at their meetring in Omaha (NE) on this very topic: "Scientists Reaching Out to the Public: A Necessary Dialogue." He continued by citing an article in *Newsweek* which characterized scientists as arrogant and unable to speak to the public in their own language. Moreover, communication with the public is further made difficult by shrinking staffs of journalists devoted to science and a shift to opinion in journalism. Stith went on to cite that the percentage of the American public concerned about climate change, believing in evolution, and favoring more nuclear power plants is much lower than the corresponding percentage of scientists.

Now the American Institute of Physics has responded – in three ways: 1) *FYI: The AIP Bulletin of Science Policy News*; 2) the Inside Science News Service (to provide science news articles that would otherwise be written by media science journalists – visit <http://www.insidescience.org>); and 3) Discoveries and Breakthroughs Inside Science (DBIS), collaborating with Ivanhoe Broadcast News, which produces science television news stories ("the only peer-reviewed news on TV") that are sold to stations below cost. Twelve pieces are produced every month, with a companion website. Although the Internet is gaining in market share, Stith stated that television is still the most important source of news for Americans. DBIS is now reaching 47 million Americans, 200 million people worldwide, he said. It doesn't pay for itself, but it has gotten scientific societies to realize the importance of working together to communicate with the public. "If we don't tell our story, no one will," Stith concluded. "Scientists must take control of science."

Two other examples of science outreach to the public at the meeting

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The TEACHERS CLEARINGHOUSE FOR SCIENCE AND SOCIETY EDUCATION, INC., was founded at The New Lincoln School on 11 March 1982 by Irma S. Jarcho, John L. Roeder, and the late Nancy S. Van Vranken. Its purpose is to channel information on science and society education to interested readers. To this end it publishes this *Newsletter* three times a year. Thanks to funds from tax-deductible contributions, the Clearinghouse is happy to be able to offer its services for a one-time nominal charge. In order to continue offering its services for a nominal charge, it also solicits underwriting of its publications by interested corporate sponsors. All correspondence should be addressed to the editor-in-chief at 194 Washington Road, Princeton, NJ 08540-6447 or via e-mail at <JLRoeder@aol.com>. The Clearinghouse is sponsored by the Association of Teachers in Independent Schools, Inc., and is affiliated with the Triangle Coalition for Science and Technology Education.

Climate Change Activities from "Little Shop"

by John L. Roeder

With a grant from the Center for Multi-Scale Modeling of Atmospheric Processes (CMMAP), Brian Jones and his staff at the Little Shop of Physics at Colorado State University have applied their skills at communicating science to the public via interactive activities to developing a series of activities to teach climate and climate change. I enjoyed experiencing these activities at a workshop which Jones and his staff presented on 31 July 2011 at the meeting of the American Association of Physics Teachers in Omaha (NE).

Climate and climate change are primarily driven by the energy we receive from the Sun. To show this, fill a film can with water and set it in unobstructed sunlight and measure the temperature of the water with an infrared thermometer as a function of time. To find the intensity of the incident solar radiation, calculate the thermal energy gained by the water in the can, knowing the specific heat of water, then divide by the time needed for the observed temperature increase and the cross-sectional area the can presented to the incoming solar rays. If this radiation were only absorbed, the temperature of the Earth would increase without limit. The average constancy of Earth's temperature is evidence that the Earth re-emits the energy it absorbs, and activities with infrared goggles are designed to show that this re-emitted energy is in the infrared region of the electromagnetic spectrum.

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Facing the Future on Climate Change

by John L. Roeder

I first learned about Facing the Future from a workshop presented by Ben Wheeler at the 2008 Annual Conference of the National Association of Independent Schools. Ben then shared with us examples of activities he had developed to teach about sustainable living (which I reported in our Spring 2008 issue).

This past year I learned that Facing the Future had also developed a curriculum to teach about climate change – through a somewhat circuitous route. I had received an e-mail offer from the Alliance for Climate Education (ACE) to present a free assembly about climate change at The Calhoun School. With my knowledge of the second law of thermodynamics, I am skeptical about anything free, and when I shared this offer with the Associate Director of Calhoun's Upper School, she unearthed a report from PR Watch on the Internet linking ACE with British Petroleum (BP) and recommending Facing the Future's curriculum on climate change, noting that it was funded by Hewlett-Packard (H-P).

I then decided to check out the Facing the Future climate change curriculum for myself, for two reasons: I was interested in the subject, and I had enjoyed Ben Wheeler's workshop, which had introduced me to Facing the Future in the first place. So I went to <http://www.facingthefuture.org> and found a website advertising "positive, solutions-based programming . . . designed by and for teach-

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Climate Change Modules from PBS and NASA

by John L. Roeder

If you're looking for some good videos, visual interactives, and short readings to teach about climate change, take a look at what PBS and NASA have for you at <http://www.pbs.org/teachers/stem/professionaldevelopment>. There you'll find plans for nine modules, using the 5E cycle (engage, explore, explain, elaborate, evaluate), on the following topics: "Introduction to Earth's Dynamically Changing Climate," "Earth's Warming Climate: Are We Responsible?" "Going Local With Global Warming"; "The Climate Change Skeptic's Argument: Natural Solar Cycles or Human Activity?" "Earth's Orbit and Climate Change"; "Coastal Consequences of Sea Level Rise"; "Climate Change and STEM Career Preparation: Building a Diverse Workforce"; "Connecting Global Climate Change with Engineering"; and "Impacts of a Warming Arctic." Each of the modules contains an Overview, Big Idea, Data Activity, Summary, Standards (indexed to AAAS *Benchmarks*). Each module has a page devoted to each step of the 5E cycle, with links to all needed videos, visual interactive, and readings. Most of the videos are from NASA or clips from *NOVA*. The readings are from NASA and other reputable sources such as *Scientific American*, the USEPA (Environmental Protection Agency), and the National Earth Science Teachers Association. And the visual interactives, showing such phenomena as the distribution of global temperatures versus year from 1885

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"Little Shop"

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Some of the activities are kinesthetic. The difference between the reaction of molecular oxygen and nitrogen in the atmosphere and the reaction of carbon dioxide and water molecules to the infrared radiation from the Earth can be modeled as follows. A person holding forearms perpendicular and alternately reversing their direction represents a quantum of electromagnetic radiation, with the oscillating forearms representing electric and magnetic fields. The key to the interaction is what the oscillating electric field vector does to the respective molecules. Because molecular nitrogen and oxygen have no electrical polarity, they don't respond to the oscillating electric field, but the polarity of carbon dioxide and water molecules causes their oppositely charged parts to oscillate in opposite directions, resulting in molecular vibration and absorption of electromagnetic energy. This absorbed energy is subsequently emitted, and the direction in which it is emitted can be modeled by a dice throw.

Two activities showed how the interaction of greenhouse gas molecules in Earth's atmosphere with infrared radiation from the Earth increases the temperature of the atmosphere, one a physical representation, the other a model simulation. The former requires shining light from an incandescent or halogen bulb onto a stack of four identical small pieces of glass separated by pieces of rubber at their corners and mounted on top of a piece of glass painted black, then turning off the bulb and measuring the temperature of each of the four pieces of glass. The latter requires four "players," representing Earth, the lower atmosphere, upper atmosphere, and outer space (including the Sun). Each of the first three players receives a card with spaces for pennies, each penny representing a degree Celsius of Earth's temperature. Each "round" of the model begins with the Sun giving three pennies to the Earth to represent the energy with which the Sun directly heats the Earth. Then the Earth, according to the number of pennies on its card, transfers the number directed to the lower atmosphere, the lower atmosphere transfers the directed number of pennies to both Earth and the upper atmosphere, and the upper atmosphere transfers the directed number of pennies to both the lower atmosphere and to outer space. To observe the difference between day and night, this model simulation can eliminate the three pennies given by the Sun to the Earth to represent night.

The effect of greenhouse gases in the atmosphere on atmospheric temperature is an example of positive feedback, and we experienced both kinds of feedback by playing "feedback poker" according to different betting rules. We also demonstrated both kinds of feedback by striking a pendulum at different parts of its cycle and in different directions.

The difference between weather and climate was imparted by two activities as well. One activity modeled the weather on the same day of successive years by the color of m&m candies withdrawn from a bag one at a time. The weather conditions represented by the colors collectively constituted the climate, and, just as no two bags of m&ms are expected to contain the same color distribution, each location has a different climate. The chaotic conditions modeling a climate are modeled in yet another activity by plotting successive points determined by values of x_{n+1} determined by the value of x_n.

One of the things we can do to reduce greenhouse gas emissions is to make more efficient use of electricity generated from power plants that burn fossil fuels and emit carbon dioxide. Among more efficient electrical appliances are more efficient light bulbs. These are bulbs that emit more light in the visible part of electromagnetic spectrum and less in the infrared. They thus appear to emit as much light as the less efficient incandescent bulbs, but – with their heightened emission of invisible infrared radiation – the incandescent bulbs are better able to activate a solar-powered toy.

Another activity presents a societal strategy to stabilize climate: selecting from among the options presented as "wedges" to add together by Pacala and Socolow in *Science*, **305**, 968-972 (13 Aug 04) (reported in our Fall 2004 issue and in several subsequent issues). Jones presented the requirements of each "wedge" as the cover on a CD case, color-coded as to whether they related to efficiency and conservation (4), fossil fuels (4), nuclear energy (1), and renewable energy and biostorage (6). When Pacala and Socolow wrote their original paper, seven "wedges" were required. Since nothing significant has been done in the intervening seven years, that number has now been increased to eight. Mounting the requirements of each "wedge" as the cover on a CD case greatly facilitated discussing the various choices in a group of participants and coming to a final decision.

"I believe the Great Creator has put oils and ores on this earth to give us a breathing spell . . . As we exhaust them, we must be prepared to fall back on our farms. For we can learn to synthesize materials for every human need from the things that grow."

- George Washington Carver

Three Celebrations of Teaching

Jones shares what he learns teaching kindergarteners

When Brian Jones selected "All I Need to Know About Science Teaching I Learned in Kindergarten" as the title of his talk to the American Association of Physics Teachers upon receiving their Millikan Medal in Omaha (NE) on 2 August 2011, he meant to describe what he had learned from teaching kindergarten students. This is an example of the outreach that he does with his Little Shop of Physics at Colorado State University, and he began his talk by describing how he got started at it. As he explained it, he had caught an intestinal parasite while teaching in Africa, and he recognized the need to develop activities for his students to do when he had to excuse himself. This introduced his African students to experiments they could do with simple equipment, and the ability to build experimental apparatus at home with simple equipment has remained a requirement for all the apparatus with which the Little Shop of Physics does its outreach. (Later that day Jones and his staff set up two big rooms full of these types of apparatus they had brought with them from Colorado.)

Along with sharing his philosophy of experimental apparatus, Jones also shared his philosophy of teaching. He offered the following aphorisms:

1. The world is comprehensible and you learn that by experimenting.
2. We learn best when we are active.
3. You can understand something better if you can touch it.
4. To make it stick, make it real.
5. It's easy to convince students that you are smart. It's harder to convince them that *they're* smart.
6. Our job is to design an environment in which students can learn.
7. If you want your students to be enthusiastic about learning, you have to be enthusiastic about your teaching.
8. There are many ways to do something well.
9. Some things are worth doing just because they are cool.

Prather: teaching astronomy to enhance scientific literacy

Ed Prather was originally trained as a mechanic, and he first learned physics by practicing his vocation. Later, as a college student, he took Lillian McDermott's course at the University of Washington for underprepared physics majors. This awakened his interest in physics and physics education research, an interest which later spilled over into astronomy, which he now teaches at the University of Arizona. His reputation there earned him the Halliday and Resnick Award for Excellence in Undergraduate Physics Teaching of the American Association of Physics Teachers in Omaha (NE) on 2 August 2011.

In his talk on "Teaching Space Science: A STEM Transformation Vehicle That Really Works," Prather expressed his concern about the scientific literacy of our society. He spoke of being one teacher of the 250,000 college students who take an astronomy course every year as a terminal science course. Because of his concern about scientific literacy, he infuses as much physics as he can into his astronomy course – "Astronomy is a great way to teach physics," he says.

McCormack recounts teaching career

Stacy McCormack is a blonde, but the title of her talk to the American Association of Physics after receiving their Zitzewitz Award for Excellence in Pre-College Teaching Award in Omaha (NE) on 2 August 2011 was a master of understatement. The physics teacher from Penn High School in Mishawaka, IN, explained how she fell in love with chemistry in Mrs. Bowersox's class as a high school sophomore – to the point that she was inspired to become a chemistry teacher. In doing so, she learned about active learning from her mentor, and this was to pay off handsomely in the rest of her teaching career.

McCormack went on to describe how her chemistry students came back to see her the following year, bored by their lecture-based physics course, imploring her to learn to teach physics. Although the title of McCormack's talk was "Blond Girls Can't Learn Physics," this she did, and she's been teaching physics ever since. She explained how she uses constructivist learning theory, with labs first, containing the content. Her class begins the year with a Metric Olympics, featuring a straw javelin and paper plate discus. She has written 30 of her guided inquiry labs into a book, *Teacher Friendly Physics*, published in 2009.

These are some of the things McCormack says she has learned from her teaching experience:

1. Make labs no more than one page long.
2. Use technology – each student gets a separate online problem.

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Three Effective Ways to Teach Physics

Three approaches to teaching physics that have been found to be especially effective were presented by people instrumental in their development at the American Association of Physics Teachers meeting in Omaha (NE) on 2 August 2011. Dwain Desbien of Estrella Mountain Community College, Avondale AZ, presented the Modeling approach; Lawrence Escalada of the University of Northern Iowa, Cedar Falls, IA, presented Physics Resources and Instructional Strategies for Motivation Students (PRISMS); and Eugenia Etkina of Rutgers University, New Brunswick, NJ, presented her Investigative Science Learning Environment (ISLE) program.

Desbien explained that the idea for Modeling came from David Hestenes in 1980 but that it was the late Malcolm Wells who first implemented it in the classroom. Jane Jackson keeps the program running from day-to-day at Arizona State University. The other founding leaders are Larry Dukerich (who spearheaded Modeling Chemistry) and Gregg Swackhamer. The present Modeling curriculum reflects the feedback of the many teachers who have attended Modeling institutes, at Arizona State and elsewhere.

Desbien went on to point out that Modeling was based on the realization that prior knowledge influences student learning. He said that Modeling appealed to him because of its coherence rather than addressing science from a piecemeal approach. It is so-named because scientists seek to make models of the physical world. A “Modeling Cycle” begins with demonstration of phenomena to be modeled, followed by an investigation of the phenomena and a coherent model to explain them. Objects can be modeled by points and extended bodies (possibly rigid). Relationships between variables can be modeled by graphs, equations, and diagrams (motion maps, free body diagrams, and field lines). Kinematics can be done with position-time and velocity-time graphs, without having to write the equations. Force Concept Inventory scores show that students show greater gains between pre- and post-instruction with Modeling.

Escalada explained that PRISMS originated under Roy Unruh and Tim Cooney as a collection of 130 high interest activities in learning cycle format (developed by Robert Karplus, *et al.*) using low-cost materials, which they assembled into a large white binder in 1982. Some of these later found their way into *Conceptual Physics* lab manuals. Working with Unruh and Cooney, Escalada has now prepared a revision of the original PRISMS materials with an enhanced learning guide. The result, known as PRISMS PLUS, presents 44 *complete* learning cycles as guides for teachers to carry out *complete* cycles. Modeling and CPU (Constructing Physics Understanding) are also integrated. In addition to exploration, concept development and application activities, there is also conceptual support. PRISMS PLUS contains four units: Force and Motion (14 cycles), Work and Energy (8 cycles), Waves and Optics (12 cycles), and Electricity and Magnetism (10 cycles).

Etkina explained how her view that learning math is part of learning physics rather than a prerequisite for learning physics is embodied in the philosophy of ISLE, in which students observe phenomena, then seek to develop explanations of them. This is done by further tests of predictions based on the explanation.

PBS and NASA

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to 2007, the effect of sea level rise up to 6 meters on the southeastern United States, the distribution of Arctic ice from 1979 to 2010, and the global distribution of carbon emissions by month from September 2002 until December 2009, are particularly useful. I was also gratified to read in an interview with Gavin Schmidt of the Goddard Institute for Space Studies the distinction between the way Goddard and the East Anglia Climate Research Unit compute global temperatures (as noted in our Winter 2010 issue, courtesy of Gordon Aubrecht, Goddard includes Arctic temperatures, as measured by the nearest stations, while East Anglia in effect replaces Arctic temperatures by the global average).

McCormack

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3. Use multiple activities per class period (her periods are 88 minutes long).
4. Students will not care about your content until you care about them.
5. Teach students to find the answers on their own.
6. Use a participatory culture to transmit information.

These are some of the things she wants her students to learn:

1. Show up and work hard.
2. Don’t procrastinate.
3. Just because something is difficult doesn’t mean you can’t learn it.

NRC publishes *Framework*

Almost to the day, a year after the National Research Council submitted its draft version for public comment, the Council published the final version of *A Framework for K-12 Science Education* on 19 July 2011. "The framework highlights the power of integrating understanding the ideas of science with engagement in the practices of science and is designed to build students' proficiency and appreciation of science over multiple years of school," states the Foreword (p. viii). The Executive Summary continues:

> Science, engineering, and technology permeate nearly every facet of modern life, and they also hold the key to meeting many of humanity's most pressing current and future challenges. Yet too few U.S. workers have strong backgrounds in these fields and many people lack even fundamental knowledge of them. . . . The overarching goal of [the] framework for K-12 science education is to ensure that by the end of 12th grade, *all* students have some appreciation for the beauty and wonder of science; possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; are able to continue to learn about science outside school; and have the skills to enter careers of their choice. . . . Currently, K-12 science education in the United States fails to achieve these outcomes, in part because it is not organized systematically across multiple years of school, emphasizes discrete facts with a focus of breadth over depth, and does not provide students with engaging opportunities to experience how science is actually done. . . . The framework is based on a rich and growing body of research on teaching and learning in science, as well as nearly two decades of efforts to define foundational knowledge and skills for K-12 science and engineering" (p. ES-1)

If these words sound like words you've read in other reports bemoaning the state of American science education, realize that in this case they are not empty. The standards which are intended to be based on this *Framework* are envisioned as the basis for the science Common Core State Standards, which have already been adopted for language arts and mathematics by 43 states and the District of Columbia.

If these words sound like the report of the draft of the *Framework* in our Fall 2010 issue, that's because the final version is more a tweaking of the draft than a major overhaul. Like the draft, it is structured in terms of three major dimensions: 1) "scientific and engineering practices," 2) "crosscutting concepts that unify the study of science and engineering through their common application

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AAPT on *Framework*

President-Elect Jill Marshall of the American Association of Physics Teachers (AAPT) reported to the Association on 2 August 2011 at its meeting in Omaha (NE) how its comments on the *Draft Framework for K-12 Science Education* fared in the publication of the actual *Framework for K-12 Science Education* a year later. She focused on three aspects of the comments which AAPT submitted to the National Academy of Sciences in August 2010: 1) separation of core ideas for physics and chemistry; 2) elimination of the use of the word "transformation" in its application to energy; and 3) portrayal of the "scientific method."

AAPT was able to move things in the right direction on the second two items on the list, Marshall reported, but the National Academy sees more reasons to treat physics and chemistry together rather than separately. "The word 'transformation' sounds 'alchemical,'" Marshall said, and it has been removed from reference to energy in the physical science core ideas. For example, the third physical science core idea, "energy and its transformations," has now been changed to "energy." However, "transformation" is still applied to systems (physical science core idea 2.C) and to matter and contact forces (physical science core idea 2.B), as well as to matter and energy in organisms (life science core idea 1.C).

AAPT "expressed concerns that [the *Draft Framework*] narrowly frames the practices in a way that reflects the traditional view of the *scientific method* (a process of questioning, developing a hypothesis, conducting an experiment, and developing a conclusion), and one which does not reflect the way that scientists work." Indeed, the *Draft* provides only a meek rebuke to those who hold that there is a monolithic scientific method: "The classic conception of scientific method . . . provides only a very general and incomplete version of the work of scientists." However, the final *Framework* makes it very clear that scientific practices are not a ritualized process by its references to "The mistaken impression that there is . . . a single 'scientific method'" (p. 3-2) and statements that "scientific reasoning is richer . . . than the image of a linear and unitary scientific method would suggest" and "The notion that there is a single scientific method . . . is fundamentally wrong." (p. 3-22)

Although the basic structure of the *Framework Draft* survives in the *Framework,* Marshall reported that she found the final *Framework* more detailed and fleshed out, an example being the above elaboration on scientific practices. Marshall also stated that AAPT has offered to work with Achieve, Inc., in developing from the *Framework* the Next Generation Science Standards.

NRC publishes *Framework*

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across fields," and 3) "core ideas in four disciplinary areas: physical sciences; life sciences; earth and space sciences; and engineering, technology, and the application of science." Note, though, that the positions of practices and core ideas in the dimensions have been interchanged, that the four disciplinary areas have been reordered, and that "application of science" has been added to "engineering and technology."

The scientific and engineering practices have been revised somewhat, too, and there is one new one: "using mathematics, information and computer technology, and computational thinking":

draft practice	final practice
1. Asking questions	1. Asking questions (science) and defining problems (engineering)
2. Modeling	2. Developing and using models
3. Devising testable hypotheses	3. Planning and carrying out investigations
4. Collecting, analyzing, and interpreting data	4. Analyzing and interpreting data
5. Constructing and critiquing arguments	5. Using mathematics, information and computer technology, and computational thinking
6. Communicating and interpreting scientific and technical texts	6. Constructing Explanations (science) and designing solutions (engineering)
7. Applying and using scientific knowledge	7. Engaging in argument from evidence
	8. Obtaining, evaluating, and communicating information

The seven crosscutting concepts are much closer to those in the draft, with only three minor changes: "similarity, diversity" is deleted after "patterns"; "mechanism and prediction" after "cause and effect" is changed to "mechanism and explanation"; and "form and function" is changed to "structure and function." The other four crosscutting concepts – scale, proportion, and quantity; systems and system models; energy and matter: flows, cycles and conservation; and stability and change – remain the same.

The four criteria for the core ideas are likewise the same as in the draft: "a core idea for K-12 science instruction should

1. Have broad importance across multiple sciences or engineering disciplines or be a key organizing principle of a single discipline.
2. Provide a key tool for understanding or investigating more complex ideas and solving problems.
3. Relate to the interests and life experiences of students or be connected to societal or personal concerns that require scientific or technological knowledge.
4. Be teachable and learnable over multiple grades at increasing levels of depth and sophistication. That is, the idea can be made accessible to younger students

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Hess addresses learning progressions

Learning progressions played an important role in the *Draft Framework for K-12 Science Education* described in our Fall 2010 issue. They also play an important role in *A Framework for K-12 Science Education*, described in this issue. Karin Hess of the National Center for the Improvement of Educational Assessment spoke about them at the summer meeting of the American Association of Physics Teachers in Omaha (NE) on 1 August 2011.

Hess began by offering two working definitions of learning progressions: "descriptions of the successively more sophisticated ways of thinking that follow one another as students learn. . . ." (Wilson and Bertenthal, 2005); "picture of the paths students typically follow as they learn. . . ." (Masters and Forster, 1996). They are used, she said, to 1) plan and modify curriculum and instruction, 2) develop meaningful assessments, and 3) monitor progress.

For Hess, the four guiding principles underlying learning progressions are that they are 1) based on research

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Effective Approaches to STEM Education

As the result of a request of Representative Frank Wolf (R-VA) to the National Science Foundation, the "Committee on Highly Successful Schools on Programs for K-12 STEM Education" was convened by the National Research Council and charged with "outlining criteria for identifying effective STEM schools and programs and identifying which of these criteria could be addressed with available data and research and those where further work is needed to develop appropriate data sources." The Committee surveyed existing research, mostly on science and mathematics, because technology and engineering are rarely taught in K-12 education, and solicited background papers for a workshop held on 10-11 May 2011. They published the results of their work in a 48-page report, *Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics*, which is available online at <http://www.nap.edu/catalog.php?record_id=13158>.

The Committee's recognition of the need to improve STEM learning is expressed in their opening statement:

> An increasing number of jobs at all levels—not just for professional scientists—require knowledge of STEM. In addition, individual and societal decisions increasingly require some understanding of STEM, from comprehending medical diagnoses to evaluating competing claims about the environment to managing daily activities with a wide variety of computer-based applications. (p. 3)

They then move on to three goals for U.S. STEM education (pp. 4-5):

1. "Expand the number of students who ultimately pursue advanced degrees and careers in STEM fields and broaden the participation of women and minorities in those fields."

2. "Expand the STEM-capable workforce and broaden the participation of women and minorities in that work force." (Here they note that while 16 of the 20 occupations with largest projected growth in the next decade are STEM-related, only four require an advanced degree.)

3. "Increase STEM literacy for all students including those who do not pursue STEM-related careers or additional study in the STEM disciplines."

They add that "Scientific research provides little evidence about how to accomplish the three broad goals." (p. 6)

The Committee begins the report of its work with three types of criteria to identify successful STEM schools:

1. <u>Student STEM Outcomes as Criteria for Success</u> – "because success typically is measured in terms of outcomes." Although "achievement test data are the most widely available measures . . . for accountability purposes . . .," the Committee writes, "test scores . . . do not tell the whole story of success." (p. 6) But they also note that it is difficult to evaluate achievement of the more abstract goals of a school, and that only now are databases linking achievement test data with school practices.

2. <u>STEM-Focused School Types as Criteria for Success</u>. Four types of schools are considered: a) Selective STEM schools, of which there are about 90 nationwide; b) Inclusive STEM schools; c) Schools with STEM-focused career and tech ed (CTE); d) Comprehensive schools (where most high school students are educated). The Committee notes that selective STEM schools benefit from resources and high student motivation but state that there is no way to know whether a student at a selective STEM school would have been equally attracted to STEM by going to another type of school. But they do note that students with a high school research experience, as an intern or an apprentice, were more likely to graduate from college with a STEM major. A network of 51 inclusive STEM schools that opened since 2006 in Texas shows higher science and math achievement test scores, better attendance, and more enrollment in advanced courses. A profile of a school in each of the four categories is included, but the report states that "the limited research base on the [first] three school types hampered the committee's ability to compare their effectiveness relative to each other and for different student populations or to identify the value these schools add over and above non-STEM focused schools. However, the available studies suggest some potentially promising – if preliminary and qualified – findings for each school type." (p. 13)

3. <u>STEM Instruction and School Practices as Criteria for Success</u>. The Committee writes that ". . . a larger body of rigorous evidence is available on practices that are associated with better student outcomes, regardless of whether students are in a STEM-focused school or in a regular school." (p. 17) They "focused on two key aspects of practice that are likely to be found in successful schools: instruction that

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STEM Education

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captures students' interest and involves them in STEM practices and school conditions that support effective STEM instruction" (p. 18) but lament that ". . . this type of STEM instruction remains the exception in U.S. schools. It is typically facilitated by extraordinary teachers who overcome a variety of challenges that stand between vision and reality." They add that "Further transformation is needed at the national, state and local levels for this type of K-12 STEM education to become the norm" (p. 19) and suggest some "key elements that might be able to guide educators and policy makers in that direction" (p. 19):

a. "*a coherent set of standards and curriculum*." (p. 19) (Lack of student learning could be the result of not knowing what is expected and not having the means to achieve it. The examples of standards cited here all focus on studying fewer topics in greater depth.)

b. "*teachers with a high capacity to teach in their discipline*." (p. 20) (It is important that professional development provide whatever is needed to achieve this, and it must be provided coherently and on a continuous basis.)

c. "*a supportive system of assessment and accountability*." (p. 21) ("A supportive accountability system focuses not just on student outcomes but also on teacher practices.")

d. "*adequate instructional time*." (p. 22) (No Child Left Behind is criticized for taking time from science instruction to use for math and language arts, because those are the only two subjects mandated for testing.)

e. "*equal access to high-quality STEM learning opportunities*." (p. 23) (As opposed to factors like poverty which contribute to "achievement gaps among students from different socioeconomic, racial, and ethnic groups," the Committee "focused on some of the structural inequalities that states, schools, and districts have the potential to address" – *e.g.*, "disparities in teacher expectation, . . . access to adequate laboratory facilities, resources, and supplies. . . .")

The Committee then turns to "School Conditions and Cultures that Support Learning," noting that ". . . although teacher qualifications matter, the school context – its culture and conditions – matters just as much . . . research . . . highlights teacher learning communities as among the most powerful sources of improvement in teacher and student learning. . . ." They add that this is supported by test scores from Chicago elementary schools, observing that the schools with improved student learning in science and math share these five characteristics: 1) "school leadership as the driver of change," 2) "professional . . . quality of the faculty and staff," 3) "parent-community ties," 4) "student-centered learning climate", and 5) "instructional guidance . . . focused on the . . . curriculum." (p. 24)

The Committee concludes its report with separate recommendations for schools and districts and for national policy makers to support effective K-12 STEM education. They recommend (p. 27) that 1) ". . . districts seeking to improve STEM outcomes beyond comprehensive schools should consider all three models of STEM-focused schools"; 2) ". . . districts should devote adequate instructional time and resources to science in grades K-5"; 3) ". . . districts should ensure that their STEM curricula are focused on the most important topics of each discipline, are rigorous, and are articulated as a sequence of topics and performances"; 4) ". . . districts need to enhance the capacity of K-12 teachers"; and 5) ". . . districts should provide instructional leaders with professional development that helps them to create the school conditions that appear to support student achievement" (consistent with recommendation 3 above for schools). They recommend (p. 28) that 1) ". . . policy makers at the national, state, and local level should elevate science to the same level of importance as reading and mathematics . . . [and to this end] states and national organizations should develop effective systems of assessment that are aligned with the next generation of science standards and that emphasize science practices rather than mere factual recall"; 2) "National and state policy makers should invest in a coherent, focused, and sustained set of supports for STEM teachers to help them teach in effective ways", and 3) ". . . federal agencies should support research that disentangles the effects of school practice from student selection, recognizes the importance of contextual variables, and allows for longitudinal assessments of student outcomes. . ."

It is the first of this last set of recommendations that, if implemented, is likely to have the largest impact: only by adding science to reading and mathematics for widespread assessment will science be accorded the importance and teaching time in the curriculum needed for students to achieve the STEM literacy the Committee calls for at the beginning of this report.

Alternative Pathways to a Career

"With the nation's economic recovery seemingly stuck in low gear, the need to better understand the link between learning and a career seems more critical than ever for high school students. . . . Most know . . . that the way to earn middle class pay is to acquire at least some postsecondary education. . . . What may be less clear is exactly how much education is enough and what kind of training is needed for the occupations that graduates might choose to pursue." So begins the Executive Summary to the 2011 edition of *Diplomas Count*, published by *Education Week*, **30**(34) (9 June 2011), which "explores career-related study pathways for students that lie in the space between a high school diploma and a four-year degree. . . ." (which Anthony P. Carnevale, director of the Georgetown University Center on Education and the Workforce, says has been overlooked).

Most emphasis on making high school graduates "college and career ready" has been on "college," the report admits. But while 72% of U.S. high school graduates enter college within two years of graduation, only 40% earn a BA by age 27. Moreover, a quarter of those with an AA or occupational certificate earn more than the mean earnings of holders of BAs.

Community college students presently comprise half of America's college undergraduates, and President Obama is looking to them to make the U.S. first in the percentage of college graduates. Yet, 60% of community college students, which enter with open admissions policies, need "developmental" (remedial) education, and only 22% of them get an AA in three years, while 56% of four-year college students get a BA in six years. The question then becomes how to improve the success rate at community colleges, and the *2011 Diplomas Count* report describes several encouraging programs to achieve this.

One of them is Linked Learning, founded in 2006 with Irvine Foundation money, which is overseen by Connect Ed in nine California school districts. One of these districts is Porterville, which oversees nine career pathways. While these pathways "fuel career choices" for some students, the report states that other students find the hands-on project-based approach of these pathways a more interesting way to learn. Part of the foundation funding is used to develop integrated curriculum units to be used by all teachers in the Linked Learning program.

Many community colleges partner with high schools to prepare their graduates for a career pathway at the community college and with industry to help find jobs for graduates of the community college. One such community college is the Community College of Northern Virginia (NOVA), where students in the Pathway program have a graduation rate almost twice that of the college overall. Portland (OR) Community College cooperates with area high schools to offer dual credit for college-level courses taught in the high schools, and Haas Automation showcases its equipment at Macomb Community College (Warren, MI) so that its customers can see students working with it and allow students to network with possible future employers. Secretary of Education Arne Duncan is quoted as saying, "There's an urgent need to reimagine and remake career and technical education." But the report adds that this must be done in conjunction with local business and industry so that the careers students are prepared for have jobs waiting for them.

One example for this is Henry Ford Early College in Dearborn, MI, founded to replace an aging local healthcare workforce. There students earn a high school diploma, an AA, and an allied health certificate in a five-year program now in its fourth year. Each year the freshman class is chosen by lottery. Students have access to all courses offered at Henry Ford Community College and on Wednesday have classes at the Henry Ford Health System, where their training will prepare them for a career. But their only traditional high school extracurriculars are available only at their "base" high school, and transportation and workload make participating in them difficult. Because of the workload and waning interest in a health career, only 24 of Henry Ford Early College's first freshman class made it through to the fourth year (this year). Fifty of the 72 members of the second freshman class remain.

Henry Ford Early College is one of over 200 now in the U.S., many of them formed as a result of a $107 million investment by the Bill and Melinda Gates Foundation in 2002. Another early college high school is Buncombe Early College High School at Buncombe Technical Community College (NC), which combines college classes with high school-level support to lead to a high school diploma and an AA in five years.

Playing an increasing role in alternative education pathways toward careers is for-profit institutions, according to the report. While enrollment in higher education increased 33% to 20.4 million between 2000 and 2009, enrollment at for-profit institutions rose 311% to 1.9 million, where the average annual cost is $13,935, as opposed to $7605 for in-state residents at public colleges and $2713 at a two-year college.

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Alternative Pathways

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Regardless of where students go after they graduate from high school, their success will be enhanced if they are provided effective guidance at their high schools. This requires empowering guidance counselors with the information to do this – *e.g.*, through attendance at meetings where this information is shared. The report states that some schools have further empowered their guidance counselors by freeing them from scheduling and standardized testing responsibilities. But commentary by Omari Scott Simmons states that only 21% of public high schools have dedicated college counselors, while 77% of private schools do. Further, only 45 of the 466 colleges offering graduate training for counselors have a course on college counseling. Simmons states that effective college counseling is key to achieving President Obama's goal to make the U.S. first in percentage of college graduates.

2011 Diplomas Count contains many useful statistics, among them average salary levels – for people with less than a high school diploma, a high school diploma, more than a high school diploma, and AA, a BA, and a MA or higher – in nine different fields: 1) managerial and professional office, 2) science, technology, engineering, and mathematics, 3) health-care professional and technical, 4) sales and office support, 5) blue-collar, 6) community services and arts, 7) education, 8) health-care support, and 9) food and personal services. Interestingly the average salary of $49,320 for a high-school dropout in the first of these fields exceeds the average salary of $37,307 for someone with a MA or higher in the last field. The salary for the first three years was observed to increase with increased education, but *only* if the education was in the field of the job.

A closing commentary by Mike Rose observes that the division between academic and vocational education was developed to serve students perceived to have different ability (which would be referred to today as different learning styles). Lest the intellectual content of vocational education be underestimated, Rose invokes John Dewey to note that vocational education is another way to learn the arts and sciences.

(*Editor's Note*: A piece extolling the value of the bachelor's degree, and thus a counterpoint to *2011 Diplomas Count*, appeared on page 3 of the "Sunday Review" of *The New York Times* for 26 June 2011. There, in an article titled "Even for Cashiers, College Pays Off," David Leonhardt lists the "salary bump" between mean salaries earned by holders of high school diplomas and holders of bachelor's degrees for fifteen occupations, ranging from 83% for a dishwasher to 1% for an electrician. "Why?" he asks. "Education helps people do higher-skilled work, get jobs with better paying companies. . . .," he answers. Actually, this is in agreement with the observation in *Diplomas Count 2011* that salary increases with education in the field of work. Where Leonhardt differs is in championing the value of the bachelor's degree. He quotes calculations by The Hamilton Project that the rate of return on investment in a four-year college education is 15%, compared with 7% for stocks and 1% for real estate.)

Science Outreach

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were presented at the Physics and Society Education session on 3 August 2011 by Ann G. Merchant of the National Academies and Brian Schwartz of the Graduate Center of the City University of New York. Merchant reported how National Academy of Sciences President Ralph Cicerone and Jerry and Janet Zucker launched the Science and Entertainment Exchange on 19 November 2008. She described how the Hollywood people who attended the meeting they convened were so fascinated by the science they learned that they stayed longer than expected. The Exchange now has an office in Los Angeles, so that consultations between scientists and the entertainment industry can be facilitated. Under their auspices, there are between three and five new consultations per week without charge to the entertainment industry or pay to the consultants, which are asked to present themselves as the plausibility patrol rather than the accuracy police. The goal is to portray science and scientists realistically, though the primacy of story and entertainment is acknowledged. Many of the scientist consultants have found a wider audience as a result of their consultations, Merchant added. For more information about the Science and Entertainment Exchange, visit <scienceandentertainmentexchange.org>.

Speaking about "Using the Performing Arts in Education and Communication of Science," Schwartz lamented that while *The New York Times* has eight arts sections per week, it has only one science section. Yet science gets more funding than the arts. This got Schwartz to think of ways that science and the arts could forge a partnership that would benefit both. Moreover, he reasoned, universities are ideal places to do this – they have departments of both science and performing arts. Another approach he suggested is to bring science to where the audiences are – *e.g.*, events at the CUNY Graduate Center and outreach events he has arranged at American Physical Society meetings. Schwartz concluded by recommending that science departments staff booths at farmers markets.

Bartlett shares latest views on sustainability

Physics Professor Emeritus Al Bartlett of the University of Colorado has long been lecturing us about how the key to a sustainable society is understanding the law of exponential growth. On 1 August 2011, at the American Association of Physics Teachers meeting in Omaha (NE), Bartlett provided his latest views in his talk on "Growth, Population, Resources, and the Meaning of Sustainability"

He attributed the first thinking about sustainability to The Club of Rome's 1972 study, *The Limits to Growth*, but he argued that the Brundtland Commission's definition in *Our Common Future* (1987) of "meet[ing] the needs of the present without compromising the ability of future generations to meet their own needs" focused too much on the present at the expense of the future: it should have been, Bartlett said, that our behavior "does not compromise the ability of future generations to meet their needs."

Bartlett next noted that we are facing the peak in world production of petroleum and global climate change, both of which threaten our way of life and derive from overpopulation. Moreover, Richard Heinberg has pointed out that "peak petroleum" will be followed by "peak everything" – *e.g.*, peaks in food production. Bartlett particularly noted that the threat of climate change suggests that we have exceeded Earth's carrying capacity (considered by David Pimentel to be only two billion). Since human impact on planet Earth is the product of our population times the average per capita resource consumption, to achieve a sustainable world we need to reduce both population and resource consumption, and we must do this equitably. A sustainable future will be energized by renewable resources, and the few remaining nonrenewables, he said, can be made to last forever by using them at an exponentially decreasing rate.

Bartlett observed that the American communities living most sustainably today are the Amish, except for their high fertility rate. By contrast, he characterized or cities as ecological deserts: "food and energy are hauled in and waste is hauled out." As products of science, engineering, and technology, our cities have supported population growth, Bartlett said, and the same is true for megaprojects like Desertec to transmit solar-generated electricity from the Sahara to Europe. Wondering how many programs purporting to work toward sustainability "serve mainly to advance narrower goals," Bartlett repeated his mantra that controlling population is the only way to solve problems caused by population growth.

Bartlett concluded with eleven principles for achieving sustainability:

1. Acknowledge overpopulation as our #1 problem.
2. Teach the mathematics of increase in population and resource use.
3. Educate elected officials about population issues.
4. Institute family planning on a major scale worldwide.
5. Grant women reproductive freedom.
6. Use fossil fuels at exponentially declining rates.
7. Improve efficiency of energy use.
8. Research alternative fuels that do not conflict with food production.
9. Shift agriculture from megafarms to smaller units that can run on alternative energy and animal labor.
10. Reorient STEM disciplines away from supporting population growth.
11. End war (and its waste of human and natural resources).

(*Editor's Note*: Al Bartlett's views on sustainability were first profiled by this *Newsletter* in our Fall 1995 issue.)

Hansen

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its energy plans cow-tow to lobbyists. He hopes that a judicial branch less influenced by fossil fuel money will be forced into a role of protecting our environment as a public trust.

In the Q&A after his talk, Hansen made some additional salient points:

1. The public needs to understand how science works and to recognize that our actions regarding the climate must be determined by scientific evidence rather than belief.

2. <www.realclimate.org> is a good website for teachers but not for the general public.

3. If we don't take action to reverse atmospheric carbon dioxide sufficiently, avoiding catastrophic consequences would require bioengineering.

4. Communicating to the public what they need to know about climate change is a one-minute "elevator talk." President Obama has not yet given it to the American public.

America's Oil Burden

by Art Hobson

America's oil imports burden us with enormous environmental, social, strategic, financial, and political costs. During the 2000-2009 decade, we paid $1.7 trillion, or 30 percent of that decade's trade deficit, for foreign oil. Oil imports exceeded 60 percent of total oil consumption every year since 2000. In 2008, high oil prices pushed the cost of imported oil to $350 billion. Total outlays are down today because our economy is down, but they will rise again as the economy improves, as oil rises again to $150 per barrel while gasoline rises again to $4 per gallon. Then high energy costs will again dampen our economy and the cycle will continue. There must be a better way.

The above information comes from an insightful article by Vaclav Smil titled "America's Oil Imports: A Self-Inflicted Burden," published this year in the *Annals of the Association of American Geographers*. Please find it on the Internet and read it. Smil is a Distinguished Professor in the Faculty of Environment at the University of Manitoba, Canada, and arguably the world's leading energy intellectual. He is author of 27 books about energy, environment, food, and related cultural matters. Here, I'll summarize Smil's article.

America's imports are not caused by any shortage of domestic oil production. America has always been among the world's top three oil producers. Today, we lag only slightly behind current front-runner Russia and second-place Saudi Arabia, and 70 percent ahead of fourth-place Iran. It's not a shortage of production that's driving our enormous imports, but rather our extraordinary per capita demand. For example, if we consumed oil at the French per capita rate, our imports would be not 60 percent but instead 22 percent of consumption. American gasoline and diesel fuel consumption, per capita, is nearly three times that of France.

Americans often shrug off such comparative figures by blaming our military, our climate, and our size. But our military claims less than 2 percent of our oil. Climate differences have little effect on transportation energy, where nearly all of America's oil consumption occurs. And larger distances dictate neither road vehicle efficiencies nor use of non-automobile transportation modes (walking, bicycle, bus, train), and these account for most of America's inferior performance.

According to Smil, our failure has three main components: low fuel efficiency, a virtual absence of diesel vehicles, and an "unpardonable" absence of high-speed rail. These problems developed over many decades and, because Smil's three challenges can be resolved only with major infrastructural investment, many years or decades are needed to achieve U.S. energy independence.

America's average automobile efficiency actually declined, from 15 to just 13 miles per gallon, during 1936 – when record-keeping began – until 1975. Then we began legislating fuel economy standards, and efficiencies rose to 27.5 mpg by 1985. But then the standards remained at this "inexcusably low" level, rising a little to 29 mpg by 2010, while foreign automobile fleets reached efficiencies of 35 to 45 mpg. Smil estimates that American efficiencies could easily have reached 45 mpg by 2010, saving lots of oil and dollars.

Diesel engines are inherently more efficient than the best gasoline engines. The gain is at least 20 percent. And new diesels conform to all existing emission standards for gasoline-fueled cars. Diesel vehicles account for 56 percent of the French car fleet, but only 2 percent of the U.S. fleet.

Japan pioneered the era of fast trains beginning in 1964, followed by the French in 1981. Today, France has six major lines, traveling at 155 to 190 miles per hour with a perfect safety record. But don't America's large distances make such a system impractical here? Actually, no, because nobody is talking about links between, say, Miami and Seattle, or Boston and Los Angeles. America has several urbanized regions suited for downtown-to-downtown fast rail links, including the Northeastern megalopolis (a region with three times the population density of France), Dallas/Fort Worth to Houston, and Los Angeles to San Francisco. Fast trains are more suitable in such regions than they are in France, yet the French (also the Germans, Swiss, British, Dutch, Belgians, Turks, South Koreans, Taiwanese, Russians, Italians, Japanese, Spanish, and Chinese) have them. Why don't we?

Smil concludes that "America has lost its global technical leadership, its exemplary innovative drive, and its political will to invest in transformative infrastructures." Even its existing infrastructures are falling apart: in its latest (2009) report card, the American Society of Civil Engineers awarded D to the country's aviation and D-minus to its roads.

We can do better.

(*Editor's Note*: This article was originally published in the *Northwest Arkansas Times* on 25 September 2011. It is reprinted here with permission.)

Alternative Energy thrives in Omaha

Beginning the fall of 2011, Creighton University in Omaha (NE) will offer a major in Energy Technology. In hosting the summer 2011 meeting of the American Association of Physics Teachers (AAPT), Creighton was proud to share information about this new program with physics teachers who came to the meeting from all over. As explained by Michael Cherney, Interim Director, it is an interdisciplinary program, with courses taught as Jesuits teach other Jesuits – with active involvement in experience, reflection on it, and repetition if necessary. A B.S. will be offered for those planning to enter the technical side of the alternative energy industry, and a B.A. will be offered for those interested in policy making. The goal is to have better understanding between technical and policy-making people, and graduates will be educated to work well in teams and be experienced problem solvers and effective communicators, with an emphasis on innovation.

The $1.4 million funding the project comes as the result of a collaborative effort with the Omaha Public Power District, with $1.14 million coming from U.S. Department of Energy funds which have been used to erect photovoltaic solar systems with panels from four manufacturers at various campus sites, where they can be used for teaching and learning as well as for electrical energy generation. The remainder of the funding is being used for solar and wind energy installations. Another grant of $1.2 million is funding development of the curriculum, which will be taught by Creighton in col-

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Flarend on solar heating of schools

Richard Flarend has been pursuing ways to harness alternative forms of energy and more efficient ways of doing it for a long time, and they first appeared in this *Newsletter* in our Fall 2007 issue. On 1 August 2011, at the meeting of the American Association of Physics Teachers in Omaha (NE), Flarend spoke on yet another approach, "Seasonal Thermal Energy Storage."

The physics professor from Penn State-Altoona began by observing that heating is our biggest use of energy in the northeast, ranging from $35/GJ for electric heating to zero for solar (for just the fuel costs). All sources except nuclear and renewable, he added, impact climate change. Solar photovoltaics are only 15% efficient and make sense only if the electricity they generate is net metered, Flarend went on, and he cautioned that the grid is limited in how much infusion of solar electricity it can accommodate. On the other hand, Flarend pointed out, solar thermal collectors are 70% efficient and don't involve the grid.

Because solar energy is most plentiful in the summer but not needed for heating until the winter, a large thermal mass is needed to store the heat collected in summer for its use in the winter. This thermal mass could be a borehole (as in the case of the Drake Landing, AB, system, reported in the Fall 2008 issue of this *Newsletter*), an above ground tank, an aquifer, gravel threaded with pipes, or a direct gravel-water mix. In Pennsylvania, Flarend and Tim Dolney have sought a coal strip mine in need of

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Which is more fundamental: Physics or Energy?

Physics has been long heralded as the fundamental science, at least by physics teachers, but two speakers at the meeting of the American Association of Physics Teachers in Omaha (NE) suggested that perhaps energy, as a transcendant concept underlying all of physics, is the *real* fundamental science, on which chemistry and biology depend as well. On 1 August 2011, Shawn Reeves, founder of Energy Teachers.org, in his "A Broad Look at the Energy Curriculum," hearkened back to the Carlsruhe Lectures of Hermann von Helmholtz, in which Helmholtz saw in a wide variety of interactions of matter the presence of a conserved quantity we now know as energy. Energy has become the theme of textbooks, Reeves noted, but he lamented that most don't emphasize the prominent role that energy plays in physics. And rather than be for physics majors, energy-focused courses are more likely to be for either non-majors or for people training to install alternative energy systems. "There should be a course on energy that would be rigorous enough for majors and not just traditional introductory physics with energy issues tacked on, and some majors at some colleges could take it instead of traditional physics," suggested Reeves. And "for high school, why not sometimes in some schools offer a rigorous energy course in place of traditional physics and see if those students have a different attitude about college physics?"

On 3 August 2011, Abigail Mechtenberg of the University of

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Nanotechnology Update

As early as the late 1990s, CD players had components with dimensions less than 100 nanometers (the range of size which defines nanotechnology). But future components will have 27.5 nm islands separated on centers by 60 nm forming magnetic "pillars" on a silicon dioxide substrate. All this and more was presented by Barbara Jones of IBM to the American Association of Physics Teachers at their meeting in Omaha (NE) on 1 August 2011 in her presentation, "Beyond Silicon: A Perspective on the Future of Nanotechnology."

Illustrating how the nanoworld is a world unto itself by the fact that the melting temperature of gold decreases with its thickness, Jones also noted that the shrinking of sizes had also led to the downside of excessive heat production. Yet, she noted that smaller means cheaper and faster, and possibly more efficient. One promising development in nanotechnology is that of carbon nanotube transistor, with a 1 nm unit cell. Another promising material is grapheme, but as yet there is no method to make it in large area sheets.

Yet another new development in nanotechnology is spintronics, which uses the spin of the electron instead of its charge to perform the functions of devices. It is applicable to storage class memory, used in a hard disk drive and random access memory, with a phase change acting as the basis of memory.

In closing, Jones observed that lithography is now able to create layers with features as small as 22 nm. She also said that future projects include synthesizing polymers from crops to use at nanoscale and quantum computing. Jones was followed by Jeremy Levy of the University of Pittsburgh, who described how the physics of Etch-a-Sketch inspired new nanotechnological developments.

Omaha

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laboration with Metropolitan Community College locally and developed in collaboration with the Olin College of Engineering in Needham, MA (see p. 29 of our Winter/Spring 2011 issue to read about the special features of Olin's program, which matches the nature of Creighton's program).

Creighton, Metropolitan, and the University of Nebraska all combined to show off their alternative energy programs to participants at the AAPT meeting on 30 July 2011. After Cherney spoke about the Creighton program and showed us the photovoltaic cells roofing one of Creighton's parking lots, Michael Shonka conducted us on a tour of the solar heating installation at Metropolitan's greenhouse, which collects thermal energy in a 400-gallon tank. Following that, Bing Chen and James Gevaney of the University of Nebraska showed us their passive solar powered earth contact heat exchanger to cool their building at the Allwine Prairie Solar Energy Research Test Facility in nearby Bennington, NE. This device uses solar energy to speed the outflow of air by heating it, thus causing cool ground-level air to flow in and provide passive cooling.

The last stop on the Omaha Energy Tour was the Zero Net Energy Test House at 6454 Woolworth Avenue. Priced at $350,000, this house has front and second story walls 6 inches thick, with other walls 12 inches thick. The insulation rating is R-30 in walls, with eventually R-50 in the roof. Heating and hot water is provided by geothermal means, using heat pumps. Flooring is made of reclaimed oak, bamboo, and cork. The dishwasher operates without a dry cycle, and the kitchen countertop is made from crushed bottles. Photovoltaic cells producing a maximum total of 1 kW grace the roof.

Hess addresses learning progressions

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(which can be cognitive, content-specific, or action), 2) based on big ideas, 3) move toward increased understanding, and 4) accompany well-designed/aligned assessments. They also avail themselves of schemes of cognitive development analysis, one of which is Bloom's *Taxonomy*, which Hess said was revised from its 1956 categories of nouns into categories of verbs in 2001 (remember, understand, apply, analyze, create, and evaluate). Another scheme of cognitive development analysis, which Hess likes, is that of Webb, which focuses on depth-of-understanding levels related to 1) recall and reproduction, 2) basic application, 3) strategic thinking, and 4) extended thinking. Hess has also prepared a Cognitive Rigor Matrix comparing Bloom's cognitive development categories with Webb's depth-of-knowledge levels.

Within the context of learning progressions, Hess pointed out that novices use all their working memory to decide how to use their stuff to do what they need to do next. As they progress to the state of expert, however, they develop a schema to use in solving problems. In view of this, teachers need to figure out for themselves what needs to be done under teacher direction, what needs to be done by group work, and what needs to be done by individual work.

UC Conference Targets Sustainable Energy

by Art Hobson

I recently attended a two-day conference at the University of California at Berkeley on "The Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably." I returned with renewed optimism that America can solve its energy problems, and lots of food for thought to share with the readers of my weekly column in the *Northwest Arkansas Times* of Fayetteville, AR.

Several conference talks underlined the scientific consensus that global warming is a threat that must be incorporated into any serious energy analysis. One was Elizabeth Deakin's addressing "Shifting Modes? Transportation and Urban Development Patterns in a Climate-Constrained Future."

Deakin began by describing our present travel patterns that we know all too well from our own experience. Of the local trips we make, 37% are to and from work, 20% are for shopping, 10% are social, 8% to drop off or pick up, 5% for school or child care, 4% for recreation, 4% for eating out, leaving 12% miscellaneous. Of those trips, 83.2% are made alone in a car, only 9.1% in a carpool and 5% by mass transit, with 2.3% by walking and 0.4% by biking. We each make on average between 2.6 and 3.1 trips per day, traveling between 10 and 12 miles to work, and between 5 and 7 miles to shop, with an average of an hour each day consumed by travel.

We have made our vehicles more efficient and have designed our fuels to reduce greenhouse gas emissions, but this threatens to be offset by an increased number of vehicle miles traveled, Deakin pointed out. Moreover, the building of limited-access highways has disrupted wildlife habitat, spawned suburban sprawl, and made for longer trips.

Deakin listed a series of transportation dilemmas that we face. How shall we deal with traffic congestion? Build more roads, or change our living arrangement – by living in higher density areas, in which housing is combined with shopping, so that we can travel by foot, bicycle, or mass transit, and combine several stops in the same trip (Deakin called this "trip chaining")? We also need to be watchful that carpools attract people from single cars rather than from mass transit.

In strategizing the reduction of the impact of our travel, Deakin called for shifting our travel modes to reduce travel by high-impact modes, shifting land use to shorten our trips, and to make more stops per trip or use telecommunications in order to make fewer trips, in addition to using more efficient and cleaner-burning vehicles. This can be facilitated, she said, by investing in transit, ridesharing, and bike and pedestrian facilities; reducing parking subsidies and providing commute allowances rather than parking spaces; taxing fuels and imposing tolls in congested zones at peak times, to compensate for the external costs of auto travel; and making auto costs more visible – *e.g.,* with pay-as-you-go insurance. Only with significant decline in vehicle miles traveled (or "a magic low-carbon fuel we don't have") will we see the decline in carbon dioxide emissions needed, Deakin concluded. And she cautioned that only mild incentives and limited funding will produce only a limited effect.

Deakin's talk pointed out ways we can reduce greenhouse gas emissions by changing our lifestyle so that we both change and reduce our use of energy. Former California Energy Commissioner Art Rosenfeld described how reduction in energy use had already been achieved in the way we cool things and added one more thing we can do. His talk was titled "Ten Years at the California Energy Commission and White Roofs to Cool Your City and (this is new!) the World."

Rosenfeld began by talking about the evolution of refrigerators and their energy use. Between 1947 and 2002, he said, the average volume of refrigerators increased from 10 to 22 cubic feet. Initially the average energy use by a refrigerator increased along with the volume, but after increasing from 350 kWh/yr in 1947 to 1800 kWh/yr in 1974, it fell back to 470 kWh/yr in 2002, as the result of federal and state standards. We have saved 40 one-gigawatt power plants from efficiency improvements in refrigerators alone, Rosenfeld added. In addition to reducing energy use by refrigerators by 75%, standards have also reduced energy used by air conditioning by 40%. The combined savings from refrigerator and air conditioning efficiency improvements are almost as great as the output of the Three Gorges Dam.

But if we painted all our roofs white, Rosenfeld pointed out, we could save even more energy from cooling. The reason is straightforward. White roofs reflect more sunlight, while black roofs absorb it, and this absorbed energy is later radiated and adds to the greenhouse effect which warms the Earth's atmosphere. The temperature of a white roof increases a maximum of 16^{o}C on a summer day, while the temperature of a black roof increases 50^{o}C, Rosenfeld observed. Converting 100 square meters

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(1000 square feet) of roof from gray to white offsets the emission of ten tons of carbon dioxide per year, he said. Whitening *all* the world's flat roofs would offset 1.2 gigatons of carbon dioxide per year, which Roseneld said is a thirtieth of the world's carbon dioxide emissions, the equivalent of taking half the world's 600 million cars off the road.

Rosenfeld closed by reporting that in 2005 California mandated white surfaces for low-sloped commercial roofs and that in 2010 the US Department of Energy mandated white roofs on its buildings if it is cost-effective.

Talks like those of Deakin and Rosenfeld reminded me of what I had learned from reading Bryan Lovell's excellent book *Challenged by Carbon: The Oil Industry and Climate Change*. Lovell, a geologist, academic, and industrial oil man, adds to the mountain of evidence supporting global warming. He compares the present era with the Paleocene-Eocene Thermal Maximum (PETM) 55 million years ago, when natural processes caused massive carbon releases from the pores of rocks beneath the ocean floor. This pumped greenhouse gases into the atmosphere at rates similar to those induced today by fossil fuel consumption. Since greenhouse gases trap infrared energy emitted by the Earth, this warmed Earth by eight Fahrenheit degrees, enough to severely affect life and bring on a new geological age: the Eocene. Excess greenhouse gas remained in the atmosphere for 170,000 years. For comparison, *Homo sapiens* has been on Earth for 200,000 years. Today, human greenhouse gas emissions total about one-third of the amount that caused the PETM warming, and are rising rapidly. This is direct evidence, if more were needed, that fossil fuel emissions are nearly permanently changing the face of our planet.

America is blessed with ample and relatively benign renewable energy resources, mostly solar and wind, assisted by biofuels, hydroelectricity, and geothermal. Furthermore, we have a huge and entirely benign "virtual resource" in the form of energy efficiency. Here, the bad news is that America is flagrantly wasteful: On a per-capita basis, America uses twice as much energy to create a dollar's worth of goods and services as do other industrialized nations. The good news is that this implies we could double our goods and services without increasing our actual use of energy, simply by following other nations. As I've preached frequently (see physics.uark.edu/hobson/), the easy and market-oriented way to do this is by requiring energy industries to pay for their environmental and health overhead, via fees and taxes. This would, for example, raise the price of gasoline to the $8 per gallon that other industrialized nations pay and triple the cost of fossil-fuel-generated electric power. It would also solve our oil problems, solve oil-related security problems, end our foreign oil payments, protect the environment, solve global warming without requiring cap-and-trade, level the playing field for renewables and efficiency, and bring in a good trillion dollars annually to the U.S. Treasury – money that could reduce income taxes and the national debt. But are we smart and bold enough to make such game-changing moves?

Generating Electricity from Renewables

The Berkeley Conference and similar analyses elsewhere convince me that America can switch to an energy economy based on renewables and energy efficiency while nearly phasing out not only fossil fuels but also (if we decide it's a good idea) nuclear power by around 2050. One way to do this was spelled out in an authoritative and detailed January 2008 *Scientific American* article titled "Solar Grand Plan" (reference #5 in our Winter 2008 issue).

Two talks at the conference that addressed basing American electric power generation on renewables were given by K. John Holmes and George Crabtree. Holmes's talk, "Electricity from Renewables: Status, Prospects, and Impediments, an NAS Study," was based on the National Academy of Sciences study of that title in their series on *America's Energy Future*, already described in the Winter 2010 issue of this *Newsletter*. Holmes reported that the charge to the Panel on Electricity from Renewables was to "examine the technical potential for electric power generation with alternative sources such as wind, solar photovoltaic, geothermal, solar thermal, hydroelectric, and other renewable sources," with emphasis on "quantitative characterization of technologies with deployment times less than 10 years."

Right now, Holmes pointed out, renewables provide only 10% of American electrical energy – 6-7% hydro, about 2% biomass, about 1% wind. But, he added, the least prevalent sources are increasing the most – 23%/year for wind and more than 30%/year for solar photovoltaics. Holmes reported estimates by the Pacific Northwest National Laboratory: 11 million gigawatt-hours per year for on-shore wind, and 16 billion gigawatt-hours per year for solar. Extracting 20% of this wind energy would provide the equivalent of 250 one gigawatt power plants, and extracting 10% of the solar energy would provide the

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equivalent of 182,000 one-gigawatt power plants, which is 400 times the 2008 U.S. electric power generation.

But there are "economic and deployment-related considerations to using these sources on a large scale." Holmes observed that geothermal, biomass, and hydro are unevenly distributed in space, and solar and wind are unevenly distributed in time. Moreover, except for hydro and wind and, in some cases, geothermal, renewable electric energy is more expensive, so policy incentives are required as well as improvements in technology (*e.g.*, in the manufacture of photovoltaic cells). The U.S. Department of Energy goal of 20% of electricity generation from wind by 2030 requires 100,000 turbines, $100 billion, 140,000 workers, and 50,000 square kilometers of land. The panel feels it's doable, but the scale points up the challenge. Regarded as "aggressive but achievable" is increasing the present 10% of electricity from renewable to 20% by 2020 and to 30% by 2035, with all growth being "non-hydro." Lastly, according to Holmes, generating more than half our electricity from renewables "will require storage, new scientific advances, and changes in how we generate, transmit, and use electricity." But "the promise of renewable resources is that they offer significant potential for low-carbon generation of electricity from domestic sources of energy that are much less vulnerable to fuel cost increases than are other energy sources and offer significant economic opportunities."

Crabtree's talk, "Integrating Renewable Electricity on the Grid, an APS Study" was likewise based on a study, this one by the American Physical Society. Like Holmes, Crabtree began with estimates of wind and solar energy in the U.S. In seven southwest states alone (Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah) he cited access to 6877 gigawatts, which far exceed the 1000 gigawatt peak of 2009, and his graph of wind energy available showed 8000 gigawatts available onshore, for less than 8.5 cents per kilowatt-hour. Of this wind capacity, only 5.4 gigawatts are presently installed.

Crabtree noted that several states have established goals for their renewable energy portfolios: California aims for 33% by 2020, New York for 30% by 2015. Other states, he said, have more typical goals of 20% by 2020 or 2030. Noting Holmes's citation of the need for energy storage when the generation of electricity from renewables exceeds 50%, Crabtree noted several possible storage devices: pumped storage, compressed air, sodium-sulfur batteries, molten salt (for thermal storage), flow batteries, and conventional batteries. Because wind is strongest in the Great Plains and solar strongest in the Southwest, while the greatest demand is in the East, Crabtree observed that an interstate highway system is needed for transmitting electricity. The best bet, he said, was superconducting DC transmission.

A question of will and acceptance of change

But this will require a great deal of willfulness and willingness to accept change. Such changes can get bogged down in arguments about big government, taxes, and NIMBY (not in my back yard) concerns. Here's one indication of such difficulties. In 2001, George W. Bush's spokesperson Ari Fleischer was asked, "Does the President believe that, given the amount of energy Americans consume per capita, . . .we need to correct our lifestyles to address the energy problem?" Fleischer's answer: "That's a big no. The President believes that it's an American way of life, and that it should be the goal of policy makers to protect the American way of life. The American way of life is a blessed one."

If this is so, we'll have to find a less ideal plan for getting unhooked from fossil fuels. We should do as much as is politically possible with efficiency and renewables, but we'll also need substantial input from nuclear and sequestered fossil power.

Concerning nuclear power: It's expected that four to six new US nuclear plants will come on line by 2018. As we know by recent news from Japan, nuclear power is touchy. It's prone to big accidents, waste storage problems and, worst of all, misuse for nuclear weapons proliferation. But it's enormously healthier than unsequestered fossil fuel burning. Fossil fuels are a planet-killer. Nuclear power doesn't come close to that.

Regarding safety issues, according to data from the International Organization for Economic Cooperation and Development, there are 161 deaths for each terawatt-hour of electric energy from coal, and only 0.04 deaths for each terawatt-hour from nuclear power. So coal is 4000 times more deadly, per unit of electricity.

Yes, nuclear waste is a problem but so is coal waste—the removed mountain tops, sludge ponds, and emissions including acid rain and greenhouse gases. The solution to nuclear waste is a used fuel repository such as Yucca Mountain, where all analysts say it would be safe for at least 10,000 years—longer than recorded history. Unfortunately, NIMBY politics in Nevada have killed this safe, nearly-completed, 30-year, $13-billion

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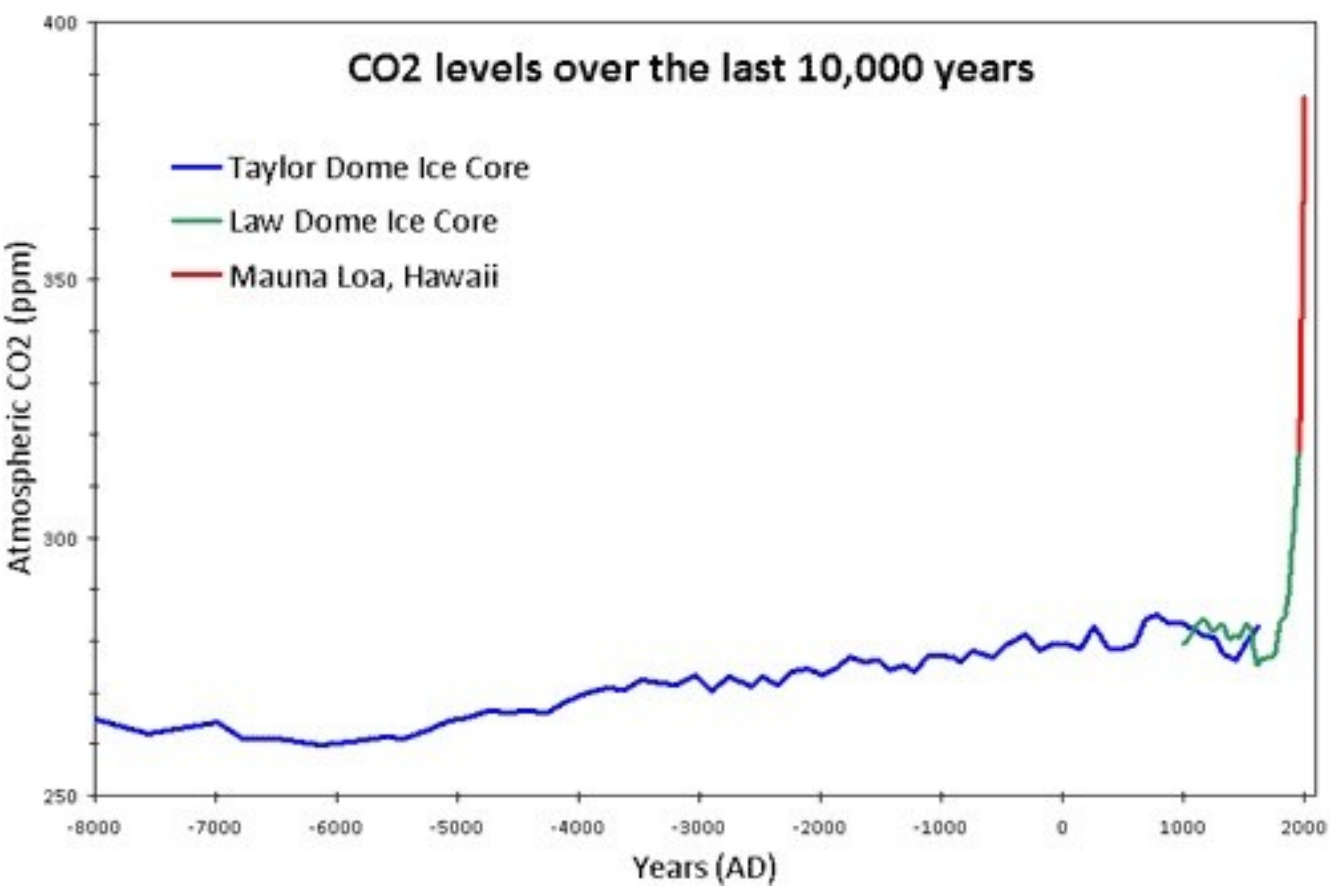
project for now. The worst way of disposing of used fuel rods is what we're doing now, namely storing them near reactors.

Nuclear power does contribute to nuclear weapons proliferation, but that damage is mostly already done. Furthermore, even a nuclear war would do less long-term damage than global warming, which could irreversibly shift the planet into a new geological era by 2100.

Concerning fossil fuels: 43 new US coal power plants might come on line by 2018, and electricity from natural gas is growing even faster. "Sequestration" refers to the capture and storage of carbon dioxide emitted by coal and natural gas power plants. Natural gas was once considered cleaner than coal and thus in no need of sequestration, but this is no longer the case. The new hydraulic shale fracturing technology to obtain natural gas, being used in Arkansas and elsewhere, turns out to emit even more greenhouse gas than does coal.

Sequestration is essential if fossil fuels continue to be used. A serious national effort could develop sequestration technology within several years. This process removes and pumps underground some 85 percent of the plant's carbon dioxide. It would increase the cost of fossil-fueled electricity by 20 to 50 percent, a reasonable price when one considers that the true price of fossil-fueled electricity is two to three times its current market price (see Paul Epstein, *et al.*, "Full cost accounting for the life cycle of coal").

As a member of the Arkansas Governor's Commission on Global Warming, I offered a proposal that all new coal plants in Arkansas be sequestered. If I had known then (2008) what I know now about natural gas, I would have included natural gas plants in this proposal. The Commission passed the proposal on a close vote, with industrial representatives solidly opposed, and this recommendation was included in the Commission's report to the Arkansas legislature. Unfortunately, the legislature has ignored the recommendation.



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The cost of "business as usual"

The ideal energy future would, by 2050, be based nearly entirely on efficiency and renewables such as solar. It's doable, and it's cheapest, but if we are unwilling to accept the change it requires, an alternative would be to get dirtier energy from nuclear power plants and fossil fuel plants that utilize carbon dioxide (CO_2) capture and storage.

But if we opt instead to continue with "business as usual," global warming will probably be sufficient to usher in a new geological age by 2100. I'll present three arguments for this conclusion, any one of which should persuade a rational person that global warming is real, caused by humans, and likely to produce massive effects.

First, a common sense argument: Even most "climate skeptics" who think global warming is a hoax agree that fossil fuels have raised the atmospheric CO_2 content by 40 percent since 1800. As you can see from the sharp spike in the graph that accompanies this article, this increase has been large, sudden, and unprecedented during the past 10,000 years. The longer geological record shows the present CO_2 level to be unprecedented during 800,000 years. And everybody agrees that CO_2 is one of the "greenhouse gases" that absorb infrared energy radiated by the Earth, further warming the planet. So why, as Nobel-prize-winning physicist Burton Richter asks in his book *Beyond Smoke and Mirrors*, wouldn't you expect the Earth's temperature to increase?

And, sure enough, the planet's temperature has increased by 1.4 Fahrenheit degrees since 1860. Ice is melting in the Arctic Ocean, in Greenland, and in mountain glaciers. Sea levels are rising, and accelerating. Just as one would expect from the additional atmospheric energy, there's been an increase in extreme weather such as we've recently experienced here: downpours, floods, tornadoes, hurricanes, heat strokes, droughts, and accompanying forest fires.

Second, an argument from the standard scientific process: Scientists are able to use well tested scientific theories together with powerful computers to predict future climate patterns and understand past patterns. When we apply these computer models to the past century, we find that the models agree with observed temperature trends and other data if human CO_2 emissions are included in the input to the models, but do not agree with observations if these human emissions are not included in the models. The scientific conclusion is that, with high probability, human CO_2 emissions are at least a partial cause of the observed temperature increase.

Third, and most ominously, an argument from geological history: Two excellent books – James Hansen's *Storms of my Grandchildren* and Bryan Lovell's *Challenged by Carbon* – have emphasized the relevance of the "Paleocene-Eocene Thermal Maximum" (PETM) to the recent warming. The PETM is a global temperature rise of 8 degrees occurring 55 million years ago that ended the Paleocene geological era and initiated the Eocene era. Studies of underwater rock layers show that the PETM was caused by 1000 billion tons of carbon released from the ocean floor into the atmosphere. This natural, but geologically unique, release was probably triggered by a slight natural warming of a portion of the ocean that in turn warmed the methane-containing ices that can form on the ocean floor. This would cause the ices to suddenly emit their methane (a greenhouse gas), which entered, and warmed, the atmosphere. This caused the release of CO_2, just as a warmed carbonated drink emits CO_2 bubbles, causing further warming, in a vicious circle.

Today we're well on the way to a repeat of the PETM event, caused this time by humans. Since 1900 AD, we have managed to inject 300 billion tons of carbon into the atmosphere. That's one-third of the way toward the level that caused the PETM. Under business as usual, we will have injected the amount that caused the PETM by 2100. But long before then, warming could melt the methane ices residing on the ocean floor, initiating the vicious circle that triggered the PETM.

The PETM raised ocean levels by 18 feet, acidified all the oceans, drastically changed animal life, and initiated a new and distinctively different geological age. Carbon dioxide levels remained significantly above normal for 170,000 years.

(*Editor's Note*: The conference on "Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably" was held at the University of California-Berkeley on 5-6 March 2011. A list of the papers presented with links to PowerPoint presentations and pdfs is available at <http://rael.berkeley.edu/apsenergy2011>. The foregoing was excerpted from PowerPoint presentations from speakers at the conference and from three articles by the author published on 3 April, 24 April, and 15 May 2011 in the *Northwest Arkansas Times* of Fayetteville, AR, and reprinted by permission.)

NRC publishes *Framework*

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but is broad enough to sustain continued investigation over years." (p. 2-6)

But a comparison between the core ideas in the draft and final versions indicates some rearrangement, with even greater changes made in the "subcore" ideas (each core idea is further subdivided into between two and five such ideas):

	draft core idea	final core idea
PS1	structure and properties of matter	matter and its interactions
PS2	interactions, stability, and change	motion and stability: forces and interactions
PS3	energy and its transformations	energy
PS4	waves as carriers of energy and information	waves and their applications in technologies for information transfer
LS1	from molecules to organisms – structure and process	from molecules to organisms: structures and processes
LS2	heredity – inheritance and variation of traits	ecosystems: interactions, energy, and dynamics
LS3	ecosystems: interactions, energy, and dynamics	heredity: inheritance and variation of traits
LS4	biological evolution: unity and diversity	biological evolution: unity and diversity
ESS1	the solar system, galaxy, and universe	Earth's place in the universe
ESS2	Earth's planet-sized structures, processes and history	Earth's systems
ESS3	Earth's surface process and changes	Earth and human activity
ESS4	human interactions with Earth	
ET(S)1	the designed world	engineering design
ET(S)2	engineering design	links among engineering, technology, science, and society
ET(S)3	technological systems	
ET(S)4	technology and society	

The principles underlying the three dimensions of the framework are the same as those stated in the draft as well: 1) "young children's capacity to learn science," 2) "a focus on core ideas," 3) "the development of true understanding over time," 4) "the consideration of both knowledge and practice," 5) "the linkage of science education to students' interests and experiences," and 6) "the promotion of equity."

After setting up the three dimensions in its first two chapters, chapter 3 of the *Framework* describes each of the eight practices, along with a goal for grade 12 for each practice, and how progression can be made toward the goal. Likewise, each of the seven cross-cutting elements is described in chapter 4, along with a statement of how progression can be made to experience it. Chapters 5 through 8 describe in detail each of the core ideas for physical science, life science, earth and space science, and engineering, technology, and the applications of science, respectively, with an illustrative question, followed by an explanatory paragraph and a separate listing of subcore ideas, with grade band endpoints at grades 2, 5, 8, and 12 for each one.

As was stated in the draft version of the *Framework*, it is the integration of its three dimensions that is to form the basis of science education standards and, in turn, curricula and assessments, as is illustrated by the following sentence in chapter 9: "Students actively engage in scientific and engineering practices in order to deepen their understanding of crosscutting concepts and disciplinary core ideas." (p. 9-1) It is acknowledged there that "integrating the three dimensions in a coherent way is

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Columbia Earth Institute: Solutions for Sustainable Development

by Michael J. Passow
Earth Sciences Correspondent

About thirty years ago when the Teachers Clearinghouse was established, “science, technology, and society” was more of a phrase or a high school elective than an entity which could have major impacts on our planet’s future. But since then, the Columbia Earth Institute (CEI) has become a world leader in the study of key problems facing our planet and development of solutions for sustainable development. The Earth Institute seeks to help the world pave a practical path toward sustainability through interdisciplinary approaches to problems in public health, poverty, energy, ecosystems, climate, natural hazards, and urbanization that blend scientific research, education, and practical solutions.

The CEI focus is on the protection of Earth's environment and the spread of social and economic opportunities for all people. CEI comprises more than 30 research centers and some 850 scientists, postdoctoral fellows, staff and students. Their experience has led to dealing with issues such as extreme poverty through tackling issues such as environmental degradation, lack of access to health care, and education. The efforts reflect the fundamental belief that the world possesses the tools needed to effectively mitigate climate change, poverty, and other critical issues.

The CEI website, <www.earth.columbia.edu>, provides a myriad of resources about their programs and projects which could be used to create Science and Society curricula. The Earth Institute focuses on nine fundamental research themes.

Research in Climate and Society investigates humankind’s role as both driver of and responder to global climate. Water-based research addresses the potentially global crisis of freshwater scarcity. Research projects that address energy focus on major energy sustainability objectives — such as the development of energy resources without increased carbon emissions and the recovery of renewable energy from solid wastes. Research in urbanization looks at how growing urban populations threaten the sustainability of cities and natural resources. Hazards and risk research at the Earth Institute aims to deepen the world’s understanding of a range of hazards and risks, from drought to earthquakes to landslides, which often become particularly threatening in highly populated areas.

Global health research addresses both the environmental factors that affect human health, the ways in which a population’s poor health in turn inhibits environmental sustainability, and the methods of delivery of health systems. Poverty-related Earth Institute projects aim to reveal and work toward the mitigation of root causes of extreme poverty while research on food, ecology and nutrition works to ensure the sustainability of regional factors of human health, such as agriculture, clean water access, and nutrition. The Earth Institute’s research theme of Ecosystems Health and Monitoring aims at stemming the loss of biological diversity in order to achieve environmental sustainability.

Director of the Earth Institute is Dr. Jeffrey Sachs. Serving as Quetelet Professor of Sustainable Development, and Professor of Health Policy and Management at Columbia University, he is also Special Advisor to United Nations Secretary-General Ban Ki-moon. From 2002 to 2006, he was Director of the UN Millennium Project and Special Advisor to United Nations Secretary-General Kofi Annan on the Millennium Development Goals, the internationally-agreed goals to reduce extreme poverty, disease, and hunger by the year 2015.

Dr. Sachs is one of the leading international economic advisors of his generation. For more than 20 years Professor Sachs has been in the forefront of the challenges of economic development, poverty alleviation, and enlightened globalization, promoting policies to help all parts of the world to benefit from expanding economic opportunities and wellbeing. He is also one of the leading voices for combining economic development with environmental sustainability, and as Director of the Earth Institute leads large-scale efforts to promote the mitigation of human-induced climate change.

Earth Institute experts work hand-in-hand with academia, corporations, government agencies, nonprofits and individuals. CEI conferences at Columbia and around the world and hands-on projects in many nations to train local experts are part of the efforts to educate the next generation of leaders in basic sciences and sustainable development.

Education at the Earth Institute, Columbia University, covers an array of opportunities, from undergraduate to graduate options of study and student programs. The

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Columbia Earth Institute

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Earth Institute coordinates over 24 academic areas to provide one of the largest collections of environmentally-oriented education degree and certification programs in the world. Among these at the undergraduate levels are B.A. and B.S. degrees in the Earth and Environmental Sciences, Engineering, and Policy, along with summer ecosystem experiences. At the graduate level, programs include M.A., M.S., and M.P.H. degrees ranging from Conservation Biology, Sustainability Management, and Climate and Society to Environmental Health Sciences, Environmental Science and Policy, and Earth Resources Engineering. Ph.D. programs focus on Sustainable Development, Earth and Environmental Sciences, Earth and Environmental Engineering, Atmospheric and Planetary Sciences, Environmental Health Sciences, Ecology and Evolutionary Biology, and Evolutionary Primatology. Certificate programs are offered in Conservation Biology, Environmental Policy, and Conservation and Environmental Sustainability.

The largest unit of the CEI is the Lamont-Doherty Earth Observatory <www.ldeo.columbia.edu>. LDEO has long been a world leader in geoscience research and is home to some of the seminal thinkers in Earth System Science, such as Dr. Wallace Broecker of the "global ocean conveyor belt" theory and much more and Dr. Taro Takahashi, foremost investigator of carbon dioxide in the oceans. Nearly a hundred graduate students work with the more than 600 scientists and staff members to continue Lamont's tradition of cutting-edge investigations.

The LDEO campus is opened to the general public one day each year for the annual Open House. This year, it will be on Saturday, Oct 1 <http://www.ldeo.columbia.edu/news-events/events/open-house>. Lamont also sponsors the Earth2Class Workshops for Teachers <www.earth2class.org>, which your correspondent has organized since 1998. The 114 Saturday sessions offered through May 2011 have enabled more than 200 K-12 teachers and students to learn directly from more than 70 Lamont scientists about how scientific research really occurs and discoveries that may not get into textbooks for many years.

Colocated on the Lamont campus in Palisades, NY, is the Center for Earth Science Information Network <www.ciesin.org>. CIESIN works at the intersection of the social, natural, and information sciences, and specializes in online data and information management, spatial data integration and training, and interdisciplinary research related to human interactions in the environment. Many governmental and non-governmental agencies rely upon CIESIN for reliable data on which to develop national and international policies.

CIESIN scientists cooperating with the Institute for the Application of Geospatial Technology in Auburn, NY, are creating new educational resources focused on global climate change and human health issues <http://www.climatechangehumanhealth.org/>. Visualizations utilizing the technology supporting the NASA World Wind will combine with lesson plans designed for middle and high school students. Roll-out of the "Change Viewer" will take place this fall, during the LDEO Open House.

On Columbia's Morningside campus, the Center for Environmental Research and Conservation <http://www.cerc.columbia.edu/> provides training in biological diversity to cultivate leadership necessary for addressing ecological challenges of the 21st century. CERC is a consortium of five world renowned scientific institutions based in New York City: Columbia University, the American Museum of Natural History, the New York Botanical Garden, the Wildlife Conservation Society and EcoHealth Alliance (formerly known as Wildlife Trust).

Given the key role of ecology in sustainable development, CERC is also committed to educating the younger generation, the ones who will have to carry forward the work toward a sustainable future – climate change adaptation, conservation of biodiversity, water, renewable energy, to name a few. Thus, CERC has designed various K-12 programs, with a focus on middle school teachers and students. This is a key age to truly make a difference in the lives of youth and in developing future environmental leadership.

Middle school teachers are central to CERC's K-12 Education, forming an important bridge to the next generation. CERC has embarked on a strategy of "multiplier effect" by training science, math, and literacy teachers in the New York City public schools. These teachers will literally touch the lives of thousands of middle schoolers, and hopefully inspire many to continue science and society studies in high school and higher education. CERC's efforts are directly primarily through three programs:

The Inquire Institute. Formerly the Teacher Training Institute, CERC's Inquire Institute trains K-12 teachers who are central to many of CERC's programs as they provide an important bridge to the youngest generation and a key multiplier effect. The Inquire Institute's training provides teachers a strong foundation in ecology and

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A Successful Outcome

by Bernice Hauser

"Of all the tyrannies which have usurped power over humanity, few have been able to enslave the mind and body as imperiously as drug addiction." - F. Adler

At a recent conference focused on the technology uses/abuses that our young students may or may not be engaged in, I was struck by the comment that one of our "more senior" educators made: "I think I may be one of the oldest individuals in this room at this conference . . . I am an 'immigrant' to this new technology . . . but our students are experts . . . they are more and more conversant and caught up in the newest technology, in the newest gadgets. . . ."

This comment set me thinking and musing on where I fit in. In my classroom I utilize many aspects of the new technology at hand, but I am certain — quite certain — that my students, albeit seventh grade students, are more technologically adept, familiar with and using the latest tools, the latest technology, and the latest gadgets in their school assignments, in their general life style as well as in their social media networks.

So what does this introduction have to do with an article on my facilitating a Middle Division interactive project on the subject of substance abuse/addicting drugs with my seventh grade students? Lots. It propelled me to reflect deeply on how I could tap into my students' technological prowess in order to make them the teacher, the creator, the researcher, the artist, the formatter, the production editor, the expert on the topic of abused drugs such as heroin, alcohol, marijuana, cocaine, and over-the-counter drugs in a process that called for class time in the library, in the computer room, and in the classroom that would allow formed groups to collaboratively make presentations on a designated topic. I would take on the role of coach/mentor/advisor. (Ordinarily the topic of smoking would be included in the above listing, but at Horace Mann, the Upper Division Health Educator/ Upper Division Health Peer Mentors take over the classroom for a presentation that is geared for this age group.)

This reflective exercise was a way of my redesigning/reinventing the course – no initial viewing of commercial videos on drugs, or on the topic of substance abuse or addiction – no initial distribution of handouts — these could be used, if necessary, at a later time to shore up the subject. The underlying premise was to provide total support for the students to become the instructors. With the aid of rubrics to assist them, their presentations would utilize the innate creativity, skills, and expertise that each possess individually to collectively work on a product that is fresh, instructive, and challenging to the learner. Thus, we'd permit the student to engage his/her style of learning, his/her particular intelligence, and his/her specific creativity to enrich the finished product. The use of technology enhances and enlarges the learning that evolves.

It is always challenging to have students work collaboratively in groups or in pairs. Often, but not always, the research states it is one person in the group who does most of the work. But collaborative learning is a style/strategy that I am comfortable with and, I believe, will be utilized increasingly in educational circles. So in spite of all the myths and misconceptions, collaborative groups, for me, were the way to go. All the literature points to the success of new products coming from teams who believe in their product, contribute their unique talents, and are not distracted from their vision or the task at hand. Knowing my students as specific individuals, I did permit this particular class to form its own groups. (I never assume, though, that students can best form their own collaborative groups — you must know your students well to have them do this exercise on their own. This course runs one trimester; time must be used wisely.)

More and more classrooms are fusing online learning with the traditional classroom set-up. Luckily for me and due to my teaching schedule, I was able to obtain the computer room for about three or four independent study class sessions as well as set up time in the Library Teaching Classroom for one session on this assigned project. So basically, three to five sessions were set aside from my face time with the students for the groups to work together and formulate what materials they would use, how they would present the material, and what format they would utilize. This schedule did not preclude the possibility that the students would have to work on their designated project outside of the normal class period.

The following guidelines were given for oral presentations:

- Everyone in the group has to present.
- It can be a combination of media.
- It can be a PowerPoint presentation, a wiki presentation, a DVD, *etc.*
- Handouts are always welcome.

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Outcome

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It was suggested that the following questions be answered in the report for each of the drugs:

What is this material?
Where is it found?
Is it legal or illegal?
What is the history of its regulation in the United States?
How does it become available?
What are its chemical ingredients?
What effect does it have on the brain, the emotions, and the body?
What is its cost to society?
What are the street names for this substance?
Who uses this substance?
How old is this substance — is it synthetic?
What are the economic and psychological costs to society?
How does the drug enter the body: skin-popping, intramuscular injection, mainlining, sniffing, orally?
Is it a depressant, stimulant, hallucinogen, narcotic, or inhalant?
Why do people abuse the drug?
Is the abuser of this drug typically an experimenter, regular user, preoccupied user, or addict?
What are reasons NOT to use this drug?
Who legally can use this substance?
What are the legal consequences of using this drug – for a dealer, seller, user, possessor, or holder of a fake ID ?
Can possession of this substance lead to a prison term?
What kind of treatment is effective for abusers of this drug?

The following questions should be answered by the group reporting on alcohol:

What is the poison in alcohol?
What does "proof" mean?
What is the path of alcohol when it enters the body?
What is the effect of alcohol on the brain — in different stages?
What are the stages of alcohol use?
What is the AA organization?
What resources/organizations do families of alcoholics have?
What number of accidents, suicides, is attributed to drunkenness?
What is binge drinking?
What happens in the last stages of alcoholism?
What is the legal age to drink in NYC? What about the rest of the United States?
What was the Prohibition Era?
How much alcohol is in a glass of wine, a bottle of beer, a shot of whisky?
What does blood alcohol concentration measure?
How do the police measure or label a person a "drunk driver?"
Why do people drink?
How do the media contribute to alcohol consumption – ads, TV shows, movies, sporting events, personalities in the media?
What is Fetal Alcohol Syndrome?
What are the legal consequences of alcohol use?
What are some beverages that contain alcohol?
How is alcohol made?
What is cirrhosis of the liver?
What warning labels are required by law to be on alcohol containers and posted near bars and places that serve liquor?
Are there differences between female addicted drinkers and male addicted drinkers?
Is alcohol a new or old beverage? Do you know of ancient civilizations that used alcohol in rituals and whose citizens drank alcoholic beverages?

References had to include at least one hardbound book and one online website from approved recognized sources. (My students submitted this data to me beforehand. But when I assign this type of project again, I would have them add this information to their actual website project presentation and/or any other type of presentation.)

Please keep in mind that these students are seventh graders. They are on the cusps of entering adolescence and their judgment and decision-making skills are just emerging and developing, albeit with some individual variations. Expert clinicians share with us the reasons young adults engage in risky behavior with drugs and alcohol: some students may be risk takers, some may be experimenters, others might succumb to peer pressures. Many young people may do it in desperation to be accepted by a particular group, many feel they are invulnerable and "won't get hooked," while others have grown up in that culture and accept that way of life as normal. Boredom, curiosity, availability, conformity, rebellion, escape, fun are all part of the equation. This article is not a treatise on why young people become addicts – the reasons are manifold, varied, and complex and cannot be explained simplistically. This project was aimed to bring the most up-to-date accurate information to my students in the most direct, truthful fashion, giving them an opportunity to dialogue with each other, question each other, make comments, make inquiries, and discuss freely and

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Outcome

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openly the information that they have received from individual presentations.

To enlarge the scope of this topic, I have often invited an individual from the Alcoholics Anonymous (AA) organization to make a presentation. I have also had the community relations department of the local police precinct make a presentation — what constitutes a misdemeanor, what constitutes a felony, the incarceration rate, the permanent record on file, the prison sentences — as well as how to navigate your way around the city, how to notify the police or where to turn for help away from the safety of your home, underage drinking, using a fake ID, possession of drugs and alcohol, drunk driving abuses, purchasing drugs, tobacco, or alcohol.

When possible, I have also obtained the services of an emergency room physician who discusses a person who come into the ER in an alcoholic coma or diseases common to addicts. Sometime I ask the school coaches to visit and discuss the controversial issues surrounding anabolic steroids. (A Values and Ethics component is an important part of this seventh grade Life Skills curriculum – we may discuss these issues from an ethical perspective including the pros and cons of this use/abuse and the implications of alcohol being a legal product sold over the counter.)

My students then spend quality time practicing what I call "communication refusal skills"—what you can say when someone offers you a substance that you *wish not to take*. Samples from my students' role-play presentations follow. (Many of them argued that telling a lie in this situation was acceptable.)

- No thank you, I am trying out for the track team tomorrow.
- I tried it and I don't like it.
- I am on a sports team, got a game tomorrow.
- No way.
- I signed the honor code.
- I don't want to be penalized.
- Are you nuts — this stuff is illegal.
- I don't want my brain messed up.
- Sorry, I have terrible allergies.
- This isn't my thing.
- Don't want my school record messed up.
- I am not into drugs.
- Hey — you might want to go to prison, but I don't.
- Peddle it somewhere else.
- Not interested.
- I am not risking getting expelled.
- I don't lie to my parents.
- No.
- Oh sorry, I just ate.
- No — I am the designated driver.
- I throw up when I take this stuff.
- I need to be in tiptop shape tomorrow for my exam.
- No, I am trying out for a part in the school play and need to know my lines.

All the components in seventh grade Life Skills are interconnected; that certainly is true for the seventh grade decision-making unit that ties in seamlessly with this drug abuse unit. We want the students to develop good discussion skills. This includes the ability to explain their decisions clearly and the more difficult skill to become active and effective listeners. This undertaking not only highlights the need to provide factual information and opportunities for discussion but also provides the opportunity for the students to practice and utilize the skills for informed decision making.

When possible, we did distribute handouts that were most current and relevant to the subject. I certainly suggest getting reprints of Douglas Quendqua's article, "Rethinking Addiction's Roots, and Its Treatment," published in the 10 July 2011 issue of *The New York Times*.

We do give letter grades in this course. There are no exams or quizzes but there are two required projects in addition to some homework assignments. However, I did ask each of my students to write a paragraph in which they shared some new concept, fact, or knowledge gained after viewing their peers' presentations. I also commented that any written reflections about the entire project would be most helpful and any suggestions that they offered would be seriously considered. Some students made DVD copies of their presentations for me to retain as resources for this class.

There are many commercial programs and resources available on substance abuse. A partial sample follows.

General Websites
www.teens.drugabuse.gov
www.thecoolspot.gov
www.freevibe.com
www.drugfree.org

PBS Video
1320 Braddock Place
Alexandra, VA 22314-1698
(800-344-3337)

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Columbia Earth Institute

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conservation to conduct their own scientific inquiry in the field and develop an integrated ecology-based curriculum unit. For educators seeking certification in science, the courses meet the New York (NY) State Department of Education's requirements.

Integrated Project Week (IPW). IPW is a designated week of the school year where groups of students are assigned to an IPW course to explore a topic or theme in depth, in a project-based format. IPW weeks have included combinations of classroom work, field trips, guest speakers and workshops that culminate in a showcase event. Teachers from many disciplines in a school have used this approach to create meaning and context for their students.

Middle School Partnership (MSP). Through MSP, CERC works with NYC Title I middle schools, training teachers to develop hands-on, inquiry-based, ecology-driven curriculum units with an accompanying teacher resource plan and assessment rubric to promote student-centered teaching and learning. Project-based learning is used for more effective student-centered learning to enhance acquisition of skills in science, math, literacy, analysis and cognition, while fostering creative interdisciplinary thinking, problem solving, and team work.

Outcome

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National Clearinghouse for Alcohol & Drug Information
11426 Rockville Pike
Rockville MD 20852
Phone: 301-770-5800 or 1-800-729-6686
Fax; 301-468-7394
E-mail info@health.org
Website; www.health.org/about/index.htm

Alcohol
Alcoholics Anonymous (AA)
http://alcoholics-anonymous.org

Facts on Tap: Alcohol & College Life
http://www.factsontap.org

National Institute on Alcohol Abuse & Alcoholism
http://www.niaaa.nih.gov

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NRC publishes *Framework*

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challenging" and that "there is no single approach that defines how to integrate the three dimensions into standards, curriculum, instruction and assessment." Chapter 9 provides two examples of integrating the three dimensions to produce performance expectations for standards – LS1C and PS1A, the same two core ideas that were treated similarly in the framework's draft. More guidance for standards developers is provided in chapter 12, in the form of 13 specific recommendations.

The remaining chapters in the *Framework* consider additional aspects of its implementation. Chapter 10 considers the components of the educational system – curriculum, instruction, teacher development, and assessment – and closes with a box showing how the *Framework* implements the four strands from *Taking Science to School*. Chapter 11 considers implementing the *Framework* with educational equity in view of the diversity of our students. And chapter 13 provides a R&D agenda "to provide evidence-based guidance for future revisions to K-12 science education standards, which we expect will occur within the next 10-15 years." (p. 13-1)

Meanwhile, the challenge of developing the first science education standards from the *Framework* falls to Achieve, Inc., a non-partisan non-profit education organization that developed the Common Core State Standards in mathematics and language arts. As reported in our Winter/Spring 2011 issue, Stephen Pruitt, Vice President, Content, Research and Development, of Achieve, spoke to the American Association of Physics Teachers at their winter 2011 meeting in Jacksonville, FL, about how they are going about doing this.

A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas can be ordered from the National Academies Press or read from their website. The pages cited for quotations in this report are from the prepublication copy downloaded on 21 July 2011 from <http://www.nap.edu/catalog.php?record_id=13165>.

Energy

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Michigan described how she had fashioned a physics curriculum based on mechanical, gravitational, wave, electrical and magnetic, light, thermal, and nuclear energies – in both the U.S. and Uganda. In Uganda, she is also applying the conversion of mechanical to electrical energy to establishing a microgrid.

NSTA issues position statement on 21st Century Skills

The Board of Directors of the National Science Teachers Association adopted the following position statement on Quality Science Education and 21st Century Skills in June 2011:

Introduction

Rapid changes in the world — including technological advancement, scientific innovation, increased globalization, shifting workforce demands, and pressures of economic competitiveness — are redefining the broad skill sets that students need to be adequately prepared to participate in and contribute to today's society. NSTA acknowledges the need for and importance of 21st-century skills within the context of science education and advocates for the science education community to support 21st-century skills consistent with best practices across a preK–16 science education system.

National organizations, including the Partnership for 21st Century Skills (P21) and the National Research Council (NRC), have sought to identify and define 21st-century skills, explore their integration within the education system, and address the intersection of 21st-century skills and the teaching of core disciplines. For the purposes of this statement, NSTA references and supports definitions of 21st-century skills provided by both P21 and NRC, which have different emphases but collectively encompass core subject knowledge; learning and innovation skills; information, media, and technology skills; life and career skills; adaptability; complex communication/ social skills; nonroutine problem solving; self-management/self-development; and systems thinking.

One could argue that 21st-century skills have always been important. There is now a need, however, for these skills to be possessed by the majority of the population. As a result, these skills should receive priority in today's education system. The growing base of human knowledge — and the need to understand and use modern tools for communicating and sharing what is learned — further increases the imperativeness for these skills.

NSTA recognizes the inherent and strong connection of many 21st-century skills with science education. Consider, for example, the goals of each: Science education reform focuses on fostering deep content knowledge through active intellectual engagement and emulating disciplinary practices and thinking, and 21st-century skills focus on developing broadly applicable capacities, habits of mind, and preparing knowledge workers for a new economy. Exemplary science education can offer a rich context for developing many 21st-century skills, such as critical thinking, problem solving, and information literacy especially when instruction addresses the nature of science and promotes use of science practices. These skills not only contribute to the development of a well-prepared workforce of the future but also give individuals life skills that help them succeed. Through quality science education, we can support and advance relevant 21st-century skills, while enhancing science practice through infusion of these skills. It is essential, however, that quality science education is not diminished in support of 21st-century skills.

The following declarations are in concert with other position statements published by NSTA that outline goals for quality science education.

Declarations

NSTA recommends that the science education community support 21st-century skills consistent with best practices across a science education system, including curriculum, pedagogy, science teacher preparation, and teacher professional development (NRC 1996). It further proposes that quality science education and 21st-century skills support each other when

- science leaders cultivate 21st-century skills that best align to good science teaching;
- science instruction aligns with the *National Science Education Standards*, *Benchmarks for Science Literacy*, *Science Framework for the 2011 National Assessment of Educational Progress*, and *Science College Board Standards for College Success*;
- students meet the standards for scientific inquiry and technological design;
- students have a complete, accurate, and working understanding of the nature of science;
- ongoing professional development opportunities and effective preservice and induction programs for science educators support the integration of 21st-century skills in classroom teaching;
- quality inquiry-based curricula and support materials promote science learning and 21st-century skills;
- assessments are aligned with 21st-century curriculum and instruction, and appropriately measure students' progress toward skills acquisition in addition to mastery of core content;
- a wide range of technologies serve as tools to engage students with real-world problem solving, conceptual development, and critical thinking;

SCIENCE & SOCIETY EDUCATION MEETINGS

1 Oct 11, Open House at Lamont Doherty Observatory, Columbia University. For more information, visit <http://www.ldeo.columbia.edu/news-events/events/open-house>.

4 Oct 11, "Driving Energy Efficiency as the 'Next Big Thing,'" presented by The Alliance to Save Energy, 8:30 a.m. – 1:30 p.m., Dirksen Senate Office Building, Room G-50, Washington, DC. Confirmed speakers include Martha Johnson, General Services Administrator; Jackalyne Pfannenstiel, Assistant Secretary of the Navy; Kateri Callahan, President, Alliance to Save Energy; Dr. Kathryn Clay, Executive Director, Drive Natural Gas; Jeffrey Eckel, President & CEO, Hannon Armstrong; David Flitman, Senior Executive Vice President & President, Water and Process Services, Nalco Company; Monica Frassoni, President, European Alliance to Save Energy; Alfred Griffin, Director, Citigroup Global Markets; Bryan Jacob, Director of Energy Management & Climate Protection, The Coca-Cola Company; Joshua Johnson, Republican Professional Staff Member, Senate Committee on Energy and Natural Resources; Honorable Franz Untersteller, Minister of the Environment, Climate Protection and Energy Sector, State of Baden-Württemberg, Federal Republic of Germany; Laura Van Wie, Vice President, International Programs, Alliance to Save Energy; Daniel Yergin, Founder & Chairman, IHS Cambridge Energy Research Associates. Contact <info@ase.org>.

20-22 Oct 11, Second China International Nuclear Symposium, Hong Kong. Visit <http://www.wna-symposium.org/china/index.html>.

28 Oct 11, Center for Sustainable Energy's Seventh Annual Alternative Vehicle Technology Conference and Expo, Lehman College, City University of New York. Call Yolanda Rodriguez or Reuben Rodriguez at (718)-289-5332.

28 Nov – 2 Dec 11, Materials Research Society Fall Meeting, Boston, MA. Visit <www.mrs.org/fall2011>.

6-8 Mar 12, Building Energy 12, organized by the Northeast Sustainable Energy Association, at the Seaport World Trade Center, Boston, MA. It brings together architects, engineers, builders, designers, policymakers, educators, developers and building managers for three days of networking, accredited educational sessions and a high-level trade show. Visit <http://www.nesea.org/be12/>. Proposals may be submitted until 6 June 2011 to

21st Century Skills

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- instruction includes a variety of opportunities for students to investigate and build scientific explanations, such as laboratory experiences; and
- science leaders build on the opportunities that already exist in school programs and teaching practices to support 21st-century skills.

(*Editor's Note*: The "21st Century Skills Framework" has been described on page 37 of our Winter/Spring 2009 issue. For a pdf of this issue, contact <JLRoeder@aol.com>.)

Outcome

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Mothers Against Drunk Driving (MADD)
http://www.madd.org
Students Against Destructive Decisions (SADD)
http://www.saddonline.com

Project Alert
Best Foundation
725 South Figueroa
Suite 1615
Los Angeles, CA 90017-5416
Phone: 1-800-ALERT-10

Gateway Drugs Action Pack
Human Relations Media
41 Kensico Drive
Mt. Kisco, NY 10549
ISBN 1-55548-404-2

Foundation for a Drug-Free World
16226 N. Wilcox Ave. #1297
Los Angeles, CA 90028
USA
Phone: 1-888-668-6378
www.drugfreeworld.org

Health Curriculum Activities Library, The Center for Applied Research in Education
Patricia Rizzo Turner, *Substance Abuse Prevention Activities* (Prentice Hall Career & Personal Development Special Sales, 2540 Frisch Court, Paramus, New Jersey 07652, 1993)

Mary Biddle, conference director, at <mbiddle@nesea.org>.

27-29 Mar 12, EEGlobal, the 2012 Energy Efficiency Global Forum, The Peabody Resort, Orlando, FL. Contact Alliance to Save Energy, (202)-857-0666, <info@ase.org>.

News from Triangle Coalition

Report Calls on Policymakers to Raise Science Education to Same Level of Importance as Math and Reading

State, national, and local policymakers should elevate science education in grades K-12 to the same level of importance as reading and mathematics, says a new report from the National Research Council. "Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics" recommends ways that leaders at all levels can improve K-12 education in science, technology, engineering, and mathematics. The report responds to a request from Rep. Frank Wolf (R-VA) for the National Science Foundation – which sponsored the Research Council report – to identify highly successful K-12 schools and programs in STEM fields. "A growing number of jobs – not just those in professional science – require knowledge of STEM fields," said Adam Gamoran, chair of the committee that wrote the report and professor of sociology and educational policy studies at the University of Wisconsin, Madison. "The goal isn't only to have a capable and competitive work force. We need to help all students become scientifically literate because citizens are increasingly facing decisions related to science and technology – whether it's understanding a medical diagnosis or weighing competing claims about the environment."

The report identifies key elements of high-quality STEM education to which policymakers could target improvements:

- A coherent set of standards and curriculum. States and districts should have rigorous K-12 STEM standards and curricula that are focused on the most important topics in each discipline and presented as a sequence of content and practices that build knowledge over time.

- Teachers with high capacity to teach in their discipline. Good teachers need to know both STEM content and how to teach it; many teachers are currently underprepared to teach STEM-related courses.

- A supportive system of assessment and accountability. Current assessments limit educators' ability to teach in ways that promote learning the content and understanding the practices of science and mathematics.

- Adequate instructional time. The average amount of time spent on science instruction in elementary classrooms has decreased in recent years even as the time on mathematics instruction has increased.

- Equal access to high-quality STEM learning opportunities. States and districts should strive to eliminate the disparities in access to high-quality STEM education between advantaged students and minority and low-income students, which contribute to the existing achievement gaps.

- School conditions and cultures that support learning. Although teacher qualifications certainly matter, so do school conditions and culture -- such as school and district leadership and parent and community involvement.

"Successful K-12 STEM Education: Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics" is available online at <http://www.nap.edu/catalog.php?record_id=13158>.

(*Editor's Note*: For more details about this report, see separate story on page 9, this issue.)

STEM Teachers Thrive in Professional Learning Communities

With the support of the National Science Foundation and in collaboration with WestEd, the National Commission on Teaching and America's Future (NCTAF) has released "STEM Teachers in Professional Learning Communities: From Good Teachers to Great Teaching." NCTAF and WestEd conducted a two-year analysis of research studies that document what happens when science, technology, engineering, and math teachers work together in professional learning communities to improve teaching and increase student achievement. This report summarizes that work and provides examples of projects building on that model.

According to the report, participating in learning teams can successfully engage STEM teachers in discussions about the mathematics and science that they teach. This seemingly basic finding is more important than it may appear. While it is considered a professional trait to continuously seek more knowledge, in reality it can actually be threatening for professionals even to acknowledge that there is something more that they should know or understand better. Teachers operating in traditional artisan isolation are often hesitant to discuss the content that they teach. The report concludes that improving teaching quality is the single most important investment we can make to prepare today's students for college and career success. But this need comes as states and school districts are struggling with dire reductions in funding. In the face of this fiscal reality, we need innovative ways to organize STEM teachers for better learning outcomes with a more

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cost effective deployment of existing resources. The report says that we can achieve this objective by enabling STEM teachers to team up for more effective teaching and learning. The report is available at <http://www.nctaf.org/documents/NCTAFreportStemTeachersinPLCsFromGoodTeacherstoGreatTeaching.pdf>.

(*Editor's Note*: The preceding two items were excerpted from the Triangle Coalition Electronic Bulletin for 30 June 2011, reprinted with permission.)

Nation's First Comprehensive Elementary Engineering Curriculum Now Complete

Triangle Coalition member, the National Center for Technological Literacy at Museum of Science, Boston, has completed the first edition of its Engineering is Elementary (EiE) curriculum. The nation's largest elementary engineering curriculum, EiE is the first to focus on engineering and technology, to reinforce science concepts, and to collect data on both student and teacher learning. All 20 curricular units will be available in Fall 2011. The EiE project began in 2003 as an innovative pilot involving eight Massachusetts teachers and 200 students. After 60,000 hours of development and rigorous field-testing, EiE has grown into a vibrant, robust curriculum that has served 26,744 teachers and 1,833,755 students nationwide. Integrating lessons in engineering with science, language arts, social studies, and math, EiE makes the subject engaging by introducing children in grades 1-6 via storybooks narrated by child characters from around the world who face community-based problems. Students in the books and in class use creativity, problem-solving, and teamwork to engineer solutions to real problems via hands-on design activities. The curriculum spans the design of water filters and knee braces to cleaning up an oil spill. Each unit includes a storybook, teacher guide, and materials kit.

Data indicate that children who participate in EiE learn more about engineering, technology, and science concepts when compared with a control group. Teachers also consistently report higher levels of engagement for all types of learners. In response to requests for a hands-on curriculum for out-of-school settings, Engineering Adventures (EA) is being created for after-school and camp programs. Similar to EiE, EA engages children in design challenges that focus on a field of engineering and ask children to use creativity, teamwork, science, and engineering. More details are at <www.mos.org/eie>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition Electronic Bulletin for 28 July 2011, reprinted with permission.)

Duncan Urges Master Teachers to Help Transform Teaching Profession

"America should radically transform the way that teachers are recruited, assigned, evaluated, and compensated in order to recognize and reward its great veteran teachers, attract top students into the field, and make America more competitive," said U.S. Education Secretary Arne Duncan. In a recent speech to the National Board for Professional Teaching Standards, Duncan urged teachers to rebuild their profession to give teachers more autonomy in exchange for performance-based accountability. Duncan also called for higher salaries to make teaching more competitive with other professions like medicine, law, and engineering. A critic of teacher preparation programs, teacher evaluation systems and a school year based on the agrarian calendar, Duncan said, "the entire model no longer works: a broken pipeline; a nine-month school year; a factory approach to staffing, compensation, and benefits; a school design from the last century; and a management structure that is simply not up to the challenge."

Duncan added, "The incentives today are all wrong. Too many schools compensate teachers without respect to their impact on student learning. This is a blue collar model left over from the industrial era, based on seniority and credentials. It is not how professionals are compensated in this age of innovation," he said. Duncan suggested that starting salaries of around $60,000 and top salaries approaching $150,000 would help change the economics and makeup of the profession but acknowledged the difficulty of finding more money when governments at every level are wrestling with debt and deficits. Duncan added, however, "We can't mortgage our future by under-investing in education."

Report Offers New Framework to Guide K-12 Science Education, Calls for Shift in the Way Science is Taught in U.S.

A report recently released by the National Research Council presents a new framework for K-12 science education that identifies the key scientific ideas and practices all students should learn by the end of high school. The *Framework for K-12 Science Education: Practices,*

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Crosscutting Concepts, and Core Ideas will serve as the foundation for new K-12 science education standards, to replace those issued more than a decade ago. The committee that wrote the report sees the need for significant improvements in how science is taught in the U.S. The framework highlights the power of integrating understanding the ideas of science with engagement in the practices of science and is designed to build students' proficiency and appreciation for science over multiple years of school. Of particular note is the prominent place given to the ideas and practices of engineering. The overarching goal of the framework, the committee said, is to ensure that by the end of 12th grade, all students have some appreciation of the beauty and wonder of science, the capacity to discuss and think critically about science-related issues, and the skills to pursue careers in science or engineering if they want to do so – outcomes that existing educational approaches are ill-equipped to achieve.

The *Framework* was developed by an 18-member committee that included experts in education and scientists from many disciplines. The committee publicly released a draft in summer 2010 to obtain and incorporate feedback from the broader community of scientists, science educators, educational policymakers, and education researchers. The framework is the first step in the development of new K-12 science education standards. The framework lays out the broad ideas and practices students should learn and will serve as the basis for specific standards, which will be developed in a process led by a group of states and coordinated by the nonprofit educational organization Achieve Inc. When the standards are finished, states may voluntarily adopt them to guide science education in their public schools. In addition to serving as the foundation for the development of new standards, the framework can be used by others who work in K-12 science education, such as curriculum and assessment developers, those who train teachers and create professional development materials, and state and district science supervisors. The framework specifies core ideas in four disciplinary areas -- life sciences; physical sciences; earth and space sciences; and engineering, technology, and the applications of science -- that all students should understand by the time they finish high school. (See separate article about the *Framework* on page 7 of this issue.)

(*Editor's Note*: The preceding two items were excerpted from the Triangle Coalition Electronic Bulletin for 11 August 2011, reprinted with permission.)

NOAA's "New" Climate "Normals"

by Michael J Passow
Earth Science Correspondent

"Weather is what you get and climate is what you expect." So what do you expect? What is the "normal" climate for an area? Actually, "normal" changes. Official "normal" climate changes every ten years, and the "new normals" were issued in July.

The National Climate Data Center (NCDC) of the National Oceanic and Atmospheric Administration (NOAA) is the largest archive of weather data in the world. Utilizing gigantic computers, the NCDC operates the World Data Center for Meteorology in Asheville, NC, and the World Data Center for Paleoclimatology in Boulder, CO. These and many other NCDC products can be accessed through <www.ncdc.noaa.gov>.

For official climatology records, "normal" is based on a 30-year average, and the "new normals" were released in July. They are based on data from 1981 – 2010 and replace the 1971 – 2000 values used for the previous ten years. Online access to these data is available through <http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html>. The NCDC website also provides a FAQ list about how normals are calculated and utilized, obtaining historic normals, and more.

The NCDC held a pre-release webcast in June to describe what users should expect. This is available at <http://www.ncdc.noaa.gov/oa/climate/normals/Normals-Webcast-061311.pdf>. It contains valuable information about the methods required by the World Meteorology Organization and NOAA to collect, collate, and disseminate climatic data.

So what do new normals reveal about the nation's climate? In most of the country, temperatures were about 0.5°F warmer than in the previous decade. Some areas did have lower January, July, and annual temperatures, but more regions had warmer conditions, in some places by more than 2°F. Overall, the 1981–2010 annual maximum and minimum temperatures for all continental 48 states were warmer than during 1971–2000.

The ongoing debate over climate change should ultimately be argued on the facts, and NOAA's NCDC is the place to go to obtain these.

Facing the Future

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ers" on climate change, population growth, poverty, environmental degradation, conflict, global health crises to "work within the education system to help teachers help students achieve academic success, while preparing them to create and maintain positive, healthy, and sustainable communities."

Facing the Future curricula can be either purchased or downloaded free online. I found two versions of *Climate Change: Connections and Solutions*, one for grades 6-8, the other for grades 9-12. I downloaded the grade 9-12 version. Funding support from H-P was noted at the bottom of the title page. Inside I found nine activities with five associated readings comprising two one-week units, the first emphasizing basic science (the carbon cycle, the greenhouse effect, and fuel types), the second emphasizing the connection of climate change to social, economic, and environmental factors. All the activities are aligned with the *National Science Education Standards* and the standards of the National Council on Social Studies.

In the first one-week unit students measure the temperature of water in an open jar, a jar covered with plastic, and a jar with a warm wet towel at the bottom and covered in plastic; graph the carbon dioxide concentration in the atmosphere as measured at Mauna Loa versus time; share the content of "Ecosystem Role Cards" for various species; calculate the carbon dioxide emissions according to their utility bills, using an EPA website; and read and fill in worksheets on natural gas, coal, solar, hydro, wind, nuclear, and geothermal energy. In the second one-week unit students apply a two-page "Climate Impact Projections" handout to climate in the Maldives, Chad, Norway, Iowa, Southern California, and the Amazon Basin; work through a worksheet to get acclimated to cap-and-trade, then play a round of a simulation game; spend the money they are given (according to the country they represent) at a global mall to meet their basic needs and evaluate the consequences of their conditions; and learn about energy use and carbon dioxide emissions for industry, transportation, and residential sectors in the US, Germany, China, and Bolivia, and participate in a "World Climate Change Summit."

Did I find any way that the curriculum was biased in favor of British Petroleum and Hewlett-Packard? The third of five readings contains statements laudatory, but to my knowledge correct, about the involvement of both companies with alternate energies. At least at the time this curriculum was published (2007) BP was a manufacturer of photovoltaic cells; and I am familiar with the programs that H-P has to recycle its toner cartridges. But *I do have a reservation about using this curriculum*: the errors with which it describes the physics of the greenhouse effect and other physical processes. The definition of the greenhouse effect on page 11 refers to the "process by which certain gases in Earth's atmosphere *trap energy* from the sun . . . *that has been reflected off Earth's surface*; this process *warms the Earth's surface*. [emphasis mine] A similar error is made in the definition of greenhouse gas on page 11, also in the first reading on page 95: "*When reflected back, the radiation changes to infrared radiation,*" followed by "certain gases . . . *act like a blanket to retain (and reflect back down to the earth)* much of this infrared radiation." [emphasis mine] What really happens is that the Earth reradiates energy it has absorbed from the Sun *back* to the Sun as infrared radiation, and "greenhouse gases" in the atmosphere absorb and reradiate it, about half of it back to the Earth. The atmosphere as well as the Earth's surface is warmed. The infrared radiation reradiated by both the Earth and greenhouse gases in the atmosphere is mistakenly stated to be "reflected."

There are other scientific errors as well. The statement on page 12 that "Heat energy from the sun passes through the glass and is retained within the greenhouse" oversimplifies by failing to clarify that visible light from the Sun passes through the glass and is absorbed by the Earth, then reradiated as infrared radiation, which cannot pass back out through the glass. And the statement on page 42 that defines renewable energy as "a source of usable *power* that can be replaced *as it is consumed*" [emphasis mine] ignores the difference between power and energy and gives the false impression that the renewable energy is replaced as soon as it is "consumed." Rather, it is replaced subsequently through cycles of nature.

Those are my only caveats on using the Facing the Future curriculum on climate change. And since it isn't strong in its scientific foundations anyway, you'd probably want to marry it up with a more science-based approach if you're teaching about climate change, anyway. As far as the free assembly on climate change presented by ACE is concerned, I can't say; we didn't invite them to present it.

NOTICE

Publication of *A Framework for K-12 Science Education* and the response of the American Association of Physics Teachers (AAPT) to it are described on page 7 of this issue. Anyone wishing a copy of the AAPT response to the *Framework* can obtain one by e-mailing <JLRoeder@aol.com>.

Clearinghouse Update

From time to time we update our readers on situations which have been described in our *Newsletter*.

Standards, School Quality, and Test Scores

This *Newsletter* has long carried coverage of the performance of American students on international standardized tests in comparison with that of students from other nations, dating back to William Schmidt's criticizing the shallowness of American science education and Iris Rotberg's criticism that international test score comparisons fail to recognize that the U.S. testing sample includes a disproportionate number of low-achieving students (whose equivalents in other countries have already dropped out of school) in our Winter 1999 issue. We have also provided continued coverage of the development of academic standards and achievement gaps between racial and ethnic groups as measured by their standardized test scores. Gerald Bracey, in *The Bracey Report on the Condition of Public Education* (Education and the Public Interest Center & Education Policy Research Unit, Boulder and Tempe, 2009), retrieved 29 June 2011 from <http://epicpolicy.org/publication/Bracey-Report>, examines two "assumptions" related to these topics: 1) "High-quality schools can eliminate the achievement gap between whites and minorities." and 2) "Higher standards will improve the performance of public schools."

Bracey notes that, with no accepted definition of the quality of a school, the default measurement of a school's quality seems to be the standardized test scores of its students. He writes that "No Child Left Behind's reliance on testing and sanctions codifies the conception that schools alone are capable of erasing the achievement gap and need only to be required to do so." (p. 2) Acknowledging Rotberg's criticism, he observes that ". . . rankings [on international tests] are determined by nations' average scores" but "average students are not likely to be the leaders in fields of mathematics and science." He further observes that the U.S. had 25% of the highest scorers on the 2006 PISA (Programme for International Student Assessment), Japan 13%, Korea 5%, Taipei 3%, Finland and Hong Kong 1%. Bracey thus concludes that improving the average U.S. scores requires improving scores in low-income neighborhood schools. But, he goes on, given the known factors affecting the lives and learning of children in low-income families, he questions whether schools alone can lift these children to the educational level of their peers in families with higher incomes, thus lending support to Rotberg's arguments. He cites the ability of eighth graders at the "no excuses" Harlem Promise Academy to outperform New York City white students in math in 2008 as a single isolated statistic.

Having deflated the first assumption, that schools alone can lift test scores of students from low-income families, regardless of the quality of these schools, Bracey deflates the second one – that higher standards will improve test scores – as well. Noting that "American educators have, from almost the outset, been *obsessed* (emphasis original) with standards," (p. 16) he observes that a cluster of American states (Iowa, Maine, Minnesota, Montana, Nebraska, North Dakota, and Wisconsin) were outscored by only one nation in science and six in math on the 1995 TIMSS, yet (except for Iowa, which had no standards) the Thomas B. Fordham Foundation gave grades ranging from D+ to F to their standards. Standards require tests to provide evidence that they are being met. But Bracey (p. 19) cites David Marshak that they won't make schools look like Sidwell Friends, where President Obama's daughters are educated. Sidwell Friends, by contrast, Bracey writes, "encourages a rich interdisciplinary curriculum designed to stimulate inquiry; the expression of artistic abilities; reflection; 'stewardship of the natural world'; service to others; scientific investigation; creative expression; group as well as individual learning; personalization of learning and education of the whole person." Rather than move toward higher standards – which can take the form of more rigorous standards or requiring higher test scores – Bracey shares the feeling of Yong Zhao that "Obama and the nation's governors should preserve the legacy of our Founding Fathers and build a nation of diverse talents and creative entrepreneurs rather than a nation of standardized test-takers."

Electricity: the Most Efficient Auto Fuel

Our Winter/Spring 2011 issue presented evidence for the advantages of running a car by electricity, even from a coal-fired power plant. The carbon dioxide emissions are less than those of an internal combustion engine, and the efficiency is greater than from using hydrogen fuel. In their article, "Driving on Biomass," in the 22 May 2009 issue of *Science*, John Ohbrogge, Doug Allen, Bill Berguson, Dean DellaPenna, Yair Shachar-Hill, and Sten Stymne make the case that the best way to energize transportation by biomass is to burn it to produce electricity. Because corn is better used as food, and "almost one-third of the chemical energy of [its]starch is lost in producing ethanol," they write, corn-based ethanol is not the best way to "drive on biomass," not to mention the green-

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house gas nitrogen dioxide "released from microbial conversion of fertilizer in agricultural fields." They point out that the 2005 "'billion ton vision' proposed by the U.S. Departments of Energy and Agriculture" to replace "30% of U.S. petroleum consumption with lignocellulosic-derived liquid fuels," would convert only 10% of the chemical energy of the biomass to the kinetic energy of a car with an internal combustion engine (only 70% of the lignocellulosic biomass energy is recoverable as fermentable sugar, this is further reduced by 27% by the fermentation process, and only 20% of what remains is converted to the automobile's kinetic energy). They also point out that it would be more efficient to burn the biomass to generate electricity, which can be done with efficiency up to 40% and result in converting 20-25% of the biomass energy to the kinetic energy of the car. In this way, they observe, the same amount of biomass can displace twice as much petroleum, and the conversion efficiency can be further enhanced by cogeneration of heat. Thus, they argue, the research goals should be to engineer biomass to maximize its energy density and reduce energy loss due to breakdown of starch.

Update on Fracking

Reference #1 of our Winter/Spring 2009 issue reported on the use of a process of hydraulic fracturing, known as fracking, to release supplies of natural gas trapped underground. Initially this process was exploited in the West, but more recently it has come to the East to exploit natural gas in the Marcellus shale formation, which, according to David Kramer in the July 2011 issue of *Physics Today*, "extends from southern New York across Pennsylvania and into western Maryland, West Virginia, and eastern Ohio." "Although fracking fluids [injected into wells to fracture the underground shale] are more than 99% water and sand," Kramer reports, "they also contain a number of chemicals, including some that are toxic at the parts-per-billion level, such as benzene. . . ." Because "Shale-gas drillers consider the composition of their fracking fluids to be proprietary," there have been many concerns raised about their effect on adjacent groundwater that is ultimately used for drinking, with the most dramatic example being a scene in the documentary film, *Gasland*, showing ability to ignite the liquid coming from a water faucet. Kramer reports that a report released by Democrats on the House Energy and Commerce Committee in April 2011 "identified 29 chemicals that are either known or possible carcinogens and are subject to EPA regulation under the Clean Water Act," but he also notes, as was reported in Reference #1 from Winter/Spring 2009, that "Oil and gas fracking . . . was exempted from the [Clean Water] Act in 2005 by a provision tucked into the Energy Policy Act." So even if the companies disclose the ingredients of their fracking fluids, as the Texas legislature required in May 2011, the exclusion of fracking fluids from EPA regulation means that the only way to protect against adverse environmental consequences of fracking is to ban it.

A difference between fracking in the West and the East that Kramer reports is the presence in the West of thousands of oil and gas wells into which the fracking wastewater can be injected. Although there are more than 144,000 of these wells nationwide, only a handful are in Pennsylvania and none are in New York, where Governor Andrew Cuomo instituted a moratorium until 1 July 2011, pending completion of an environmental impact assessment. At the federal level, the EPA is responding to a 2010 directive of Congress "to examine the relationship between fracking and drinking water," but "an initial report generated by the EPA study is [not] expected to be issued [until] the end of 2012" and "parts of the study won't be completed until 2014."

Desertec Industrial Initiative

One of the ideas expressed in David MacKay's *Sustainable Energy – without the hot air*, covered in our Fall 2009 issue, is to provide electricity to Europe from solar energy generated from the deserts of the Middle East and North Africa (MENA). In the July 2011 issue of *Physics Today*, Toni Feder reports on the Solar Energy for Science symposium, which attracted 250 representatives of 35 countries to Hamburg, Germany, in May 2011 to discuss the Desertec Industrial Initiative (Dii) of Gerhard Knies. Many of the productive ideas generated at the symposium focused on collaboration between the nations of Europe and MENA both to generate solar energy and do scientific research. This would include solar energy for MENA as well as for Europe. Feder reports that "Many MENA countries . . . have strategic policy goals to get 10-20% of their energy from renewable sources in the next 10 years" and that "To send solar energy from the Sahara to Europe" would require installing high-voltage DC cable under the Mediterranean Sea. The importance of the latter is underscored by "the late-May announcements that Switzerland and Germany would phase out their nations' nuclear power plants in the wake of the Fukushima partial nuclear meltdown." The cost of "infrastructure required for solar energy from MENA to satisfy 15% of Europe's energy needs by 2050" is pegged at $580 billion.

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RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

1. Antonio Regaldo, "Reinventing the Leaf," *Sci. Am.*, **303**(4), 86-89 (Oct 2010).

The reinvented leaf would ideally convert sunlight into hydrogen fuel more efficiently than natural leaves create biofuel. John Turner has done this with 12 times the efficiency of a leaf, but the expensive materials required meant a cost of $\$10,000/cm^2$ (and his solar-fuel cell lasted only 20 hours). Perhaps more promising is a plastic film laced with silicon nanowires that can convert sunlight to electrical energy with 7% efficiency.

2. Emily Anthes, "The Bad Daddy Factor," *Miller-McCune*, **4**(1), 70-75 (Jan-Feb 2011).

The "bad daddy factor" is the chemical environment of the father when the sperm fertilizing an egg is produced. Everything from chemicals in the external environment to chemicals taken into the body – from chemotherapy to recreational drugs – has been found to have an effect. While women can protect their fetuses by staying away from these chemicals during pregnancy, this article raises the question: "What do you do with men who are constantly making sperm and could contribute to a pregnancy at any point?"

3. Rodger W. Bybee, "Advancing STEM Education: A 2020 Vision," *Technology and Engineering Teacher*, 30-35 (Sep 2010).

The acronym, STEM, needs to be recognized as standing for a quartet of fields – science, technology, engineering, and mathematics – whose collective focus is quantitative problem solving. Although technology and engineering do not presently merit the positions occupied by science and mathematics in school curricula, this should not be so in the future. All four STEM disciplines play a role in solving such problems as health, energy efficiency, natural resource use, environmental quality, and hazard mitigation, and using all four STEM disciplines to solve these problems can provide the basis for integrated curriculum units to learn the essentials of all four fields, while also fostering development 21st century skills. To this end Bybee provides a matrix showing how these problems can be addressed at the personal, social, and global levels.

Bybee envisions that the first model STEM curriculum units can be developed in two years. But he allows another six years after that for these units to be tested and for systemic changes in the educational system that will accept these units. A final two years is allocated for an initial trial of the new system.

4. Howard A. Smith, "Alone in the Universe," *Am. Sci.*, **99**(4), 320-327 (Jul-Aug 11).

The author is a senior astrophysicist at the Harvard-Smithsonian Center for Astrophysics, and this article is based on an invited talk given to the annual meeting of the American Association for the Advancement of Science. Requiring that intelligent life have the ability to communicate through outer space and therefore have the ability to transmit and receive electromagnetic waves, Smith observes that our own society has fulfilled this requirement only about 100 years. He considers the likelihood that we will receive a response to the radio signals planet Earth has been emitting during that time within 100 human generations, each considered to be 25 years. Therefore, he limits his "search" to a sphere of radius 1250 light years, within which there are about 30 million stars. For intelligent life to originate on a planet around one of those stars, four conditions must be met:

1) "The host star must be stable in size and radiative output for the billions of years it takes for intelligence to evolve." Smith notes that "over 90 percent of stars are smaller than the Sun, many with less than one-tenth of the Sun's mass." The problem with smaller stars is that their "habitable zone" lies closer to them than is the case with our Sun, and "when a planet is in this closer region, it tends to become gravitationally (tidally) locked to the star, with one side perpetually facing the star" – such a planet, hot on one side and cold on the other, would not be hospitable to life. Larger stars are also not acceptable, because they burn up their hydrogen in less time than it takes intelligent life to evolve. Smith considers stars with masses between 0.7 and 1.7 solar masses to be acceptable and notes that fewer than 10 percent of all stars are in this range.

2) The planet must be habitable and maintain water in its liquid state. "The orbit must be stable as well, sufficiently circular or otherwise unchanging, so that it remains suitable for billions of years." Smith notes that "of the 431 extra-solar planets currently known with confirmed and published orbital parameters, only 11 – 2.2 percent –

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have eccentricity values less than that of Earth; 20 percent vary in their stellar distances by a factor of two during their year, and 50 percent vary in stellar distance by 20 percent. Large variation in the distance from a planet to a star means large variation in climate, which is not hospitable to the development of life. Smith notes the related importance of the planet's obliquity, "the angle between its spin axis and the axis of its orbit around its star. Earth's obliquity, 23.5 degrees, is the consequence of a massive collision it had with a giant object early in its existence, which created the Moon. The approximate stability of Earth's obliquity is maintained by torque from the Moon." This obliquity angle keeps Earth's climate from varying between extremes, as would be the case if it were larger, but Smith observes that "current models of Earth-sized planet formation suggest that high obliquity angles should be common, the result of collisions from all directions in early stages of formation."

3) "The third condition is planetary mass. . . . planets smaller than about 0.4 Earth masses are unsuited for long-term atmospheres; if a planet is bigger than about 4 Earth masses, assuming it is rocky, then planetologists estimate it will be unable to produce the plate tectonics thought necessary to refresh the atmosphere with volcanoes or other processes associated with the carbon cycle. . . . For planets in close orbits, about 13 percent are Earth-sized. . . ."

4) "A suitable planet obviously must contain the elements needed for complex molecules (carbon, for example), but it also needs elements that are perhaps not necessary for making life itself but that are essential for an environment that can host intelligent life: silicon and iron, for example, to enable plate tectonics, and a magnetic field to shield the planet's surface from lethal charged winds from its star. The core of Earth remains liquid because of the presence of radioactive elements, whose heat keeps the iron molten. . . . the need for radioactive elements means that a supernova, the primary source of radioactive elements, must have exploded in the vicinity of a suitable planet relatively recently. . . ."

In addition to all these constraints, Smith also observes that "there were roughly 15 mass extinctions, six of them catastrophic, on Earth before humans emerged on the scene." He quotes Frank Drake as guessing that "only about 1 in 10 million stars has a detectable civilization," which would mean, at most, only two others in the sample of stars Smith has considered. Smith comes away from his analysis with "a renewed appreciation for our good fortune" and stresses the need "to acknowledge that life on Earth is precious and deserves respect. . . . An awareness of our rare capabilities can spur deeper humility and an acknowledgement of a responsibility to act with compassion toward people and our fragile environment."

PBL in Action

Page 31 of our Winter/Spring 2011 issue contained a sidebar on Project Based Learning. Two teachers using Project Based Learning in their classrooms presented the way they implement it at the American Association of Physics Teachers meeting in Omaha (NE) on 1 August 2011. Simon Huss of the Windward School in Los Angeles presented two projects he has his students complete: 1) a CSI investigation of a fake car crash, given testimony and lab measurements, for his ninth graders, *after* content learning. 2) a trebuchet competition for his seniors, *coincident* with content learning. David Schultz of Maine East High School, Park Ridge, IL, described how he focuses on experiential learning based on messy, real-world problems: 1) choosing the best of several renewable energy options for a school district according to an agreed-upon rubric, 2) abating noise in a school, 3) designing an overpass at a school.

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from a young age. Our nation and the rest of world benefit from students of science who always find the means of feeding their passion for this enthralling human endeavor.

(*Editor's Note*: The preceding is republished from the 15 August 2011 issue of *AIP Matters* -- A Weekly Update for the staff of the American Institute of Physics, with permission of the AIP. It is republished here as part of the *Newsletter*'s interest in publishing the importance of scientific and technological innovation.)

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The "favored technology for the Desertec vision of collecting solar energy in MENA deserts" is concentrated solar power (CSP), in which "sunlight is focused to heat a fluid." Presently favored is molten salt, which "can be heated to 500°C or more . . . and piped to other locations," where "the energy is stored as a hot fluid and converted to electricity via steam engines." This procedure would eliminate the need for an independent energy storage system, as would be required if the solar energy were converted directly to electricity by photovoltaic cells.

REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Susan Freinkel, *Plastics: A Toxic Love Story* (Houghton Mifflin Harcourt, Boston, 2011), 324 pp. $27.00. ISBN 978-0-547-15240.

Like many a romance in the first half of the twentieth century, the love affair between Americans and plastics was interrupted after its brief beginning in the 1930s by World War II, after which it thrived in full bloom. Freinkel tells this story – and its toxic effects – in eight chapters, each focused on one particular plastic item. Chapter 1 uses the comb to begin the story of plastics, starting with celluloid and Bakelite, which led to the development of other plastics that proved invaluable in World War II and popular in post-war consumer goods. Chapter 2 uses the chair to point up the wide variety of potential in plastic – from dazzling design to cheap utility. Chapter 3 uses the Frisbee, as a prototype plastic toy, to illustrate the rise of plastic as a manufacturing material, from its post-World War II origin to its export to burgeoning Chinese factories. Chapter 4 points up problems of "endocrine disruption" from the plasticizer DEHP (Di(2-Ethyl Hexyl) Phthalate) added to give polyvinyl chloride (PVC) in IV bags and plastic tubing its needed softness. Chapter 5 highlights that disposable plastic lighters and similar items must go somewhere and where they go can reap serious environmental consequences. Chapter 6 highlights that a repeatedly reusable item is preferable to a series of throwaways, especially bags with a short lifetime. Chapter 7 points up the plastic bottle as a product for which increased recycling seems to be the best answer to the disposal problem. Chapter 8 considers the credit card as an example of how the manufacture of a plastic can be designed to minimize the impact of its disposal.

Most of us have relied on the eight items that are the focus of Freinkel's chapters. Of the consequences of using those items – and many like them – I was aware of many, but some I learned for the first time in reading this book. For example, I learned that the most commonly used polymer, polyethylene, was first discovered by two chemists at Imperial Chemical Industries in 1933, but its industrial development came at Standard Oil as a by-product of ethylene gas which had previously been flared off. But we no longer get enough ethylene gas this way. "About 4 percent of global supplies of oil and gas is used as feedstock for plastics, and another 4 percent is used to actually produce them," Freinkel writes (p. 60). So one of the toxic aspects of our love affair with plastics is that we are drawing on our finite supplies of fossil fuels to produce them.

Most of the other problems with plastics relate to their disposal – since they are synthesized and therefore do not originate in nature, they do not biodegrade after we no longer need them. This is particularly true of the disposable lighter and grocery bag considered in Chapters 5 and 6, which often end up as plastic pollution in the oceans, where its ingestion by marine life and sea birds has increased the death rates of more than 260 species. Although plastics constitute only 10% of the world's garbage, it is the most persistent 10% – and this becomes between 60% and 70% of ocean debris. In the case of both the disposable lighter and grocery bag, the most sensible solution is to replace them with reusable devices, the practice during World War II, when materials were scarce. Freinkel's history of the efforts to tax or ban plastic grocery bags is fascinating, but most instructive is her citation of psychologist Robert Cialdini's finding the people are most likely to show environmentally-responsible behavior when they are caused to believe that it is the social norm.

The same might be said about the plastic bottle in Chapter 7, except that Freinkel writes that shipping beverages to the armed forces in cans during World War II was already leading to the end of the era of returnable bottles. The high pressure of carbon dioxide dissolved in carbonated beverages, though, meant that a special polymer would be needed, one whose strength grew when it was stretched. The answer, found by artist Andrew Wyeth's brother, Nathaniel, was PolyEthylene Terephthalate (PET). Here the solution to the disposal problem is recycling, and Freinkel points out that PET meets the three criteria for recycling: 1) abundance, 2) ease of reprocessing, and 3) secondary markets (clothing, bristles – for carpets and brushes, fill for pillows, and even new PET bottles). (The polypropylene caps to the PET bottles are separated by flotation and sold separately.) Still, Freinkel says, only a quarter of all PET bottles are recycled (with the highest rates in bottle deposit states) and only 7% of plastics overall, compared with 23% of glass, 34% of metal, and 55% of paper.

But the consequence of plastics use that intrigued me most was the addition of DEHP to give PVC the softness it needs in IV bags and plastic tubing. The danger of

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DEHP was substantiated by the sexual aberrations found in male rats exposed to high dosages *in utero*. Although similar studies with marmosets showed no phthalate sensitivity, Shanna Swan of the University of Rochester School of Medicine did find a correlation in an epidemiological study done with humans: she measured the phthalate levels in pregnant women and found a correlation in their newly-born sons of effects like those in the rat study. A definitive study with humans would require 250,000 children and cost $10 million, but a recently-begun National Children's Study will study 100,000 children.

The response of the American Chemistry Council was to insist on the safety of DEHP and criticize the work of Shanna Swan, much as the tobacco companies sought to sow doubt among the public in light of the first correlations between smoking and lung cancer. Although Freinkel reports that the Environmental Protection Agency (EPA) "recently announced that it would take steps to limit use of phthalates," she also reports that the Food and Drug Administration (FDA) considers their benefit to outweigh their risk – they act as a preservative to red blood cells in PVC blood bags, even though the blood is found to leach DEPH from the bag. To its credit, the U.S. Congress banned DEPH from children's toys in 2008, but even this came nine years after similar action by the European Union.

DEPH is one of a list of 30 endocrine disruptors compiled by a conference called by Theo Coburn after she found animals with dysfunctional endocrine systems as the result of exposure to toxins at critical points in their life in the course of studying the effects of pollutants in the Great Lakes. These disruptors can function in several ways – by replacing a hormone at its binding site or by binding to the hormone to interfere with its transmission. Another endocrine disruptor is Bisphenol A, a primary ingredient of the polycarbonate used to make baby bottles which can leach from the polycarbonate when the bottles are washed with detergents and hot water. Bisphenol A is also used in the epoxy resins used to line cans for food and drinks.

Although the U.S. government has yet to act, except for banning DEPH in children's toys, Freinkel has more encouraging news to report from the private sector: American manufacturers have developed DEHP-free products to meet the requirements of European markets, and an American organization, Health Care Without Harm, has persuaded some hospitals to purchase more expensive DEHP-free products. One alternative is to use polypropylene instead of PVC – it has the added advantage of not containing chlorine (which leads to dioxins and furans when PVC is incinerated), and it doesn't require any plasticizers. In other cases, DEHP has been replaced as a plasticizer by citrates and Hexamoll DINCH (which underwent $7 million in safety tests). Freinkel also reports that big-box stores have stopped carrying baby bottles with Bisphenol A, an action which caused *Fortune* to characterize Wal-Mart as the "new FDA." But she notes that vinyl tubing with DEHP is still used for heart-lung machines.

One last observation I would make about this book is what it says about exportation of the plastics industry to China. Frankel writes about visits to two sites in Guangdong Province, near Hong Kong, and this is only part of the extensive research she has done to write this book (her acknowledgments fill six pages and her notes another 53.). She visited the factory where the Frisbee was manufactured at the time the book was being researched (though its new owner has expressed intent to return its manufacture to the U.S.) and also a warehouse to which the fractions of plastics sorted at U.S. recycling centers are shipped for further use in manufacturing (because ships carry less from the U.S. to China than the other way around, the rates are very cheap). In both cases these facilities were staffed with migrant workers living in company dormitories.

"The forces that shaped our marriage with plastics," Freinkel reflects toward the end of her book (p. 231), "evolved in a political culture that assumed a world without biological limits. That genie can't be put back in the bottle, but we can remold our political culture to make the genie a better citizen." The first plastic, celluloid, had environmental benefits, because its use to make the comb of Chapter 1 meant that there would no longer be a market for tortoise shells and elephant tusks. Likewise, celluloid was partly based on plant material, cellulose, and today one way to make plastics more environmentally benign is to produce them from living organisms rather than fossil fuels, so that they have the following advantages: 1) biodegradability, 2) no consumption of fossil fuels, 3) no net carbon dioxide emissions. One such example is PolyHydroxy Alkanoate (PHA), which was originally found to be produced by bacteria, which have now been genetically engineered to enhance their production (though the dextrose corn sugar used to feed them requires fossil fuels and thus causes carbon dioxide to be emitted). Subsequently, tobacco and switchgrass have been genetically engineered to produce PHA, and Archer

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Daniels Midland opened a PHA production plant in 2010. Freinkel writes that production of PHA in this way is competitive with petroplastics when the price of oil is greater than $80 per barrel.

\- John L. Roeder

Sherry Turkle, *Alone Together: Why We Expect More From Technology and Less From Each Other* (Basic, New York, 2011). xvii+360 pp. $28.95. ISBN 978-0-465-01021-9.

According to the author's introduction, this is the third book she has written about the role of electronic technology in our lives. She wrote *The Second Self* in 1984 about the interactions of humans with their personal computers as of then and *Life on the Screen* in 1995 about the ways people have networked and found alternatives to "real life" through that time. *Alone Together* was sparked by a newfound human dependence on robots. "I tell two stories in *Alone Together*: today's story of the network, with its promise to give us more control over human relationships, and tomorrow's story of sociable robots, which promise relationships where we will be in control, even if that means not being in relationships at all." (p. 17)

Turkle benefits from the unique perspective of being a person on the faculty of an engineering school (MIT) who is trained in psychotherapy. The first half of this book describes implications for our lives that have been made possible and hold forth in the future by advances in robotic technology. Robotics technology is a combination of computer technology and animation technology that has now led to creation of a wide variety of devices that can not only think and move but also give the appearance of having feelings and needing "care." As such, they have the ability to form relationships with those who need care and benefit psychologically from giving them care, particularly the young and elderly. Turkle writes that Japan has decided that it would compensate for a shortage of young people to care for its elderly by building a corps of robots to perform some caregiving procedures. "If human nursing care is regimented, scripted into machinelike performance, it is easier to accept a robot nurse. . . . (Similarly, if children are minded at daycare facilities that seem like little more than safe warehouses, the idea of a robot baby sitter becomes less troubling.)," she writes (p. 107), then asks, "Will only the wealthy and 'well adjusted' be granted the company of their own kind?" (p. 108) "I believe that sociable technology will always disappoint because it promises what it cannot deliver," she adds. "It promises friendship but only delivers performance. Do we really want to be in the business of manufacturing friends that will never be friends?" (p. 101)

With electronic networking, it is in some ways the opposite: "With sociable robots we are alone but receive the signals that tell us we are together. Networked, we are together, but so lessened are our expectations of each other that we can feel utterly alone." (p. 154) This feeling of aloneness results from the way people prefer to use their options for electronic communication. A two-way conversation by cell phone demands full attention of the other person and may be regarded as intrusive, and it doesn't allow a person to "rehearse" what to say in the same way as can be done in texting, immediate messaging, or e-mail. Turkle finds the beginning of this trend away from direct telephone communication in the answering machine – "telephone tag" is like a series of texts. Because of this trend away from direct communication, people have taken to saying online what they should say directly to each other, things like apologies, for example. And it is because of this that Turkle feels that electronic networking has lessened our expectations of each other.

"With sociable robots, we imagine objects as people. Online, we invent ways of being with people that turn them into something close to objects," Turkle writes. (p. 168) This is especially true in the case of creating avatars and joining social networking sites, both of which allow people to recreate themselves as they would like to be perceived. She writes about the anxieties about writing a profile to present on Facebook and adds that "an avatar . . . 'is a Facebook profile come to life.'" (p. 191) Both also can consume a lot of time, depending upon how much a person wants to devote to "performance," and there is no way to be sure that other avatars or Facebook sites are developed by the sincere actions of another person. "Online, we easily find 'company' but are exhausted by the pressures of performance," Turkle writes. "We enjoy continued connection but rarely have each other's full attention. . . . We can work from home, but our work blends into our private lives until we can barely discern the boundaries between them." (p. 280) Moreover, maintaining any privacy in our lives requires keeping it out of the electronic network.

Like all technologies, robots and electronic networks have their pluses and minuses, and they're not going away. It makes no sense to talk about addiction to cell

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REVIEWS

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phones or the Internet, because there is no expectation that we would go "cold turkey" and do completely without them. "We have to find a way to live with seductive technology and make it work to our purposes," Turkle writes. (p. 294) "Because we grew up with the Net, we assume that the Net is grown up . . . . But in fact, we are in the early days. There is time to make the corrections," she continues. (p. 294) She sees us at "a point of inflection, where we can see the costs [of digital communications technology] and start to take action." (p. 296)

In her Epilogue, Turkle raises a completely different question to consider. She writes that after World War II Vannevar Bush proposed (in his *Alantic Monthly* article, "As We May Think") that physicists who had worked on the Manhattan Project be re-employed to develop a "memex" to store all one's "books, records, and communications, and which is mechanized so that it may be consulted with exceeding speed and flexibility." (p. 299) She cites examples of people attempting this and notes, that if this is done, "we may end up with a life deferred by the business of its own collection" (p. 306) and asks, "When we know that everything in our lives is captured, will we begin to live the life that we hope to have achieved?" (p. 306)

As Turkle twice notes in her book (pages 165, 242) and Macknik and Martinez-Conde note in *Sleights of Mind* (reviewed in our Winter-Spring 2011 issue), attempts to "multitask" really result in poorer performances on those tasks. Thus, to review everything in one's life would require another lifetime. Self-written summaries of the highlights are more likely to spark the most important memories. After all, we can focus only one thing at a time.

- John L. Roeder

Flarend

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remediation to store solar thermal energy, and, using LIDAR, they found one near a school. Flarend expects that reclamation benefits and federal/state incentives could reduce the cost of the stored solar thermal energy to between $10 and $20 per gigajoule. A computer simulation showed that the system would be operable in principle but needed modification to the schools' heating systems for direct use of the stored heat which is of lower quality (temperature) than is generated by the current furnace.

Infusion Tips

The late Dick Brinckerhoff suggested the following criteria for ways to infuse societal topics into our science courses: items should be a) challenging, b) relevant, c) brief, and d) require a value judgment. Consider the following:

According to Paul Tullus, "The Delta Water Blues," *Miller-McCune*, **4**(1), 62-29 (Jan-Feb 2011), there are three solutions to problems that would result from an earthquake in the Sacramento San Joaquin River Delta. Halting the exporting of water from the Delta would be best for the fish there but would deprive those dependent on exported water and leave adjacent low-lying agricultural land more open to flooding. The *status quo* is "risky and unsustainable," because the earthen levees protecting the agricultural land could rupture, and bad for the fish, because spring runoff is channeled to Southern California. Diverting water to Southern California before it reaches the Delta would eliminate the flooding problem but be a disaster for the fish. California is famous for its ballot propositions to be decided by the voters. If you were a California voter, how would you vote on a proposition to spend $750 million on levee repairs? A proposition to spend $4 billion for a diverting canal?

Read any good books lately?

Review them and send your review to JLRoeder@aol.com for publication here!

A Primer on CCS

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to reduce atmospheric CO_2 to near preindustrial levels [roughly 4000 years]." Schrag also offers hope in his perspective that the billions of tons of carbon dioxide emitted every year can be sequestered, once it is captured, below offshore sediments at the bottom of the ocean, and offers reasons that make offshore sediments an attractive place for carbon dioxide sequestration.

In his editorial, Chu also offers some lessons on carbon sequestration from nature: ". . . in the natural world, sequestration of CO_2 occurs through photosynthesis, calcification of CO_2 by phytoplankton, and mineralization in ground root systems. . . . nature provides proof that the energy penalty for releasing adsorbed CO_2 in postcombustion capture can be decreased: Through carbonic anhydrases, our blood captures CO_2 created by cell metabolism and releases it in the lungs with no enthalpic energy penalty."

A Primer on CCS

Readers of this *Newsletter* were first introduced to dealing with climate change by carbon capture and sequestration (or storage) (CCS) by our coverage of Michael Celia's talk at Princeton University in our Spring 2008 issue. The Clearinghouse Update feature in our Winter/Spring 2009 issue cited a story on National Public Radio on capturing 1% of the carbon dioxide emitted at a Chinese power plant for fire extinguishers, dry ice, and carbonated beverages by an unidentified solvent.

Now the 25 September 2009 issue of *Science* presents a full-fledged primer in a special section on this topic. In a comprehensive review, "Carbon Capture and Storage: How Green Can Black Be?" R. Stuart Hazeldine points out that there are three ways to capture carbon dioxide emitted by a fossil fuel electric power plant before sequestering it:

1) *Postcombustion* capture separates the emitted carbon dioxide with chemical solvents, which are regenerated by several hours of heating in recovery columns. In a perspective, "Amine Scrubbing for CO_2 Capture," Gary T. Rochelle identifies the solvent separating carbon dioxide from the exhaust of a fossil fuel power plant as low volatility aqueous amine, according to a process patented by R. R. Bottoms of the Girdler Corporation in 1930. Hazeldine describes the advantage of postcombustion capture of carbon dioxide as its ability to operate with existing plants and its flexibility to be turned off as needed during peak demand (CCS currently uses between 25% and 40% of the power plant's energy, with hopes to reduce this to between 10% and 20%). The disadvantage of postcombustion cited by Hazeldine is the large equipment and volume of solvent required and the possibility that the solvent's regeneration can produce toxic byproducts.

2) *Oxyfuel combustion* requires that the hydrocarbon fuel be burned in the absence of molecular nitrogen (which comprises 78% of the Earth's atmosphere), so that only water and carbon dioxide are produced, the latter pressurized into liquid form, and Rochelle points out that it requires a stoichiometric combination of molecular oxygen with the fuel to be burned. The advantage of oxyfuel combustion, according to Hazeldine, is its smaller size (than postcombustion) and no need for a solvent; it can also be retrofitted to existing plants. However, it has not yet been tested for plants producing more than a megawatt of electric power (a thousandth of the power produced by a typical power plant).

3) *Precombustion* capture strips the carbon from fuel to leave behind molecular hydrogen to burn. Hazeldine cites the advantage that multiple fuels can be accommodated by this process and the disadvantage that it requires gasification prior to the carbon renewal; it, too, has not been tested with an operational power plant.

What is the prognosis for the effectiveness of CCS? In his news item on "Carbon Sequestration," Robert W. Service describes a dozen current CCS projects all over the world, none of which sequesters more than four megatons of carbon dioxide per year, while in his editorial on "Carbon Capture and Sequestration" Energy Secretary Steven Chu states than the world's present combustion of six billion tons of coal per year gives rise to 18 *billion* tons of carbon dioxide.

Hazeldine feels that two learning cycles from demonstration plants are needed and calls for immediate action in order to reach climate change goals for 2020, with the present level of funds committed to research multiplied by a factor between four and ten. He is also concerned about lack of financial incentive for CCS, since its purpose is to pay for heretofore ignored environmental costs. And given the multiplicity of approaches to CCS, Hazeldine is concerned that the demonstration projects will not point the way to one particular approach – he notes that at present all three methods are equally efficient and expensive. Rochelle notes that postcombustion by amine solvents has not been given federal funding, presumably because it is farther advanced than its two competitors – just as lime/limestone slurry scrubbing for flue gas desulfurization (first applied in 1936) was not deemed worthy of federally-funded research and development in the 1960s. But just as lime/limestone slurry scrubbing is now the dominant flue gas desulfurization process, Rochelle expects that "amine scrubbing will probably be the dominant technology for CO_2 capture from coal-fired plants in 2030" and points out that it could be implemented in full-scale plants right away if there were financial incentives to do so or "if some institution would assume the financial risk."

Hazeldine portrays CCS as "a direct emissions mitigation option, usually considered as an interim system to enable a 50-year transition away from fossil fuels." In his perspective on "Storage of Carbon Dioxide in Offshore Sediments," Daniel P. Schrag adds, "Luckily, geologic storage does not have to last forever – only long enough to allow carbon sinks in the natural carbon cycle

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Google Science Fair Winner has Record of Innovation

by H. Frederick Dylla,
Executive Director, American Institute of Physics

For most of the Northern Hemisphere, the pace of activity slows down in August. Much of the working world tries to squeeze in a vacation, many governments take a break, and academia takes a few more summer breaths before the start of the fall term. The latest tremors in the world's economy, continued turmoil in the Middle East, the famine and conflict in Somalia, and surprising unrest in England have rattled our consciousness. That spate of bad news cries out for some positive news. I welcomed the minor splash that the impressive winners of Google's inaugural science fair were able to make in the national press. More than 10,000 students from 91 countries joined the online competition, and the top three winners were young women from the United States. Theirs is a reassuring story that highlights the opportunities in science available to young people. And it counters the misconception that young women have neither the interest nor the DNA to excel in science.

One of AIP's science correspondents, Steve Corneliussen, reported for *Physics Today* Online on the national coverage of the story, including an article published in *The New York Times* on 18 July. Almost a month later, the reporter's characterization of the grand prize winner, Shree Bose, a 17-year-old high school student from Fort Worth, TX, still has me captivated with her achievements and her obvious fascination with scientific discovery:

> As a budding inventor and scientist, Shree Bose, in second grade, tried to make blue spinach. In fourth grade she built a remote-controlled garbage can. In eighth grade she invented a railroad tie made out of recycled plastic and granite dust, an achievement that got her to the top 30 in a national science competition for middle school students. In 11th grade Ms. Bose . . . tackled ovarian cancer, and that research won her the grand prize and $50,000 in the Google Science Fair. . . .
>
> For the winning research Ms. Bose looked at a chemotherapy drug, cisplatin, that is commonly taken by women with ovarian cancer. The problem is that the cancer cells tend to grow resistant to cisplatin over time, and Ms. Bose set out to find a way to counteract that.
>
> She found the answer in a cellular energy protein known as AMPK . . . [that] added later on, when the cancer cells were growing resistant, . . . worked to maintain the effectiveness of cisplatin, allowing it to continue killing the malignant cells.

Such a finding would pass muster for many an NIH postgraduate research project. This young lady will no doubt have an even more productive research career as she passes rapidly through undergraduate and graduate training and joins the scientific workforce. But she has already contributed to the body of science.

This anecdote calms my nerves during our current period of angst because it tells me that this country still provides plenty of opportunity for bright kids to discover and excel in science. As a Sputnik kid growing up in the 1950s and 1960s, I was afforded many opportunities to be exposed to science, from being given free samples of some of Bell Lab's first transistors, to meeting engineers from RCA who helped me build a laser with "loaned" parts, to a very patient high school biology teacher who let me study physics instead of biology because I liked the subject better.

Shree Bose no doubt has very supportive parents and teachers who have let her grow her passion for science

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