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NYAS revisits "The Two Cultures"

It was 9 May 2009, fifty years and two days after C. P. Snow delivered his now famous lecture, "The Two Cultures," and Sheril Kirshenbaum and Chris Mooney, co-authors of the forthcoming *Unscientific America: How Scientific Illiteracy Threatens Our Future* persuaded the New York Academy of Sciences to let them stage a conference, "The Two Cultures In The 21st Century," which not only commemorated Snow's original address but also sought to gather members of the "two cultures" to explore their interactions.

The keynote speaker was E. O. Wilson of Harvard University, whose book, *Consilience*, had sought to pick up from where the Enlightenment had left off in trying to unify the academic disciplines. The term "consilience" to denote a unification of all fields of learning was coined by William Whewell in 1840, Wilson said, and he added that the time has come for a renewal of the Enlightenment – a try at universal consilience. Wilson displayed a two-dimensional surface marked off into four quadrants, with "ethics" in the northeast, "environmental policy" in the northwest, "social science" in the southwest, and "biology" in the southeast. Each quadrant has its own expertise, Wilson said, but we need to learn to traverse the quadrants, perhaps even multiple times rather than allow each to remain its own island of ignorance. The lines separating the quadrants should not be viewed as unbridgeable walls but rather the regions for borderland disciplines, such as cognitive neuroscience, behavioral genetics, environmental biology, and environmental science.

Human problems, Wilson went on, devolve from not knowing what we are and what we are to become. We need to understand human nature, he said, by embracing what all disciplines can bring to bear on it. It's not the genome but rather epigenetic rules (genetic-cultural co-evolution), of which he gave the following examples:

color perception: as cultures distinguish additional numbers of colors, they do so by adding basically the same sequence of colors (only 22 sequences of 11 colors show up among 2036 possibilities).

avoidance of incest: this is a practice also found in nonhuman primates.

arousal by abstract patterns with commanding delineated lines.

attraction to certain physical facial characteristics (high cheekbones, wide eyes).

Attraction to environments with height overlooking a savannah or grassland and water, with animals and trees with nearly horizontal branches.

We know little about the relationship of these rules to genetics, Wilson added, because they haven't been studied.

The circuit from the basal ganglia to the thalamus to the frontal cortex is found to be the key to cultural human behavior, Wilson continued. We have acquired all the means needed to establish the goal of consilience. And we are increasing our ability to understand emerging levels of greater complexity in systems, ranging from colonies of insects to human society. In response to the question whether consilience implied answers to all presently unanswered questions, Wilson responded that there will still be challenges, such as how to sustain our ecosystem, but he expected that there will be a meeting between religion and science, and he didn't feel that it would be good for religion.

The Two Cultures in Historical Perspective

Next on the program was a panel moderated by Princeton University History Professor D. Graham Burnett. Members of the panel were Harvard University History

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Science at the Carnival

When you go to a carnival, do you think of science? Maybe you don't, but two veteran Ohio physics teachers, Gene Easter and Bill Reitz have researched how the operators of the carnival have certainly applied science to make their experience more profitable than yours. In an hourlong presentation to the American Association of Physics Teachers (AAPT) in Ann Arbor, MI, on 27 July 2009 that they plan to expand into a half-day workshop at AAPT's meeting next year in Portland, OR, they shared their "Carnival Knowledge."

Easter and Reitz have classified carnival games into such categories as hanky-pank games, alibi ganes (which allow the operator to object that the player has stepped over a line and is thus disqualified), and, yes, even games of skill. In the category of hanky-pank are all sorts of deceptions that actually turn out to be applied science. Darts intended to break balloons can be intentionally bent or blunt, and underinflating the balloons also decreases the chances of bursting them. Because sights of guns in shooting games are likely to be bent, Easter and Reitz advised aiming with the barrel of the gun. Using a ring on a fishing line to right a Coke bottle is hard enough to do – they said only 1 in 500 physicists could do it at an AAPT picnic – but the odds become slimmer when the bottle is weighted to raise its center of mass or the support of the platform is jimmied. On the other hand, if the objective is to knock a bottle down, it is weighted to *lower* its center of mass. And, if the fallen bottle is to remain on a table to win, its position on the table matters. A ring that will fit over a target vertically will not fit over the greater area presented to a person throwing from the front. Finally, to make it difficult to toss a ball into a basket, the carnival operator places springs under the basket's bottom to cause the balls to bounce back out.

Games of skill at a carnival? Yes, but you need to know the skills. Shooting out a star is best done by shooting out a circle around the star. Pushing a ball on a track over a low hill to get it to stay in the valley beyond the hill requires just enough kinetic energy to get it over the hill, so that friction losses will not allow the ball to come back over the hill. Easter and Reitz reported that this can be learned in 10 to 12 tries. Likewise, the ladder climb can be mastered, but it requires putting your arm out farther than the opposite leg. When rings are tossed onto bottles, they will always bounce off, Easter and Reitz said, if they are thrown one at a time. If two are dropped together, the lower one will sink, with the upper one bouncing off. If throwing two together is not allowed, the only way to win is with a ricochet.

One type of game that always has a winner is a "group" game – but Easter and Reitz noted that all except the winner is a loser. If you are hoping for more than just entertainment for the money you spend at a carnival, their advice is the following: 1) Play the "right" game. 2) Be the "turtle." 3) Follow the KISS principle (don't play unless there are less than six rules and less than three ways to win). 4) Play dumb. 5) Assume the worst. 6) Visit <wereitz.googlepages.com/carny>.

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.

IN THIS ISSUE

Galileo at The Franklin

This year marks the 400th anniversary of Galileo's first astronomical observations with his telescope, and the Franklin Institute of Philadelphia mounted the first exhibition of that telescope outside of Italy in those 400 years: "Galileo: the Medici and the Age of Astronomy." Thanks to support from the John Templeton Foundation, with additional support from A. Bruce Mainwaring, GlaxoSmithKline, the National Endowment for the Humanities, and John Diebel, and sponsorship from Celestron and PECO, "The Franklin" was also able to present a Symposium on "The Legacy of Galileo" 18-20 June 2009.

What Would Galileo Think?

The opening night panel on 18 June, hosted by Physics Professor Stephen M. Barr of the University of Delaware, was asked to "speculate what Galileo might think about today's controversial scientific issues." Galileo overturned many applecarts, Barr said, treading on institutions – Aristotelian cosmology as well as the Catholic Church. To what extent, he asked, are there similar collisions between science and contemporary culture?

Barr began by reading the prepared statement of panelist Joel R. Primack, Physics Professor at the University of California-Santa Cruz, who was late in arriving. Thomas Kuhn's model of paradigm shifts has the Copernican Revolution overthrowing Aristotle, Primack had written, but this model need not always hold. Einsteininan relativity did not overthrow Newtonian mechanics. It only circumscribed the range of phenomena to which it applies.

Professor of History and of Science and Technology Studies Peter R. Dear of Cornell University noted that since science as we know it since the nineteenth century didn't exist in the seventeenth, the closest thing was "natural philosophy," which was a philosophy of God's creation. There was then, therefore, no boundary between science and religion, but there was a distinction between acceptance of beliefs from the authority of faith and the authority of reason. Dear also looked at Galileo's work within the context of the Reformation and the Counter-Reformation.

Following up on Dear's assertion of no boundary between science and religion in Galileo's day, Philosophy Professor Maurice A. Finocchiaro of the University of Nevada-Las Vegas noted that Galileo himself didn't feel that there *was* a conflict between science and religion. Finocchiaro went on to say that Galileo gave us both the content and practice of science. His treatment by the Catholic Church, Finocchiaro said, made him a cultural icon. Current scientific topics to test the relevance of Galileo are stem cell research, climate change, and evolution. In the last case, all we need to change from the Galileo story is to change astronomy to biology and Earth's motion to evolution. Finocciaro went on to point out that Galileo's 1632 *Dialogue* did not give equal treatment to Aristotle and Copernicus – and he did not treat Copernicanism as a "convenient hypothesis" as he was allowed in 1616.

The last panelist, Professor of the History and Sociology of Science Ruth Schwartz Cowan of the University of Pennsylvania, began by saying that she has always taught Galileo as a pragmatist. After the Counter-Reformation died down, she noted, controversy about Copernicus died down. In the second half of the 19th century, the belief in the Bible as a historical document and Darwinism contributed to science becoming a social institution, which *did* war against religion. Most people have been pragmatic about science *vs.* religion (not seeing any conflict between the two) in the 20th century, Cowan said, but she observed that there are still "absolutists" on both sides of science *vs.* religion, and she felt that religious absolutists are more dangerous. As an example of pragmatism in the context of science *vs.* religion, Cowan cited a dreaded chronic single recessive gene disease on Cyprus. Cyprus mandates genetic screening to eliminate this disease, Cowan said. Although the Cypriote church generally opposes abortion, the bishop approved this program because of its potential to eliminate human suffering.

Their initial presentations complete, the panelists then fell into sparring among themselves. Primack, who had by then arrived, observed that Galileo "took on" the Pope. Was that pragmatic, he asked? Finocciaro responded that Galileo was required to include the Pope's argument in his *Dialogue*, so that he was really being deferential. Primack rejoined that if Galileo hadn't voiced the Pope's argument through the character of Simplicio, he might have gotten off the hook. Panel moderator Barr also pointed out that while the phases of Venus disproved Aristotle, they did not disprove the system of Tycho Brahe, which differed from that of Copernicus in having the Sun orbit the Earth instead of the other way

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Energy and Environment considered by AAPT

Concerns about energy and the environment and how to educate students about them were raised at the meeting of the American Association of Physics Teachers in Ann Arbor, MI, 27 July 2009.

Opening the session was John Welch, who described a one-month-long NSF-funded summer academy to increase the number of STEM (Science, Technology, Engineering, and Mathematics) majors at Cabrillo College. This academy acts as a bridge to mark the transition of 25 students from high school to college and also provides them background leading to "green jobs," Welch said. The enrollment in 2009, he added, was 38% female, 24% Latino.

After "energy basics," Welch reported that students move on to games, projects, and field trips. He added that there is a heavy community service component. Among the "games" was a challenge to determine how many black beans, representing oil, stratified in garbanzo beans can be extracted in a 30 second "year" with a teaspoon. Successive years, Welch said, eventually show a peak followed by a dropoff.

Welch also described a cap-and-trade simulation to include the effects of greenhouse gas emissions and an electrical grid game to show that the grid can't store electrical energy and acquaint students with peak demand. Welch said that students also measure how much electric power they can generate on a bicycle and make wind generators. And they complete the spreadsheets developed by Pat Keefe and Greg Mulder to plan the energy futures of the U.S. and the world, as described in our Fall 2002 issue (these spreadsheets are available online at <www.oraapt.org>).

Among the academy's field trips are visits to local utility plants and homes relying on energy conservation and renewable energy. The last week of the academy found students engaged in community service presentations, including an animated film, "Fossil Failure," showing the formation of fossil fuels. Some students follow their academy experience with internships, Welch noted.

Global Warming an Important Component of Science Literacy

Art Hobson of the University of Arkansas followed with a talk that reflected his twin concerns of scientific literacy and global warming. The need for scientific literacy, he began, is emphasized by the American Association for the Advancement of Science in their *Science for All Americans*. The survival of industrialized democracies, he emphasized, depends on science literacy of its citizens, even though a majority of them are not scientists. Science literacy can be fostered by including societal topics in science courses.

One of those societal topics that Hobson feels deserves the highest priority is global warming, and he argued that it should be taught as soon as the requisite physics is developed, not added on at the end. Hobson pointed out that in his own teaching he spends a period on ozone depletion and then a period on global warming immediately after discussing electromagnetic radiation. He regards preserving the ozone layer as a global success story while global warming is the opposite.

To illustrate the effect of global warming, Hobson showed a visual display of energy flow to and from the Earth. Adding the effect of greenhouse gases showed a huge feedback loop in the infrared radiation emitted by the Earth, which has caused an increase in global temperatures, on average, since 1950. We now emit eight gigatons of carbon dioxide into the atmosphere every year, Hobson said, and we need to reduce it by a factor of four. We need to keep the global temperature increase to less than 2°C more than its value in 1950, but an increase of 0.75°C has already occurred, and further emissions already in the atmosphere will cause a further increase of 0.50°C. This leaves only 0.75°C to go, and this requires strong action.

Concluding with some personal reflections, Hobson expressed his view that the business community was the key to solving the problem. He noted that preservation of the ozone layer was in doubt until governments and industry (previously in opposition) banded together in 1985 to formulate the Montreal Protocol. In contrast, he noted that the Global Climate Coalition (led by Exxon-Mobil) and the George W. Bush Administration opposed attempts to deal with global warming, and the fate of the cap-and-trade bill passed by a slim majority in the House of Representatives is uncertain. Regardless of the probability of the reality of global warming, Hobson insisted that it is worth investing in insurance to prevent it.

Auto Fuel Economy, Size, and Safety

Next to speak – about auto fuel economy, size, and safety – were Marc Ross and Abigail Mechtenberg of the University of Michigan, host institution of the meeting. Fuel intensity, weight, and engine displacement of cars

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MacKay lays out plans for sustainable energy

by John L. Roeder

From my earliest days as an energy educator, during the energy crises of the 1970s, I often pondered the energy future of planet Earth. Given the finite supplies of nonrenewable energy sources, I realized that ultimately we would need to rely solely on renewable sources, as had our forebears prior to the Industrial Revolution. Except for biomass and direct heating from solar or geothermal, these renewable sources seemed particularly primed to produce electrical energy. Biomass seemed to be the only source that could yield a substitute for the fossil fuels which presently provide 85% of our energy.

An energy future based entirely on renewable energy: that was point B. It was very different from the point A at which we presently still stand. And there was no road map to tell us how to get from point A to point B. Until now. Such a road map has been provided, at least for citizens of the United Kingdom, by David J. D. MacKay, Professor of Physics at the University of Cambridge, in his "free book," *Sustainable Energy – without the hot air*. It's free in the sense that you can read it and download it from the Internet at <www.withouthotair.com>. You can also download a 10-page synopsis. But the book is so handsomely produced and depends so strongly on its use of color that you might find it really worth springing for $49.95 to purchase a softbound copy.

MacKay's basic program is to tabulate the sources of energy "consumption" and "production," the former in red, the latter in green, and see how they "add up," and he does this in very personalized energy units – kilowatt hours per day per person (kWh/d-p) – energy units that people can relate to from their electric bills. He uses "consumption" and "production" in the sense that they are commonly referred to in everyday use, and this enables him to reach the general public better with what he has to say; but, as a physicist, I feel the need to remind readers of this article, as I do in *Teaching About Energy* (recently published by the American Association of Physics Teachers), that – given the First Law of Thermodynamics – energy is neither "produced" or "consumed." Rather, it is *transformed* – from one form to another. Our transformation of energy usually transforms energy from a "more useful" to a "less useful" form (typically thermal energy). This is what underlies the *Second* Law of Thermodynamics, which is really responsible for our energy crises.

In Part I of his book, which he calls "Numbers, not adjectives," MacKay alternates between sources of consumption and production, representing the respective amounts by red and green boxes, respectively, as he goes along. The 15 sources so described in 18 chapters are further elaborated in eight technical chapters in Part III. The first to be considered are automobile travel, which costs 40 kWh/d-p for one 50 km round trip, and wind energy, which can provide only half that if a tenth of the United Kingdom is covered with twice the current number of windmills in the world. The consumption further outpaces the production when MacKay next takes on air travel: one round trip flight per year to a city 14,000 km distant (he gives his readers in London the choice of Capetown or Los Angeles) amounts to 30 kWh/d-p, almost the cost of driving all year long.

But this energy cost seems related mostly to the length of the trip. Planes are already designed for operating at maximum efficiency, he points out, and the efficiency of a full plane is equivalent to that of a double occupancy automobile (with the plane's efficiency further improved by flying short hops in order to reduce the weight of fuel carried). Both planes and autos, MacKay notes, need to overcome air resistance, but a plane at optimum speed (540 mph for a Boeing 747) needs the same amount of energy keep the plane up as to overcome air resistance. Making a longer plane would require more energy to keep it up, but adding additional cars behind a land vehicle adds cargo space without extra air resistance, hence the efficiency improvements afforded by swing buses, tractor trailers, and trains (which MacKay cites specifically on p. 118). Only if the distance between stops is less than 750 meters does braking exceed air resistance as the primary source of energy "loss" (transformation to thermal energy) for land vehicles.

Adding solar energy puts production ahead of consumption, but this requires a hundred times the photovoltaic panels now in operation worldwide. This enables energy production to stay ahead of energy consumption – until he gets to "stuff" at the end, which he says is known as "goods" in a shop, becomes "clutter" and eventually "rubbish" at home. In his prospects for offshore wind energy, though, MacKay is leery about the materials requirements, but he is surprisingly sanguine about the prospects for tidal energy and gives seven reasons therefor: 1) it's predictable and regular; 2) it will last millions of years; 3) its hardware cost is lower than that for photovoltaics; 4) its power density is greater than that of wind; 5) it is not endangered by severe weather; 6) it's not visible from land; and 7) the staggering of tides at UK tidal

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Rigden: "post-bachs" to increase support for physics

John Rigden is no stranger to the readers of this *Newsletter*. When it comes to physics education, he has been "thinking outside the box" for years, and his remarks upon receiving the Andrew W. Gemant award from the American Institute of Physics on 27 July 2009 at the American Association of Physics Teachers meeting in Ann Arbor, MI, were no exception.

Rigden began his address on "Physics and the Public: Who? Why? What? How? When?" by observing that the world changed for physicists in 1989-1990. That was when the Cold War ended, he noted, and until then physicists were pampered because they were needed for their knowledge of missiles and nuclear weapons. The year 1990 also saw the launch of the Human Genome Project and the Hubble Space Telescope, Rigden pointed out.

Rigden then moved to 2004 and noted that the American Physical Society (APS) that year established the Historic Sites Initiative to place plaques on sites important in the history of physics. Historical plaques call attention to things that cause their viewers to change what they were thinking, he observed. Wouldn't this be a good way to get people to think about physics? In this way, he said, these plaques could showcase physics. Sixteen sites have been so honored, Rigden went on, but only two held commemorative ceremonies beyond the scope of a weekly colloquium. Such colloquia did little more than showcase physics to physicists, he observed, and we don't need to do any more of that. Rigden cited a Pew – APS survey which found that 85% of physicists consider public ignorance of science to be a problem, yet only 3% of them had spoken to a reporter.

The year 1990 also saw finalization of the Superconducting Super Collider (SSC) site in Texas. This was something that would collect the data needed to spark a resurgence of particle physics, Rigden continued, but this was not communicated to the public, and three years later Congress defunded it. He noted that, in contrast, Congress has looked more kindly on the Hubble Space Telescope (HST), funding costly repair missions five times, the last time in reaction to cancellation of the mission by then President George W. Bush. Moreover, the Hubble Heritage Project established by astronomers has sifted through HST pictures and distributed them publicly on a weekly basis. These pictures have provided us insight into our place in the universe and, in return, the public has shown its gratitude. Rigden pointed out how the examples of the HST and the SSC make clear the importance of support of science by the public.

Rigden then reported the results of a survey he took by asking fellow passengers at an airport whether they had taken a course in physics. Eight of twelve said yes. But when they were asked what they remembered, six said "nothing" and the other two recited "A body in motion . . . ." A single required course in physics is unlikely to build the needed public support of physics, Rigden concluded.

Rigden next cited the thesis of Princeton senior Wendy Cobb, which advocated that the brightest college graduates commit to teach two years in urban schools. This thesis later became the basis of Teach for America, under which countless students have benefited from good teachers. Those who have served in Teach for America will take with them firsthand knowledge leading to advocacy of education, Rigden pointed out.

Like Wendy Cobb, Rigden added, many college seniors don't know how they want to spend their lives. What if we invited them to serve as "post-bachs" in physics laboratories? We might be surprised how they could catch on and develop support of physics, he suggested.

The applications of physics to everyday life are not the way to appeal for public support of it, Rigden maintained. Rather, support of physics needs to be based on the basic knowledge it will provide. To illustrate this, Rigden said that when he shows slides of Alexander Fleming and John Bardeen, whose work has touched our everyday lives in significant ways, no one recognizes them. But when he shows a picture of Einstein, the picture is immediately recognized by all.

From taking a fine arts course he didn't want to take, Rigden said he was liberated from his until-then ignorance of art. In our physics courses we need to liberate our students from their ignorance of how the world works. But, he emphasized, we need to show them the big picture, rather than build up incrementally from space and time, so that they can see why it is important to them for a lifetime. If we don't, he cautioned, we might find ourselves keeping company with the ghost of the SSC.

(*Editor's Note*: Rush Holt's review of Al Gore's *An Inconvenient Truth* (both book and movie) in the 13 July 2007 issue of *Science* suggests that Gore achieved the kind of recognition of science that Rigden is talking about. Holt's Ph.D. in physics gave the 12th district Congressman from New Jersey plenty of background to critique the former Vice President's science, but Holt lauded

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Smolin: continue the culture of science

In speaking on "The Role of Scientists and Science Teachers as Public Intellectuals" upon receiving the Klopsteg Memorial Award from the American Association of Physics Teachers at its meeting in Ann Arbor, MI, on 28 July 2009, Lee Smolin of the Perimeter Institute of Theoretical Physics in Waterloo, Ontario, focused on the importance of preparing the next generation to carry on the practice and progress of science and to promote its ethics and values. The health of our common culture is a responsibility of all teachers, he said, noting that not everyone appreciates what is expected in a democratic society.

Smolin listed the following ethical principles, adherence to which forms the basis of science:

1) Decisions must be based on rational arguments based on public evidence if it is available.

2) If sufficiently public evidence is not available, we must tolerate diverse points of view.

These principles embody the values not only of science, he emphasized, but also of a pluralistic democratic society.

However, Smolin went on, even a pluralistic society must have coherence – a vision of itself – and must relate to the natural, social, imaginative, and spiritual worlds in which we live. Without coherence among these worlds we cannot give a consistent message to the next generation. One symptom of this was the "two cultures problem" posed by C. P. Snow. One consequence of the incoherence of these worlds is lack of talk about the future, and a society without a coherent conversation about its future may not have one, Smolin said. In today's world, Smolin said he particularly noted failure of neoclassical economics and mismatches of electronic interfaces as symptoms of incoherence.

Smolin's advice to teachers is that they teach the *real* subject, with all its mystery, challenges, and discoveries as early and widely as possible. He noted that, as a high school dropout, his first introduction to physics – from Herbert Bernstein at Hampshire College – had been quantum mechanics. Smolin said that he would deemphasize Newton as the core of the introductory physics course, since the applications of Newtonian mechanics are limited, and cited John Dell at Thomas Jefferson High

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Eisenkraft: Physics for All

The awarding of the Millikan Medal of the American Association of Physics Teachers (AAPT) to *Active Physics* Director Arthur Eisenkraft happily coincided with publication of the program's new third edition, and Eisenkraft used that occasion to explain how that program addresses his fundamental concern about science education, "Physics for All." Speaking on 27 July 2009 at AAPT's summer meeting in Ann Arbor, MI, he distinguished "Physics for All" from "Physics First" and then went on to talk about what he meant by "physics" and "all."

By "all" he meant the same "all" as in "freedom for all." To illustrate what he meant by physics, he observed that we let youngsters play little league baseball and the cello – and we don't expect them to meet the standards of the National League or Yo-Yo Ma. So let it be with physics, he said: the argument that "it doesn't have enough math" doesn't show up in any other field.

Although Eugene P. Wigner talked about the "unreasonable effectiveness" of mathematics in explaining the physical world, Eisenkraft argued that physics shouldn't be a second math course. He added that physics teachers shouldn't think that they can cover the math in less time than the math teachers. Given d and asked to find t, he claimed that students can use $d = \frac{1}{2} at^2$ by trial and error faster than they can by transforming the equation to $t = \sqrt{2d/a}$. Noting the self-education of one of history's greatest physicists that left him with a weak mathematics background, Eisenkraft wondered whether we would turn down Michael Faraday if he applied to be a student in a 21st century physics course.

Active Physics uses the Activity Before Concept approach, Eisenkraft next noted, and this calls for students to experiment with lenses before being told about the images they can form. Many students, he said, are surprised to find that the images are upside-down. With some students, Eisenkraft went on, a model of ray formation can be developed, similar triangles identified, and the lens equation derived. But all can graph the distance from the image to the lens vs. the distance from the object to the lens, and some can recognize that the graph is a hyperbola, determined by the lens equation. How many students, Eisenkraft then wondered, can predict what happens if the lens is split? What, then, is the "real" physics in this situation: being able to come up with the lens equation or being able to predict what would happen if the lens is split?

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Smolin

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School as an example of a teacher who does this. Smolin so advocates quantum mechanics as an AP physics course or freshman college course.

Smolin also urged ambassadors of science to tell the truth, admitting failures, because they are an integral part of the process of science, and *not* to try to do fund raising. Moreover, in interacting with those who do not share the views of science, we must be respectful, lest we violate our own values of tolerance.

As critics and philosophers, Smolin pointed out, our aim is not publicity or outreach but rather reflection on deep, fundamental issues. We should write in plain language and avoid jargon of our own specialized field.

Smolin closed by sharing encouragement he has found from blogging and collaborations between scientists and artists. He said that he sees the present two cultures as those who work with nature and those who work with their fingertips and texts. He also sees a third culture that doesn't fit into the other two and urges that it be treated respectfully as well.

One contributed paper later in the afternoon would have made Smolin happy. David Jackson of Dickinson College described how he had used Daniel Styer's *The Strange World of Quantum Mechanics* in a freshman college seminar which required students to make podcasts based on what they had learned.

Getting the physics right on a TV sitcom

David Saltzberg is a neutrino physicist at UCLA. But about three hours of his week are spent as a consultant to the TV sitcom, "The Big Bang Theory," because they are interested in "getting the physics right." Being available (because of his nearby location) to give quick responses with multiple options was instrumental in his getting this job, he said in an hourlong presentation to the American Association of Physics Teachers in Ann Arbor, MI, on 27 July 2009, "A Physicist Scattering on Hollywood," which featured illustrative clips from the show.

Saltzberg said that he sees the show as a way to enhance science in the media, especially when other sources are cutting back. To help "The Big Bang Theory" represent physics accurately, he has not only reviewed their scripts but has also arranged tours of physics labs and graduate students' apartments, to show the show's producers how physics is actually done. As a result of this, there is no wearing of lab coats on the series and no pristine labs.

Eisenkraft

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Active Physics addresses "real" physics, Eisenkraft pointed out, with project-based learning, with experiences designed to give students opportunity to learn what they need to complete the project. Prior understandings are elicited with "What Do You Think/See?" questions, an "Investigate," "Physics Talk," "Active Physics Plus" (for some), "What Do You Think Now?" and the essential questions: What does it mean? How do we know? Why do we believe? and Why should I care? We claim to be able to predict the future with physics but caution students against predictions from pseudoscience, he went on. This is why "What do we believe?" is important.

Returning to the theme of "Physics for All," Eisenkraft observed that going from teaching physics to 25% of U.S. students to 100% is "harder for us and harder for them." But he cautioned that lowering expectations of our students has the effect of lowering their performance. Rather, our slogans in aiming for "Physics for All" should be "This is important," "You can do it," and "I won't give up on you." Noting that Galileo wrote his *Dialogue* in Italian so that *all* his fellow countrymen could read it, Eisenkraft issued the following concluding call: "Let's finish what Galileo began – physics for all."

Rigden

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Gore more for doing what pronouncements by the AAAS, AGU, AMS, and IPCC had not done – awakening public concern to the point that politicians noticed. Now that the public is aware of human-induced climate change, though, Holt observed, it needs to recognize the threat posed by such climate change but also realize that solutions are possible.

Holt also suggested in his review that the science community take note of how Gore conveyed his message – by using effective graphics and telling a story, including the invocation of a similarity with the doubt-sowing employed by tobacco companies. Holt likened the dramatic impact achieved by Gore to that of Rachel Carson's *Silent Spring*.)

Westinghouse President Charts Nuclear Renaissance

With demand for energy expected to double by 2030, concern about greenhouse gas emissions making continued use of fossil fuels counterproductive, and renewable energy sources not being practical for meeting baseload requirements, President and CEO Aris S. Candris of Westinghouse Electric answered "yes" to the question posed by his talk, "Nuclear Energy – Is There a Renaissance?" to the American Association of Physics Teachers in Ann Arbor, MI, on 28 July 2009.

In addition to providing reliable baseload electric energy with no emissions of greenhouse gases, nuclear energy, according to Candris, is characterized by low cost per kWh (1.72¢ versus 2.37¢ for coal, and even more for other fossil fuels) and a high capacity factor. The capacity factor is the percentage of time an energy source actually produces electricity, and it is now 90% for nuclear, as opposed to 71% for coal, 32% for hydroelectricity, 30% for wind, and 19% for solar. One reason for this high capacity factor is a tenfold reduction in unplanned reactor shutdowns – compared with about 530 in 1985, there were only about 20 in 2007.

Nuclear, Candris said, now provides 20% of all energy worldwide. Moreover, he added, because of high transmission losses and the large distance from the Midwestern plains which generate the largest amount of U.S. wind energy to the coasts where it is most needed, T. Boone Pickens has now abandoned his once-heralded wind energy plan.

Mindful of the cost overruns and construction delays that characterized the U.S. nuclear industry even before the 1979 accident at Three Mile Island, Candris went on to emphasize that these negative aspects of yesterday's nuclear industry have changed. The industry now offers nuclear power plants that are already designed and licensed, with modules delivered to the site from factories, thus ensuring quality, and a short (48-month) construction schedule. The footprint of new plants is only about a third that of the old ones, with passive safety designs.

Although the Three Mile Island accident thirty years ago was publicly perceived as a disaster, it turned out not to have any serious health effects, Candris said. Although the 1986 accident at Chernobyl *did* have dire consequences, Candris emphasized that it was an accident that could not happen in a western reactor, because of design and licensing differences. Since then, he noted, nuclear power has enjoyed an excellent safety record, with radiation exposure of workers now only a sixth of what it was in 1985. As a result, nuclear now has a greater than 50% public approval rating.

Regarding the issue of nuclear "waste" which still is the greatest concern that many have about nuclear power, Candris pointed out that the "spent nuclear fuel" removed from reactors is really not waste, because 95% of the potential energy originally contained in the fuel rod is still there, some in the form of fissionable U-235, and Pu-239, but most in the form of U-238. Although our current policy of once-through processing of nuclear fuel can't extract energy from U-238, U-238 can be converted to fissionable Pu-239 by absorbing a neutron in a reactor and experiencing two beta decays which occur rather quickly. But with the Yucca Mountain site once slated to be the repository of spent reactor fuel now on "hold" (the current Senate majority leader comes from Nevada, which has long opposed the site), Candris suggested that the time is ripe for "reprocessing" the spent nuclear fuel – in advanced recycling reactors. These reactors have not been developed yet, and their design – from "scratch" – is presently only in the conceptual stages. (U-238 cannot be fissioned directly by neutrons with amounts of energy typically found in the light water reactors operating today, and this would discount the implication of a reactor that could fission U-238 directly and bypass the role of plutonium, which is more toxic, as portrayed in the coverage of articles in the June 2009 issue of *Discover* in our Winter/Spring 2009 issue.)

From a present 372 gigawatts worldwide, Candris projected that nuclear electricity generation would rise to 498 gigawatts in 2030 and after that soar to 1280 gigawatts in 2050. Much of the increase, he emphasized, would be in China, where Westinghouse has already signed contracts to complete new nuclear power plants in 2013. Meanwhile, Candris noted, 25 applications have been made to the Nuclear Regulatory Commission to build new nuclear plants in the U.S., with six of them followed up by contracts, all with Westinghouse, for plants due to come on line in 2016. These new nuclear plants would be what Candris calls "generation III+," whose design has evolved from that of today's operating "generation II" reactors with the addition of enhanced passive safety features. As noted above, they are prelicensed and predesigned, and built with modular construction.

(*Editor's Note*: The design features of Generation III reactors and the possible design features of the generation to succeed them are reported in fuller detail in our Fall 2005 issue.)

R_xeSEARCH portrays drug development

The discovery of a new disease gives the pharmaceutical industry a new to develop a new drug – to treat or cure the new disease. Development of a new drug approved by the Food and Drug Administration (FDA) starts with testing as many as 10,000 in a process called "drug discovery." Of these about 250 will be chosen for "Pre-Clinical" trials, which could lead to an IND (investigational new drug) application for five to undergo three phases of Clinical Trials. Total cost: about $800 million.

Introducing high school students to this process is *R_xeSEARCH: An Educational Journey*, which "follows the drug-development process from the spark of an idea to the delivery of medicines to patients. . . . ." It "was created by a public/private partnership team including the National Science Resources Center . . . ; the New Jersey Department of Education; seven New Jersey and New York State school districts; and various educational and pharmaceutical consultants, with Bristol-Myers Squibb as the originator and catalyst" (it was based on a program Bristol-Myers Squibb developed to educate new employees).

The eleven lessons in the curriculum provide students a simulated experience of the drug development process through a series of activities and readings, through which the case study of developing an antibiotic to treat the fictitious disease "High School-related Syndrome" (HSS), caused by *Rickettsia*, is interweaved. The first activity, which introduces the process of disease transmission, is a variation of the "Red Disease" activity in the "Epidemiolgy" module of the New York Science, Technology, and Society Education Project in the late 1980s and early 1990s, in which students are given a cup of liquid and interact by exchanging the liquid in their cups and are then tested by adding phenolphthalein to the liquid in their cup to see whether it turns red. Other activities illustrate compound identification through paper chromatography, model the synthesis of aspirin from its precursors with molecular model kits, simulate paperwork related to testing the drug, named Amacidin, developed to treat HSS, and eventually develop ways to market it under its brand name of "AMASIM."

Although development of a new drug must be based on scientific considerations, subtitling the name of the curriculum "An Educational Journey" is a reminder that economic considerations must be made as well. This shows up early in the process in the need to weed out all but the most promising chemical leads in the pre-clinical trials: since compounds that are not safe or efficacious cannot be approved for pharmaceutical use, testing them is a waste of money. And once a drug is approved, usually about seven or eight years after its 20-year patent has been taken out, the company must develop optimum marketing to maximize earnings for the remaining years the patent gives the company exclusive control over manufacture of the drug, for without earnings, the company has no financial resources to develop further new drugs.

PEP addresses chem and bio of drugs

In order for drugs to have an effect on the human body, they must get to their site of action by interacting with enzymes or cell surface receptors and "mimic or block the effects of chemicals in the body that interact with these same cellular targets," according to six modules on the effects of drugs developed by the Pharmacology Education Partnership (PEP), a "joint venture among Duke University Medical Center, the North Carolina School for Science and Mathematics, and biology and chemistry teachers across the U.S."

According to an article in *Science* (Nicole C. Kwiek, Myra J. Halpin, Jerome P. Reiter, Leanne A. Hoeffler, and Rochelle D. Schwartz-Bloom, "Pharmacology in the High-School Classroom," **317**, 1871-1872 (28 Sep 07)), the partnership was formed to develop these six pharmacology content modules to offset the low TIMSS performance of U.S. high school students. The goal was to reach high school students with concepts in chemistry and biology that directly affected their lives – through the action of drugs on their bodies.

The drugs considered in these modules include nicotine, tetrahydrocannabinol (THC), cocaine, morphine, methamphetamine, nerve gas, aspirin, digoxin, and steroids. In order for a drug to have an effect on the body, it must enter the body, and there are basically four ways to do this: 1) direct injection, 2) smoking (inhaling a vaporized form of the drug), 3) snorting, and 4) oral ingestion. Direct injection leads to the fastest action of the drug, because it has no barriers to traverse to get into the bloodstream. Ingestion is the slowest, because the drug must pass through the mucosal lining of the stomach and survive digestion or breakdown to reach capillaries leading to the bloodstream.

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PEP: chem & bio of drugs

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The stomach has other effects on drugs as well, due to its acidic pH. Alkaloid drugs like nicotine, cocaine, and morphine (distinguished by containing a nitrogen atom) are all weak bases. In the plants that produce them – *nicotina tabacum*, *erythroxylon coca*, and *papaver somniferum*, respectively – these drugs are water soluble and exist in ionized form. In this form, the only membranes through which they can easily pass are those of capillaries (and *not* capillary membranes in the brain). The stomach's acidic pH converts these drugs to acid salts. Once into the bloodstream, their next stop is the liver, where they are partially metabolized, usually into more ionized forms of the parent drug, which are more easily excreted into the urine. (This is the basis of urine tests for drug use.) Thus, activity of these drugs is diminished if administered orally.

Although morphine is typically administered by direct injection, cocaine and nicotine are usually taken in by smoking (which achieves fast action because of the large surface area of the lungs), but not even this is as simple as drying and grinding the plant, then setting a match to it. Remember that these drugs are produced in ionized form, and there are two reasons that they need to be converted to unionized form: 1) the ionic bonds holding the ionized form of these drugs together are so strong that the vaporization temperature is higher than the molecular structure of the drug can withstand; and 2) only the unionized form of the drug is able to penetrate the membranes needed for it to have its desired effect in the body. The unionized form can be achieved by adding a base, as is the case with "freebasing" cocaine; tobacco companies achieve the same effect in nicotine by adding the base, ammonium hydroxide. The reason that the more traditional snorting of cocaine enables an effect is that the body's slightly basic pH (7.4) converts the acid salt to a free base, though the "high" from snorted cocaine is delayed (minutes versus seconds for smoked cocaine) and not as great but also lasts longer. Presumably the same relationship would hold for snorted tobacco (snuff), although this is not discussed in these modules. In contrast to the alkaloid drugs, THC is an oil. Because it exists only in unionized form, it requires no "chemical tricks" to be made smokable.

In addition to urine, drug tests can be done with hair samples. Drugs in the blood can enter hair follicles through capillaries or sebaceous glands connected to the follicles. Drugs in the air, like second-hand smoke, can also enter the part of the hair exposed to the atmosphere. In either case, the drug binds to melanin, the compound in the hair that gives it color, and since darker hair contains more melanin, it will absorb a larger amount of drug. The acidity of melanin also causes melanin to convert alkaloid drugs to their acid salt form, making it harder for them to diffuse back across the capillary membranes. Drugs incorporated into hair from the atmosphere will be incorporated uniformly over the exposed part of the hair and will not include any metabolites of the drug, as would be the case for drugs entering hair follicles. Drugs will appear in hair roots eight hours after use and move upward in the hair with its growth at the rate of about one centimeter per month.

As noted above, once a drug molecule has reached its target in the body, it must interact with it in order to cause an effect. For example, nerve gas, which can enter the body through the skin and eyes as well as the lungs, binds to the enzyme acetylcholinesterase and competes with the enzyme's natural substrate, acetylcholine. Acetylcholine, a neurotransmitter, modulates signals between a neuron and another cell. Acetylcholine is an ester made from choline and acetic acid, and its hydrolysis by acetylcholinesterase to produce choline is necessary for synthesis of new acetylcholine molecules. The binding of acetylcholinesterase by nerve gas molecules thus leaves the neurotransmitter free to activate dendrites in other neurons repeatedly, thus overactivating the nervous system.

Because nicotine targets the same receptors which acetylcholine activates, nicotine has the effect of mimicking the action of acetylcholine. In fact, nicotine serves as an insecticide by paralyzing the muscles of insects and would do the same in humans with sufficiently high doses. Nicotine also increases blood pressure and heart rate in the circulatory system and reduces appetite when bound to receptors in the hypothalamus; but the pleasurable effect of nicotine comes from binding to receptors in the forebrain.

The action and effects of cocaine are very similar. Cocaine binds to plasma membrane transporters and blocks the transport of the other neurotransmitters, namely dopamine and norepinepherine. Dopamine is associated with feelings of pleasure and reinforcement, and its effects are inactivated when dopamine is transported into neurons via a transporter where it is enzymatically broken down. The pleasurable effects of cocaine are felt upon binding to dopamine transporters and increasing the lifetime of dopamine in the forebrain. Also, as with nicotine, cocaine affects the hypothalamus to reduce appetite and raises blood pressure and heart rate in the circulatory system as well. Cocaine's anorexic effect on insects makes

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Another Archaeological Dig

by Bernice Hauser

Last fall I wrote an article, "Simulating an Archaeological Dig" for this *Newsletter*. Fortuitously I then discovered that the Jewish Museum, located at Fifth Avenue and 92nd St. in New York City, was offering an educators workshop called "Archaeology and the Dead Sea Scrolls." I eagerly signed up for this educator's workshop, because it offered the opportunity to learn about daily life in the ancient world in a dynamic and engaging way. Participants would explore additional strategies for teaching the development of complex societies through the use of artifacts as primary source material. The main speaker was Dr. Neil J. Goldberg, who is Archaeologist in Residence at the Dalton School. His address highlighted his unique way of teaching with artifacts, thus bringing archaeology to life in the classroom.

How did his strategies, lesson plans, and activities differ from what I had described in my Fall 2008 article? The primary difference is that my approach – very generic – was an introductory set of activities aimed at a primary grade level to introduce both teachers and students to the rudimentary tenets of using archaeology as a scientific tool to learn about not only past cultures but also present ones and those in the future. Goldberg's creative program at the Dalton School in New York City is very specific: it carefully connects with the disciplines and core curriculum of each of the grade levels at Dalton. Goldberg has structured a special program mapped out so skillfully that educators could easily replicate his suggestions and lesson plans for each of the grade levels. What was so enthralling was his explanation of how he came to create a site-structure that is the lynchpin of this exciting program. With the support of Dalton's trustees, parents, faculty, and administration, he fashioned a structure built to specification that could hold various layers of artifacts. Thus students, studying a particular era of a city's or culture's history would actually have to dig through myriad layers in this site-structure and then clean, analyze, weigh, draw and discuss any artifacts that they had discovered buried and concealed in a specific layer. This last procedure/process activity is not radically different from the systemic approach that I had employed in my article, which mirrors and complements many of the same activities.

So if one studies how Goldberg is using archaeological simulations, one perceives how sophisticated and advanced his conception and orchestration and facilitation are. It is to Dalton's credit that they hired someone who has expertise in the field of archaeology. In his discussion and slide show, he walked us through the process that went into the creation of this site-structure. He also displayed slides of students engaged in the scientific tasks of analysis, making observations, mapping the sites, keeping logs, using description cards, and incorporating team work and cooperation among the budding student archaeologists. He worked closely with each grade to integrate their social studies curriculum with this hands-on approach. What I particularly gleaned from him was that his site-structure (as shown in his Power Point presentation) had different layers that incorporated the different eras of New York – the era of the Native Americans, New Amsterdam, and colonial times through the present New York City. I noted how carefully students had to tunnel through the various layers in order to research the specific layer of artifacts that would enhance their social studies curriculum. Goldberg usually limits the structure to four layers; he found many of these objects that he uses in these layers on the streets of New York City. But he also has a list of vendors whom he uses to supply certain artifacts for his site-structure that he feels crucial to the students' knowledge and concept-building abilities.

The Jewish Museum also issued to the workshop participants a book titled *Archaeology: A Resource for Educators*. The following activities are taken from this resource book.

#1. Activity: Time Capsule – appropriate for second and third grade

Aim: To create a representative portrait of contemporary culture by choosing appropriate objects to include in a time capsule.

Materials: A container for the time capsule, time capsule objects brought in by students, and shovels.

Procedure: Future archaeologists will study objects from the present to learn about our lives and culture. The time capsule can be buried on property owned by the school or on another location.

Discussion: In deciding what to bury in their time capsule students should think about questions such as the following:

- What do you want future generations to know about you?

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Archaeological Dig

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- Which objects best reflect what you want people to know about your culture?
- Do you think people could misinterpret any of these objects?
- Which objects do you think will be most likely to survive intact?
- Which objects do you think would be least likely to survive?
- Do the objects you have chosen to include create an accurate picture of life in this time and place?

Students should not be concerned about bringing in a valuable or non-valuable artifact. Archaeology is about piecing together a picture of the past based on all the evidence. Every artifact contributes to understanding and sometimes the simplest objects offer the most salient clues.

#2. Activity: Making Forms of Currency

Aim: To design a coin with personally meaningful imagery

Materials: Pencils or markers, copies of coins brought in by the students

Procedure: Ancient and modern coins reflect a wide range of imagery and ideology. Their designs express nationalistic, religious, and artistic themes. Students examine coins and discuss the imagery they see. They discuss what are similar and what are different about the coins. They discuss ideas that might be expressed through the images on the coins. Students then are given the opportunity to design their own coins. They may work alone or with a partner. The coin has to have an image on both sides. Student share their work and discuss their ideas with the class.

Follow-up: Visit the United States Treasury Department in Washington, DC. Take a class trip to visit the Philadelphia mint. Visit specific museums that house old coins and/or currency of different countries. Talk about exchange rates and learn the names of the currencies used in places outside of the United States. Learn about the history of money and how currency evolved from the barter system to the present global monetary infrastructure.

#3. Activity: The Ravages of Time

Aim: To experiment with different materials and environmental factors; to draw conclusions about an object's potential for survival under various conditions.

Materials: Samples of materials such as a nail, a rock, fruit, pottery chards, an old spoon, a fragment of old cloth, a fountain pen, an old tool, blank chart, paper, and pencil

Procedure: An archaeologist usually works with an incomplete set of data. One reason is that not all objects survive from ancient times intact. An object's survival depends in large part on its materials and the environment in which it was stored. Students can experiment to see how different materials are affected by environmental conditions. Working with an organic material like fruit, and an inorganic material such as stone or pottery place some of each substance in a different environment such as in a freezer (arctic environment), in water (under-water environment), under a lamp (hot-dry environment), in a sealed cup with a little water (humid environment), or bury them in moist clay (mud or bog environment). Over the course of a few weeks have students observe and record the conditions of the materials in the different locations. Have students note changes in color, texture, smell, and size. Have them discuss these changes. They should be able to answer: to what do they attribute these changes. To what extent does it depend on the material? Which environments created the most change? Which ones created the least change? Why might that be?

Students should observe that the inorganic material remains essentially unchanged in all environments but the organic substance such as the fruit often rots or shrivels in most contexts. Student should chart their results and repeat this activity using other organic and inorganic materials to verify this experiment. In science if the results can not be replicated they are not considered true scientific facts.

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Resources

For teachers:

Archaeology: A Resource for Educators (The Jewish Museum, New York, 2007).

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Katherine Barrett, *et al.*, *Investigating Artifacts: Making Masks, Creating Myths, Exploring Middens* (Teacher's Guide for Grades K-6). (Great Explorations in Math and Science (GEMS), Lawrence Hall of Science, University of California at Berkeley, 2000).
This teacher-friendly curriculum guide for elementary school educators includes diagrams, worksheets, activity ideas, and resources. Two of the four sections – "Uncovering the Past" and "Putting Together Clues from the Past" – are especially relevant.

Colin Renfrew and Paul Bahn. *Archaeology: Theories, Methods, and Practice* (3rd edition). (Thames & Hudson, New York, 2000).
This introductory level college textbook provides a broad overview of the field, with more than 600 illustrations, an extensive glossary, and full index.

Niall Ferguson, *A Financial History of the World* (Channel 13, New York City).

For students:

Michael Avi-Yona, *Dig This! How Archaeologists Uncover Our Past* (Rinestone Press, Minneapolis, MN, 1993.
This slim volume offers an introduction to the methods and pioneers of archaeology and includes concise descriptions of several ancient civilizations. Black-and-white and color photos accompany the text. 64 pages. (Upper, Elementary, and Middle School)

David Macaulay, *Motel of the Mysteries* (Houghton Mifflin, Boston, 1979).
In the year 4022 amateur archaeologist Howard Carson discovers the remains of an ancient ceremonial tomb – which looks an awful lot like a 1970s motel. The gentle satire is funny and clever. 96 pages. (Upper, Elementary, and Middle School)

Richard Panchyk, *Archaeology for Kids: Uncovering the Mysteries of Our Past, 25 Activities* (Chicago Review Press, Chicago, 2001).
The 25 activities outlined in this book cover a wide range of archaeological topics, from the study of the first people to a survey of historical archaeology. 146 pages. (Elementary and Middle School)

websites for educators:

www.digonsite.com
Dig: An Archaeology Magazine for Kids

www.archaeology.org
Archaeology Magazine, a publication of the Archaeological Institute of America

www.saa.org
Society for American Archaeology

www.archaeological.org
Archaeological Institute of America

http://ology.amnh.org/archaeology
Educational resources and activities from the American Museum of Natural History

The Environmental Cost of Science

A pair of articles in the 5 October 2007 issue of *Science* discusses a topic that has become quite sensitive for environmental scientists – the environmental cost of the work that they do. The first article discusses the environmental cost of scientific meetings; the second focuses on the environmental cost of a scientific laboratory.

Writing about "Greening the Meeting," Benjamin Lester notes that the carbon dioxide emissions to fly the 9500 participants an average of 7971 km to the 2002 American Geophysical Union meeting equated to the emissions of the normal driving of 2250 Honda Civics for a year. Virtual conferences using Access Grid emit less carbon dioxide but can be even more costly, and many feel that there is no substitute for the live interplay that only a "live" conference can provide.

In an article titled "This Man Wants to Green Your Lab," David Grimm writes about the efforts of Allen Doyle of the University of California, Santa Barbara, to audit science labs to reduce their consumption of energy and materials. One cited example of energy saving is that turning off an unused fume hood can save the equivalent of the energy used by three average American homes. While some enthusiastically support Doyle's work, others – more concerned about the research – resist it. One sticky point is the risk of rewashed glass rather than once-through plastic in biology labs.

CORRECTION

The lifetime of the tidal barrage on the Severn River (in comparison with that of nuclear plants) in reference #12 of our Winter/Spring 2009 issue should be 120 years, not 12.

MacKay

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sites would allow a combination of plants at all these sites to produce a more constant source of energy over time. (This is only one place at which MacKay cites the problems posed by the time limitations of renewable energy sources and notes the need for ways to match the availability of energy and the demand for it, among them pumped energy storage, diversion of electricity from batteries in electric automobile that are plugged in for re-energizing and from heating and refrigeration that can be interrupted for short terms. He also notes that Denmark backs up the intermittency of its wind-generated electricity (much of which is exported) with hookups to hydroelectric plants in Norway, Sweden, and Germany.)

Also noteworthy are MacKay's analyses of the energy differences in providing different kinds of food. Vegetarians need to provide energy to grow plants and then eat the fruit they bear, at a cost of 3 kWh/d-p for a 2600 Calorie daily diet. But a daily serving of half a liter of milk and 50 g cheese requires a sixteenth of a cow, which consumes 24 kWh/d-cow, which makes the energy cost of the milk and cheese 1.5 kWh/d-p. Likewise, a chicken laying 290 eggs/year requires 110 g feed/day, and this makes the energy cost of an egg 0.1 kWh. But the cost goes up if you want to *eat* the chicken instead of only its eggs. You have to feed the chicken for 50 days, which means an energy cost of 50 times the mass of the chicken times the same energy cost rate as feeding a vegetarian (3 kWh/kg, assuming a 65 kg vegetarian). The cost of pork is greater, because you need to feed the pig 400 days before slaughtering it, and even greater for beef, which requires a "maturity" of 1000 days. The energy cost of eating a half pound of meat, equally divided among chicken, pork, and beef, is 8 kWh/d-p, which means that the energy cost of meat alone for an omnivore is more than twice the total diet for an herbivore.

When MacKay adds all his red boxes in Part I, he gets 195 kWh/d-p, which he notes is greater than the British average energy consumption of 125 kWh/d-p (though this doesn't include the 48 kWh/d-p he has calculated for imports and "embodied" energy). Against this he totals only 182.5 kWh/d-p from renewables, and he notes that this is far more than the projections of reports from five British energy analysis groups. Of this he feels that, given public protests of what massive renewables would do to people's lifestyles, he feels he can count on only 18 kWh/d-p, as listed in the table below.

Source	Present (kWh/d-p)	Projected (kWh/d-p)
Wind	0.16	3
Solar hot water	0.014	2
Solar photovoltaic	0.0003	2
Biomass	0.62	4
Hydroelectricity	0.21	0.3
Offshore wind	0.03	4
Tides	0	3
TOTAL	1.05	18.3

MacKay concludes Part I with two observations: 1) Renewable facilities have to be country-sized; 2) It's not going to be easy to get all our energy from them. And he warns his fellow Brits that "If we are serious about getting off fossil fuels," they "are going to have to learn to say 'yes' to something." (p. 112)

Noting that *BIG* changes are needed to make the transition from fossil fuels to renewable energy, MacKay then begins Part II, which he calls "Making a difference." He notes three ways to reduce demand – reduce population, change lifestyle, and reduce energy intensity through "technology" and "efficiency." He focuses on reducing demand in three principal "uses" of energy – transport, heating, and electricity – in the next three chapters. The following three chapters are devoted to ways to increase the supply, by importing renewable energy or using non-renewables on a renewable basis of lasting 1000 years. He shows that this is impossible for coal worldwide, because it would mean using it at a rate of only 1.6 Gt (gigaton) per year, which is less than the present rate of 6.3 Gt/y. Furthermore, continued increase in the rate of coal use would exhaust worldwide supplies before the end of the 21st century. Things are not that much better with nuclear, for once-through use of uranium could provide only 0.55 kWh/d-p for the required 1000 years, although breeder reactors could escalate this to 33 kWh/d-p. As regards nuclear fission, MacKay isn't holding his breath for it, but he notes that the world's 9.5 Mt lithium deposits could produce 10 kWh/d-p for 1000 years from deuterium-tritium fusion, a figure that could be multiplied by 10 if the 0.17 ppm concentration of lithium in seawater could be tapped.

If Britain decides to import solar energy from the world's deserts, MacKay says that the more economical way to go is to concentrate the incident sunlight, even though focusing the collectors reduces the energy intensity of 20 W/m^2 for energy from direct sunlight on photovoltaic cells. A square 1000 km on a side could accommodate the world's present 15,000 GW

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MacKay

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power consumption, and twice this could accommodate the entire world at the present British energy standard of 125 kWh/d-p. The most suitable locations for solar energy plants are Libya, Kazakhstan, Saudi Arabia, Algeria, and Sudan, which MacKay chooses for their large areas and low population densities. He also notes that locating these plants on coasts would also enable them to desalinate water.

MacKay then formulates five energy plans for Britain that "add up" to provide the following energy needs for transport, heating, and electricity, as follows: 40 kWh/d-p transport, halved by 2050 and 90% electrified, with biofuels apparently providing only air travel; 20 kWh/d-p heating, reduced to 30 kWh/d-p, this too mostly electrified, using heat pumps whose coefficient of performance is now exceeding 4, with only 5 kWh/d-p from wood and 1 kWh/d-p from solar hot water; plus 18 kWh/d-p for electricity, where MacKay sees energy reduction only from replacing light bulbs by LEDs and turning off "vampire" appliances, which use energy when not really being used, all for a total of 68 kWh/d-p.

All five plans include 12 kWh/d-p from pumped heat, 0.2 kWh/d-p from hydroelectricity, 1.1 kWh/d-p from waste incineration (which would also eliminate methane from landfills), 5 kWh/d-p from wood, 1 kWh/d-p from solar hot water, and 2 kWh/d-p from biofuels. They all also include energy from wind (both on and offshore), photovoltaics, and tidal barrages, lagoons, and streams; and some of them include wave power, carbon capture and sequestration, nuclear, and imported solar. In a subsequent chapter MacKay costs a mixture of these five plans at 871 billion pounds, which he notes is not much more than the 500 billion pounds spent to bail out UK banks.

If readers outside the United Kingdom are curious how MacKay's analysis applies to them, MacKay does them the favor of sketching out the renewable energy available to them – again in kWh/d-p – as listed in the table below.

The bottom line MacKay would like readers to take away from this is that renewables cannot fuel our energy future without massive arrays of solar energy.

Although MacKay initially did not intend to discuss carbon dioxide in this book, since fossil fuels can't be burned sustainably anyway, he recognizes it in his penultimate chapter as "the last thing we should talk about." After already advocating a system that charges carbon dioxide emitters $100 for every ton they emit (this would allow other taxes to be reduced and avoid what he considers to be the sham of a cap-and-trade system), he now turns to ways to remove it from the atmosphere. According to the laws of physics, the minimum energy to extract a kilogram of carbon dioxide from the air is 0.2 kWh, and the lowest actual energy cost he has encountered is Klaus Lackner's technology to concentrate carbon dioxide from the air and compress it to a liquid for less than 0.48 kWh. At this rate, the energy cost to remove the average Briton's daily emission of 30 kg of carbon dioxide would be almost that Briton's present use of electricity for all other appliances. Other ways to remove the Briton's daily emission of carbon dioxide require the same big size which MacKay finds required of renewable energy systems: twice the Briton's share of the UK planted in trees, spreading of pulverized rock (to convert silicates to carbonates), and seeding the ocean with urea to stimulate plant growth for fish farming (presently illegal).

"If we are serious about getting off fossil fuels, Brits are going to have to learn to say 'yes' to something." - David MacKay

MacKay closes his Part II the same way as his Part I – with the need to "say yes" to something that will enable one of the energy futures he has found to "add up." Unless we do, he is afraid that we will content ourselves with half-measures that won't "add up" to produce the change that is really needed.

Source	Europe	North America	World
Onshore wind	9	42	24
Offshore wind	-	4.8	-
Hydroelectricity	6.4	7.2	1.4
Wave	2	-	0.5
Tide	2.6	-	0.32
Solar thermal	3.6	3.6	3.6
Photovoltaics on roofs	7	-	-
Biomass	12	-	8 – 36
Geothermal	-	8	8
Subtotal	42.6	65.6	38 + biomass
Photovoltaic farms	54	250	-
TOTAL	96.6	315.6	38 + biomass

"Two Cultures"

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Professor Ann Blair, Brown University Professor Kenneth Miller (whose *Only a Theory* was reviewed in our Winter/Spring 2009 issue), and University of Virginia History Professor Guy Ortolano (who wrote *The Two Cultures Controversy: Science, Literature and Cultural Politics in Postwar Britain*). Burnett posed the following questions to his panel:

What is the pre-history of the concept of Two Cultures?
Why did Snow set it up the way he did?
Why does this concept deserve commemoration 50 years later?

Blair led off by suggesting that the gap between cultures is good, because it creates opportunities for independent pursuit of different types of problems, as happened when philosophy separated from theology, the former leading to the basis of science. In 1833, she said, the term "science" was coined by Whewell as an umbrella term for the further demarcated fields of zoology, geology, *etc.* Concerned that science can be co-opted by politics to shore up political arguments, she argued that science needs to stay demarcated from politics. We need multiple cultures, distinguished by their own authority, she said, yet also bridged.

Miller noted that by coauthoring a best-selling biology text, he has had to serve as a bridge between the scientific and political cultures. At the Dover, PA, trial, he showed that one human chromosome (#2) shows evidence of being the fusion of two previously separate chromosomes, thus accounting for 48 chromosomes in great apes rather than 46 in humans. Although this has been known for 28 years by biologists, it is hardly known to the public. Miller cited this as a lamentable example of the great cultural divide. He also said that, after Dover, he felt that the ID (Intelligent Design) movement was regrouping and that he expected them to re-emerge in terms of "Critical Analysis."

Miller also noted Snow's concern about compartmentalization in education. Noting that the history of science makes a great detective story, he favored teaching it in science courses. But at Brown, he said, where there are no common studies requirements, 35% of Brown's graduates do not take a science course, because they feel that they would never "use" it.

Ortolano pointed out that Snow's more than 15,000 letters are an unusually rich resource. He added that Snow's lecture ran in two parts in consecutive issues of *Encounter*, a monthly – and discussion of it continued in 1960. Ortolano cited four sections in "The Two Cultures" – "Intellectual Luddites" (scientists thinking about the future *vs*. literary intellectuals thinking about the past), "The Scientific Revolution" (in the 20th century – the USSR *vs*. the US), and "The Rich and the Poor" (the importance of the emerging Third World) in addition to "The Two Cultures" – and, given this, he questioned which two-cultures formulation we should be considering.

More Effective Communication of Science Issues to the Public

The next panel, moderated by Deputy Editor of *Discover* Robert Keating, consisted of Paula Apsell, executive producer of *NOVA*, Ira Flatow, host of NPR's "Science Friday," Andrew Revkin, environmental reporter for *The New York Times*, and *Discover* columnist Carl Zimmer. In assessing cultural divides between science and the public, each member of the panel saw a different one. Zimmer saw anti-evolutionism from the right being replaced by opposition to vaccines from the left; Apsell saw a divide between scientists and a public who felt science was "geeky"; Revkin saw divides on both sides of the political spectrum, with opposition arising from being overwhelmed by the complexity of science; and Flatow saw a cultural divide between the "science satisfied" and "religious extreme," the latter of which is not likely to be persuaded otherwise.

Apsell elaborated that *NOVA* has freedom to tell a straight story about controversial science, but some PBS stations are under pressure from local opposition. She has also found technically-employed people at *NOVA* focus groups who are not *NOVA* viewers and complain that they are too tired to want to learn anything from watching *NOVA*. On the other hand, she has found most scientists she has encountered recently to be more willing to communicate the results of their research. She added that she likes *Myth Busters* and feels that it is a science show whose viewers could be won over to *NOVA*, but she wasn't sure about *Dirty Jobs*.

Revkin also found more young scientists interested in spending time, in a world of shrinking science journalism, to communicate the results of their research, and he acknowledged that one good way is their website.

Flatow interjected that in a world of decreased funding for science, scientists should be *trained* to communicate. He recalled a time when his boss asked whether they

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should be concerned about a nuclear reactor in Pennsylvania that could come close to meltdown and cited this as a cultural divide between science and the public, but he also noted that the high ratings seen for "Science Friday"(it is among the top ten downloads on i-tunes) show the public to be hungry for science. Unfortunately, the reduction of science journalists from collapsed newspapers means there are fewer people for scientists to talk to, he lamented. And, in spite of the popularity of "Science Friday," the impression persists that science "doesn't sell," Flatow mourned.

Although Flatow felt that Internet science reporting can compensate for reduced science journalism in print, Zimmer felt that while newspapers provide all their stories in one place, blogs must be sought out by Internet users. Yet, he acknowledged that they do enable conversations that otherwise would never occur. But he cautioned that greater web access to published science papers, though good for science, is not likely to increase science communication to the public.

Porter Urged Scientists to Seize the Moment

The lunchtime keynote speaker was former Congressman John Porter, a moderate Republican who served 20 years on the House Education and Labor Committee and, like Senator Arlen Spector, feels that his party left him. Porter reported relishing the time he spent with scientists and credited the Union of Concerned Scientists (UCS) as being the only group protesting former President George W. Bush's undermining of scientific integrity (see review of the UCS's efforts in this regard in our Winter/Spring 2009 issue). Porter expressed that we now have the right mix in Washington to make the case for science – and, with fewer students wanting to be stockbrokers in the present economic recession, he wondered when we shall have such a window of opportunity again. But it will not be easy, he cautioned: few among the public were focused on President Obama's speech to the National Academy of Sciences, and half the public still believes in Intelligent Design.

Urging scientists not to pass up the opportunity to reverse the regression of communication between science and the public since Snow's lecture 50 years ago, Porter exhorted scientists as he did in his editorial in the 26 September 2008 issue of *Science* to "volunteer to advise . . . candidates on science matters and issues." "They'll love it," he exclaimed. "Offer to serve on their science advisory committee. If they don't have one, tell them you'll create one. Chair it yourself and recruit suitable colleagues. Once your candidate has won the election, offer to continue in your role as a science adviser. Wouldn't it be wonderful if all candidates had science advisers or science advisory committees? They will if individual scientists step up to the plate."

The Role of Political Science

The next panel, hosted by conference co-organizer Chris Mooney, consisted of Darlene Cavalier, founder of ScienceCheerleader.com; Matthew Chapman, a Darwin descendant and cofounder of Science Debate 2008; Francesca Grifo, Director of the UCS's Scientific Integrity Program; Shawn Otto, cofounder and CEO of Science Debate 2008; and former Congressman Porter, who now chairs the Board of Directors of Research!America. Mooney began by observing that in a subsequent lecture, given at Harvard, "Science and Government," Snow recounted how the Battle of Britain might have gone differently had Lindemann's advice not to pursue radar had been followed.

Before World War II, Otto observed, science's appeal was its mystery. After World War II the appeal for science funding was based on fear, and scientists went into the position of resting on their laurels, he continued. But he lamented that of almost 3000 questions asked 2008 presidential candidates, only six related to science, and three were on UFOs. Otto registered his concern about the divide between science and other issues that concern the public more, also that Science Debate 2008 failed to bring about a debate devoted to science policy. He added his opinion that scientific journalists need to be allowed to do general coverage, and general journalists need to cover science.

Grifo lamented that the system is not set up for scientists to do outreach – it doesn't help them get tenure in academia. The system needs to be reconstituted to reward scientists for reaching out, she said. On the political side of things, Grifo noted that the UCS website sports a periodic table of abuses of scientific integrity during the George W. Bush Administration. That efforts are made to adulterate scientific data points up how important it is. The Obama Administration has made major efforts to reverse this, she acknowledged, but at present she said the only grade she can award is "INC."

Porter stated that even if people don't understand science, they should have an appreciation for it and what it does. He lamented that the "amazement factor" about science is gone, and that there are other programs com-

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“Two Cultures”

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peting with it for funds. But Porter cautioned that we cannot take science for granted. Without science, he said, our economy has nowhere to go.

Cavalier asked how scientists can set up a dialog with the public. She saw promise in setting up panels containing both social and natural scientists under President Obama’s guidelines. She also called for reinstating the Office of Technology Assessment (also a recommendation of the UCS).

Chapman acknowledged public ignorance about science and advocated educating the public about what science can do for them. Then, he said, they can be attracted to appreciate it.

The Role of Education and Citizenship

The last panel was hosted by the other conference co-organizer, Sheril Kirshenbaum. Devoted to Education and Citizenship, it consisted of Stacy Baker, Biology Teacher at the Calverton School in Huntingtown, MD; Kevin Finneran, Editor-in-Chief of the National Academy of Sciences policy journal, *Issues in Science and Technology*; Adrienne Klein, Co-Director of Science & the Arts at The Graduate Center of The City University of New York; and Stuart Pimm, Doris Duke Professor of Conservation Ecology, Duke University.

Noting research showing students losing their excitement about science from their elementary years in the interval of grades 6-8, Baker showed a video of her students which indicated that many of them would like a visit from a scientist to their classroom.

When Snow gave his lecture, Pimm observed that he was ten years old, facing the prospect of passing the 11+ exam or a career of working in the coal mines. He agreed with Snow that scientists need to be cultured in the sense of familiarity with the humanities, also that humanists have an obligation to acquaint themselves with the sciences. Pimm held up President Obama’s Science Advisor John Holdren as a good example of a reputable scientist held in good repute for his science outreach.

Klein saw public interest in science reflected by public attendance at science cafés, which have grown to number six in New York City. She also cited examples of art inspired by science and performances, including Lisa Randall’s *Hypermusic Prologue*, reflecting seven levels; *Self Comes to Mind*, premiered at the American Museum of Natural History on 2 May 2009; and *Ferocious Beauty: Genome*, by Liz Lerman and Bonnie Basler.

Finneran observed that there have been many scientific developments that have interfaced critically with the public, with some yet to come – *e.g.,*nanotechnology and synthetic biology. Like fish who don’t realize that they live in water, scientists are not aware of the reaction from the public to their work. He urged scientists to become better listeners to what the public has to say. And, he added, it is important for the public to voice their concerns to scientists. Not everyone has to do everything, though, Finneran remarked. Some people are best teaching students, others best speaking to the public, still others best working in a lab not talking with anyone.

Kamen on Inspiring the Next Generation of Innovators, Engineers, and Scientists

The Concluding Keynote address was a powerful example of what one person motivated about the importance of science and technology to the future of the United States can do and has done. That person was Dean Kamen, who has invented the first wearable insulin pump for diabetics, the HomeChoice™ portable peritoneal dialysis machine, and the Segway® Human Transporter, all as the founder of DEKA Research & Development Corporation.

Kamen prefaced his talk on “Inspiring the Next Generation of Innovators, Engineers, and Scientists” by observing that he has his own thoughts on how the world got as wacky as it is and feels it’s going to get wackier – and that he has ideas on what to do about that, too. “I make stuff,” he said.

Most people on the planet don’t fall into either of Snow’s two cultures, Kamen opined. “They’re ignorant. That’s sad.” Although most scientific developments were not winners of popularity contests, Kamen stressed that the world is increasingly based on science and technology. We don’t need everyone to be an engineer of scientist, he continued, but in a democracy we need at least 51% of our citizens appreciative of what science and technology can do.

Attributing to Einstein the quotation that “the difference between genius and stupidity is that genius has its limits,” Kamen observed that the same National Academy of Sciences (NAS) that produced *Rising Against the Gathering Storm* also published *A Nation at Risk* some twenty years before (see the lead story of our Fall 2005 issue), and he registered his concern that the second NAS

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Energy & Environment

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declined (by 37%, 24%, and 35%, respectively), Ross pointed out, but after we achieved those reductions, we "went to sleep." We make changes only when we have to, or when the public demands it, he added.

Data through 2006 show a decline in traffic deaths per vehicle, Ross continued, but data that would show any effect of the present economic downturn are not yet available. Ross next went on to say that side collisions have been as big a safety problem as frontal collisions. The number of deaths in cars struck at an angle (between 8 to 11 or 1 to 4 o'clock) is least for luxury imports, but second least for compact cars, and greatest for half-ton pickup trucks.

Mechtenberg felt that safety should be considered from the societal point of view (akin to secondhand smoke) rather than the individual point of view. She said that it turns out that areas with the greatest population density have lower death rates from auto accidents than areas with low population density. She and Ross found that the risk to drivers was inversely related to the price of 1998 model cars in 2003 with a correlation of 0.80.

Mechtenberg displayed graphs relating various variables (time, fuel economy, personal risk, societal risk, and combined risk) which can be manipulated to change the variable and played forward in time. They can be accessed online at <http://sites.google.com/site/safetyandfueleconomy/>.

Liquid Fuels

Andy Johnson of Black Hills State University (SD) then addressed the liquid fuels situation. He noted that not until 1984 did world production of oil rise to the level of the discovery of new oil resources and cited Campbell's analysis of worldwide oil production (similar to that of Hubbert for U.S. oil production) which suggests that we are now at the time of peak world oil production. Presently 20% of the U.S. corn crop is replacing 2.4% of U.S. gasoline needs, mostly to replace MTBE (which had previously been used to oxygenate gasoline). But even 100% of the U.S. corn crop could replace only 15% of U.S. gasoline, Johnson said. Our economy depends on cheap oil and gas, and biofuels are not the answer. He sees future changes in our economy that are starting to be felt now.

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report would gather dust like the first. He said that he saw the lack of scientists and engineers as a culture problem (too much obsession with nonsense) and a demand problem (not enough demand for it).

The culture problem, as Kamen identified it, is that kids see Hollywood and sports as their ticket to wealth and feel that they are not cut out for a career in science or technology. Sports are glamorized by trophies and movies by Oscars, he added, presented to people beginning their careers. Science's achievements are Nobel Prizes, presented at the end of careers for things done 30 years previously. Moreover, he went on, science does things so well that it's taken for granted – people complain when the lights are off but don't cheer when they are on.

Kamen's response to this culture problem was to stage sporting events to attract all kids, but with content – robotics competitions among teams sponsored by companies. To this end he founded FIRST (For Inspiration and Recognition of Science and Technology), and its competitions – with 1684 teams from 11 countries – have expended to the point that the finals are held in the Georgia Dome from the 1996 Olympics, after they outgrew Epcot and the Astrodome. Kamen quoted Walt Havenstein of BAE Engineering as saying, "It's the only sport in which every kid can turn pro." He added that Brandeis University has documented that participants in FIRST competitions are 50% more likely to attend college and three times as likely to major specifically in engineering.

Kamen closed with a quotation from William Butler Yeats: "Educating is not filling a pail . . . it is lighting a fire." He urged the technology community to get out there to light the fire.

(*Editor's Note*: Kirshenbaum and Mooney's *Unscientific America: How Scientific Illiteracy Threatens Our Future* is reviewed in this issue by Art Hobson.)

FORTHCOMING MEETINGS

15 October 2009, Twenty-fifth Anniversary of the Pittsburgh Regional Center for Science Teachers (PRCST), Carnegie Museum of Natural History, Oakland, PA. Devra Davis, Director of the Center for Environmental Oncology, UPMC Cancer Center, keynote speaker.

30 November – 4 December 2009, Materials Research Society fall meeting, Boston, MA. For more meeting information, visit <www.mrs.org/fall2009>.

PEP: chem & bio of drugs

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it an insecticide, and its anorexic effects are noted on humans as well.

The physiology of THC seems less well understood. Its molecules bind to receptors which bind to a chemical in the body called amandamide, whose function is still being studied. What is known is that THC targets many receptors in the brain, where it acts to "elevate mood, cause perceptual distortions, increase appetite, and impair short-term memory."

The action of drugs on the body has interesting applications of many chemical concepts. In the case of alkaloid drugs, pH plays an important role. For nerve gas, esterification is a key concept. In the case of methamphetamine, the key concept is oxidation. Methamphetamine causes an increase in the release of the neurotransmitter dopamine, which is normally oxidized with the help of mitochondrial oxidases after its action is terminated. But under the influence of methamphetamine, dopamine can be oxidized without help from oxidases, and highly active oxygen radicals are formed. Normally, these oxygen radicals are converted by enzymes into hydrogen peroxide, but these enzymes can be saturated when concentrations of hydrogen peroxide becomes too high. In the presence of ferrous ions, the hydrogen peroxide is reduced to even more reactive OH- free radicals, which can then oxidize cellular proteins, lipids, and DNA. Such oxidation of cellular proteins, lipids, and DNA can cause cross-linking and polymer formation, which destroys cell function and causes cell death.

The above content is covered in the first five of the modules, all of which were written by Project Director Schwartz-Bloom of Duke University Medical Center and Project Co-Director Halpin of the North Carolina School of Science and Mathematics. Their titles are as follows: "Acids, bases, and cocaine addicts," "Drug testing: A hair-brained idea!" "How do drugs damage neurons? It's radical!" "Military pharmacology: It takes nerves," and "Why do plants make drugs for humans?" The subject of the sixth module, "Steroids and athletes: genes work overtime" is how steroids promote muscle growth by regulating gene transcription. This is risky, the module points out, but many athletes seem to feel that this risk is justified, not only to their health but also to being caught in a drug test.

Steroids are synthesized from cholesterol in adrenal glands and the gonads. Anabolic steroids, which are related to the hormone testosterone, have androgenic properties that participate in the development of masculine characteristics. Steriods can easily cross membranes in the body. These steroids then bind a family of nuclear receptors, which contain domains that bind DNA and activate transcription, leading to synthesis of proteins, according to the cell type and binding site. For instance, muscle fiber proteins are synthesized in muscle cells. Because they are unionized, steroids are difficult to remove from the bloodstream. Instead, they are absorbed into fat cells. This is why, even if an athlete stops using steroids, their presence will still show up in a blood test.

As is noted above, steroids are naturally made in the body. But when sex steroids are taken excessively, the pituitary gland stops the process which causes the body to produce them, and vice versa. The body has difficulty adjusting to abrupt changes in steroid consumption.

Although the authors made every effort to provide an inquiry basis to these modules, it is understandable that there is a limit to hands-on experimentation when controlled substances are involved. But analog experiments have been developed with uncontrolled substances, such as aspirin. In contrast with cocaine, nicotine, and morphine, aspirin is a weak acid, so it becomes primarily unionized in the acidic environment of the stomach and can pass easily through its membranes (but less likely to do so in the less acidic environment of the intestines). Students are asked to adjust the pH of 50 mL water in four separate separation flasks to 3, 5, 7, and 9, respectively, by adding 1 M NaOH, then add one 325 mg aspirin tablet to each, and after that 50 mL of ethyl acetate. Each flask is then shaken, and after the layers separate, equal volumes are removed from the four water phases and spotted on separate pieces of filter paper until the spot is as big as a penny. Finally a 354 nm ultraviolet lamp is shown onto each spot to identify the amount of aspirin in the water mixture at each pH level.

Salicylic acid, a precursor to making aspirin, is produced in large amounts by birch and willow trees for protection against insect attack, and it can be produced by other plants when they are stressed. The activity in the fifth module asks students to test this by stressing a plant, then drying its leaves and massing 0.5 grams and determining how much salicylic acid is extracted into water by 0.25 M NaOH by comparing this solution with that of a known concentration of salicylic acid after Trinder's Reagent has been added. A Spec 20 or a colorimeter can be used to do this.

To illustrate the effect of oxidation in an organic system, the browning of apples exposed to air is considered.

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PEP: chem & bio of drugs

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We are told that this browning results from the presence of both polyphenol and polyphenoloxidase in the apple. Once the interior of the apple is exposed to oxygen in the air, the polyphenolozidase acts to oxidize the polyphenol, and the brown color results. This is inhibited by chilling to $4^{o}C$ and eliminated altogether by boiling, which denatures the enzyme. Inhibition can also be achieved by applying chemical solutions such as those containing chloride ion or ascorbic acid. Students are asked to design an experiment to test a variable that will affect the rate of browning.

In the other modules, paper and pencil activities are the order of the day. The second module presents profiles of people applying for a job that requires drug testing and the results of analyses of their urine and their hair, then asks students to determine which candidates should not be hired and which should be asked for a retest (after, for example, abstaining from eating poppy seeds). In the fourth module students are asked to create a presentation on nerve gas in the format of "Sixty Minutes," with each group of students contributing one portion to the total presentation. In the last module, each group of students is charged with developing a skit about a specific aspect of steroids according to a prescribed scenario.

The modules can be downloaded from the PEP website, www.thepepproject.net, along with an Appendix showing how the content of the modules relates to the *National Science Education Standards*, a content supplement on chemical bonds and forces, and a student self-quiz with answers for each module. According to the article in *Science*, these modules have been field tested by 47 teachers, with an equal sized cohort serving as a control group. When the test scores were analyzed, it was found that the larger the number of modules used, the higher the scores.

(*Editor's Note*: The editor is grateful to Betty Chan for reviewing and revising this article.)

Ehrlich hosts "Rev-up" website for renewable energy resources

by John L. Roeder

If you're looking for education resources on renewable energy, Robert Ehrlich's "Rev-up" website may be just the thing for you. Just go online to <http://www.rev-up.org> and you will find something like what I found when I checked it out on 17 June 2009:

- Reviews of 62 books (one a book by Horn and Krupp, reviewed in the April 2009 *Physics Today*), with requests for reviewers
- A list of 27 media resources, with links
- A list of 14 resources for student projects, some with online links
- A list of 50 speakers
- A list of notes from 8 courses, with links
- A list of 118 places to visit, with links
- A list of 66 college programs, with links
- A list of 47 current research programs, with links
- A list of 12 simulations, with links
- A list of 36 demonstrations and kits, with links
- A list of 50 internships, with links.

If you know of resources that are not listed, you can tell Ehrlich about them (at <rehrlich@gmu.edu>), and you can add your own contributions to his lists of resources as well.

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:

1. The R_x*eSEARCH* curriculum described in this issue describes the role of economics as well as that of science in the development of new drugs. That a company needs to employ optimum marketing strategies to maximize earnings from a new drug for the remainder of the 20-year duration of its patent, so that the company can continue to build up its financial resources in order to develop further new drugs, gives one pause to wonder about the extent to which decisions were made *not* to develop drugs because their projected earnings were too small. What incentives could be provided to foster development of drugs that would satisfy unmet medical needs but not bring about "blockbuster" earnings?

2..Michael Scott Moore reports in the July-August 2009 issue of *Miller-McCune* that Germany's "feed-in" tariff, which requires electric utilities to pay producers of electricity from renewable sources more than the market rate, has driven the percentage of electricity from renewable sources up to 14%, more than double the percentage in the U.S. (Utilities can recoup the added cost by selling "green electricity" to those willing pay more for it.) Moore also reports that Gainesville, FL, has "inspired a surge in solar-panel installation" by instituting a similar tariff. Do you feel that a "feed-in" tariff should be instituted in your town or city? How many times the market rate should generators of renewable electricity be paid?

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around. But, Barr added, Newtonian dynamics made no sense in the Tychonic system, only in the Copernican.

Barr also noted that the Catholic Church learned from the Galileo incident that it is dangerous to condemn a scientific theory – they were consequently reluctant to condemn Darwin. Agreeing, Cowan observed that the contention between science and religion has shifted from Galileo *vs*. the Catholic Church to evolution *vs*. Evangelical Protestants.

The Importance of Galileo

Beginning the first full day of the symposium, Philosophy Professor Ernan McMullin of Notre Dame University spoke to "The Importance of Galileo." In December 1609 Galileo was the first to turn his spyglass toward the heavens and publish the results (quickly!) – in *The Starry Messenger (Siderius Nuncius)*, McMullin began. (Thomas Harriot had observed and sketched the Moon's surface earlier, McMullin said, but Harriot's spyglass was not as good and he didn't publish his results.)

Galileo benefited from the Italian Renaissance and suffered from the Reformation and Counter-Reformation, which sought to restore the literal truth of the Bible, McMullin continued. He then went on to focus on four separate reasons for Galileo's continued importance:

1. ***Instrumentation***. Galileo improved the telescope, so that it could be used to observe the heavens; and additional observations – made from reversing the telescope's orientation – led to development of the microscope. Galileo also pioneered in the measurement of time – through his observation of the nearly isochronous swings of the pendulum as their amplitude varies – and of temperature, through his development of a thermometer.

2. ***Scientific Methodology***. McMullin felt that Einstein was justified in calling Galileo the "father of modern science," because Galileo transformed our ideas of motion with the laws of falling bodies and projectiles and he transformed the way science was done by placing importance on observations. McMullin added that Galileo's house arrest in 1633 gave Galileo the opportunity to return to his previously unfinished work on motion and write the *Discourses on Two New Sciences*. In doing this, Galileo showed his methods to be the following: 1) observations, 2) observations that yield quantitative measurement, 3) measurements made with appropriate instruments, and 4) mathematically idealizing the world.

3. ***Astronomical Advances***. Galileo's *Dialogue Concerning the Two Chief World Systems* tipped the scales from the Artistotelian point of view toward the Comperincan.

4. ***Science* vs. *Religion***. Lastly, McMullin said, Galileo is noted for his confrontations with the Catholic church – which occurred in two phases, 1616, and 1633 (and, he added, it is doubtful that the confrontation of 1633 would have occurred without that of 1616). Galileo's "Letter to Castelli" sought to save the Church from an error in his Copernican explanation of the Sun's "standing still" in the book of Joshua. But it conflicted with the provision of the council of Trent, McMullin explained, and the intensity with which Galileo pressed his case (including making a trip to Rome) alienated his critics. Consequently, the Church in 1616 defended the traditional science of the day against an assault by a mathematician.

Pope Urban VIII reacted violently to the 1632 *Dialogue*, McMullin continued, because it claimed Copernicanism to be true and expressed the Pope's anti-Copernican arguments through Simplicio. Yet this reaction and the subsequent charges brought against Galileo were much stronger than Urban's previous support of Galileo's writing the *Dialogue* would lead one to expect. Why – and the degree to which Urban was feeling the pinch of the Spanish Inquisition – we shall never know. Galileo thought that his *Dialogue* stayed within the bounds of what Urban had allowed, but he miscalculated. There are many who wonder how Galileo ever felt he could get away with what he did, McMullin confided. Given the decision of 1616, the decisions of 1633 were all the easier to arrive at. Given today's conflict between evolution and those who continue to insist on the literal truth of the Bible, McMullin felt, "Galileo still has a long reach."

The Lineage of Genius: from Galileo to Hawking

Derrick Pitts, Chief Astronomer of The Franklin Institute, then hosted a panel asked to assess the role of "genius" in the flourishing of science in the Renaissance, whether that role still applies today, and the impact of culture on science. In addition to Dear and Primack, who had already participated in the previous evening's panel, History Professor Nick Wilding of Georgia State University was on hand to respond.

Dear began by observing that today we apply the term "genius" as an honorific applied to someone whose ideas are beyond our understanding. It is applied to individuals, Dear went on, whereas science is largely *not* an indi-

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Galileo at The Franklin

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vidual activity – it is actually cultural. What constitutes science at any place and time constitutes what people want to learn.

Wilding then pointed out that "genius" is a post-romantic term that didn't even exist in Galileo's time. But, Wilding noted, Galileo was highly intelligent, and he had a high regard for his intelligence. Regarding science, Wilding observed that it was enhanced in Galileo's time by the development of scientific academies and Jesuit universities. Also supporting the development of science was stronger linkage among various points of the globe.

Primack pointed out that another development important to Galileo was the printing press and the library it enabled Galileo to have. He also lamented the division of intellectual turf between science and religion *à la* Descartes.

Pitts then began a dialog with his panel members by asking whether Galileo was a scientific opportunist? Yes, responded Wilding, but this should not be viewed derogatorily. When Pitts then asked "What about Einstein?" Primack responded that Einstein was concerned with the importance of details in his job in the Swiss Patent Office. When Pitts asked whether the term "genius" could be applied retroactively to Galileo, Wilding replied that calling people "ahead of their time" puts scientists out of jobs. Newton, he said, created a *persona* that people reacted to with awe.

Still trying to "feel out" his panel, Pitts next asked whether "marketing" was the correct term for what Galileo did. Galileo was the first modern scientist, Primack responded, but his theory didn't go beyond his own time. Although Newton didn't publish his notes on calculus, they basically were all the mathematics of the next 100 years. Likewise, Einstein's general theory of relativity has had far-reaching implications – even the GPS depends on it. Wilding interjected that Galileo also recognized the military and commercial applications of the telescope.

This led a member of the audience to ask whether another term for "genius" is "entrepreneur." Entrepreneurship, Wilding responded, connotes a profit motive, and this was not Galileo's main motive. Primack interjected that Galileo, Newton, and Einstein were all inventors. However, Galileo's mathematics was inferior to that of Kepler. One thing that Galileo had to confront in defending Copernicanism was the equivalence of reference frames moving at relative constant velocity. This evolved in the special theory of relativity into the notion of no preferred reference frames, though in general relativity we *do* have a preferred reference frame, he said – that of the cosmic microwave background.

Another questioner noted that the panelists had not addressed "saving the appearances," which has been important in scientific tradition. Ptolemy wasn't sure that his model was really true, the questioner maintained, and Galileo was allowed to use the Copernican model for calculational purposes. To this Primack responded that "saving the appearances" is not acceptable to those seeking the truth. Given repeated confirmations of predictions of general relativity and cold dark matter, though, Primack added that this could be a sign of getting close to finding the truth.

A final questioner asked whether Aristotle was a genius, and Primack had this response: Yes, although he didn't get the physics quite right. Attesting to this is creation of the Library at Alexandria by his pupil Alexander. The only person of Aristotle's time superior to him, Primack said, was his teacher, Plato.

After lunch Dava Sobel read the first chapter of her book, *Galileo's Daughter*. She prefaced this with an acknowledgment crediting Owen Gingerich with the *imprimatur* for her book, noting that when she wrote him to inquire whether Sr. Maria Celeste would be a good way to tell the Galileo story, he replied that all he knew is that Galileo had "dumped his daughters into a convent and that was that." As it turned out, there was a richness of correspondence from Galileo's younger daughter to her father, more than Sobel could fit into her book, a correspondence that greatly comforted Galileo in the troubled last years of his life, which turned out to last longer than hers.

Will the Real Galileo Stand Up?

Later that afternoon Derrick Pitts hosted yet another panel, to which he posed the following questions: What was Galileo's real intention? to force the Catholic Church to change its position? Or was he just a well-meaning scholar caught up in the course of events?

Annibale Fantoli, Philosophy Professor from the University of Victoria, shared two responses: 1) the 1992 apology of Pope John Paul II, and 2) that of a Catholic apologist, noting Galileo's high self-esteem and (for lack of a better word) "pushiness." Pope Paul V, Fantoli said, had Cardinal Robert Bellarmine admonish Galileo to abandon the Copernican theory in 1616, with a strong

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prohibition to result if Galileo refused. The commissar is said to have read the strong prohibition without giving Galileo an opportunity to not refuse, but Bellarmine later confirmed in writing to Galileo that this had been done prematurely and that Galileo *could* continue to consider the Copernican theory to be a "useful hypothesis."

After Cardinal Barberini, who had been supportive of Galileo and his telescopic observations, became Pope Urban VIII, Galileo met with him about the possibility of re-examining the system of the world in the form of a dialog, with all points of view considered, and received Urban's permission to do so. The eventual *Dialogue*, which was to have been unbiased, turned out to favor the Copernican theory, but an *imprimatur* was granted after a prefatory statement was added that the systems under consideration were only mathematical models and the Pope's argument was added at the end.

Finocchiaro, who had spoken on the opening evening panel, continued the Galileo story by observing that both Copernicus and Galileo realized that a heliocentric solar system did not mesh with Aristotelian physics; but before his telescopic observations of the heavens, Galileo worked on developing a new physics, which still, however, offered no evidence of a moving Earth. After arguing that the Sun standing still in the book of Joshua favored Copernicanism, Galileo was warned in 1616 to abandon the theory, and Copernicus's *De Revolutionibus* was banned pending "correction."

Finocchiaro then pointed out that when the *Dialogue* Galileo later wrote with encouragement from Pope Urban VIII was felt to favor Copernicus, events of 1616 came back into play, and the ambiguity of the record of those events in 1616 posed problems in determining what to do. If Galileo had indeed agreed to give up the Copernican theory except to regard it as a "useful hypothesis," Finocchiaro said, the Church would have a weak basis for pressing further charges. If he had not, then lack of his signature acceding to a complete prohibition would be embarrassing.

McMullen, who had spoken earlier in the day, added that both St. Augustine and St. Thomas Aquinas interpreted the creation story of Genesis metaphorically. But in a meeting with Galileo in 1616, Cardinal Bellarmine interpreted it literally. McMullin felt that Bellarmine's position was a significant part of the story of Galileo.

As to whether Galileo had a plan, McMullin felt that Galileo was confronted with evaluating new evidence, which he found very amazing, particularly the phases of Venus. Although the phases of Venus *could* be explained by the Tychonic theory (Tycho Brahe's theory that the other planets revolved about the Sun but that the Sun revolved around the Earth), Galileo never brought it up, because he felt that it wouldn't work physically.

McMullin added that after Galileo's friend became Pope Urban VIII, Galileo once again felt emboldened – and he felt that his efforts were trying to save the Church from committing an egregious error, but he wasn't able to pull it off. Moreover, he felt that inserting the Pope's argument at the end of his *Dialogue* had protected him and that he could defend himself at his trial. At the last session of the trial, though, Galileo realized that things weren't going well and, in effect, he threw up his hands: "Do with me as you please." Yet, Galileo did not give in, until forced to abjure Copernicanism as a result of the trial sentence.

In response to a question of what screening of the *Dialogue* had been done prior to publication, McMullin responded that the censor may not have known how far Galileo was allowed to go, and he knew that Galileo was an admired friend of Pope Urban VIII. The final decision was left to the censor in Florence, where the *Dialogue* was published.

Galileo's Legacy

A key maxim of show business is to finish with a strong finale, that that rule was applied to this Symposium by concluding with a presentation by the same Owen Gingerich already acknowledged by Sobel in her lunchtime reading. Emeritus Professor of Astronomy and of the History of Science at Harvard University, Gingerich spoke on "The Legacy of Galileo."

Gingerich began in 1597, when someone gave Galileo a copy of Kepler's *Mysterium Cosmographicum*. At that time, Gingerich said, Galileo was a professor in Padua and Kepler was an obscure math teacher. But by 1609 Kepler was the Imperial Mathematician in Prague, about to publish the *Astronomia Nova*, which Gingerich felt, along with *De Revolutionibus* and Newton's *Principia*, was one of the three great books of the Copernican Revolution. But it was Galileo's *Dialogue*, Gingerich said, which "won the war."

Galileo's *Siderius Nuncius* worked as a job application for Galileo to move from Padua to employment with the Medici. Galileo let the Medici determine has salary, but the wanted his title to note that he was their philoso-

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pher as well as their mathematician. When it came to titling his *Dialogue*, Gingerich said, he was not allowed to call it *On the Flux and Reflux of the Tides*. The cover featured Aristotle, Ptolemy, and Copernicus, but the main protagonists were Salviati, Sagredo, and Simplicio (all names of real people) – in which Galileo delighted – but Gingerich felt that it was with arrogant stupidity that Galileo placed the final Aristotelian argument in Simplicio's mouth.

After these prefatory remarks, Gingerich reviewed the structure of Galileo's *Dialogue*, which, he said consisted of four days of discussion – of the following topics: 1) day 1 on Aristotle's error of dividing the universe into two zones; 2) day 2 on Galilean relativity; 3) day 3 on a fraudulent argument for Earth's motion based on sunspots; and 4) day 4 on Galileo's incorrect theory of the tides, disparaging Kepler's more correct theory.

Gingerich made the following observations about Galileo's telescopic observations:

- Galileo had fitted the objective lens of his telescope with a paper diaphragm (still visible on the telescope displayed at The Franklin) in order to compensate for its spherical aberration. At the time of his observations, Galileo had gotten his telescope up to a magnification of eight, which Gingerich pointed out is the minimum needed to see lunar craters, up from the magnification of six achieved by Harriot (already cited by McMullin).

- Galileo's first observation of Jupiter may have been an afterthought to observing the nearby Moon. After Galileo recognized that the three dots near Jupiter – and later a fourth – were changing places, he started making more systematic observations, shifted from Italian to Latin, and became an avid Copernican (interpreting Jupiter and its moons as a miniature solar system).

- Galileo's drawings of the Moon were hampered by not being able to see the whole Moon at once. The times of his diagrams can be dated by the location of the terminator (edge of sunlight), and one of them showed the Moon rotated from its normal position relative to the Earth.

- There is no evidence of Galileo's getting up before dawn to make astronomical observations, and this excluded observations of Venus, which was then the morning star. Gingerich said that it was Castelli who alerted Galileo to observe Venus, and then Galileo became concerned that the Jesuits could scoop him.

Although Galileo didn't prove the Copernican system, Gingerich concluded, he made it respectable by persuasion. Galileo changed the way science is done – and that is his legacy. He was "vehemently suspected" of heresy, but he was actually convicted for disobeying orders by teaching the Copernican system and for thinking that the Bible was not a final authority on matters scientific.

Galileo and the 400th anniversary of his telescopic observations also played a role in the summer meeting of the American Association of Physics Teachers in Ann Arbor, MI. The University of Michigan has an original Galileo manuscript in its collection, and Peggy Daub of the U of M Library not only arranged a special exhibition of it but also spoke about it at a session on Highlights of the International Year of Astronomy. Daub said that that it had been bequeathed to the University by Tracy McGregor to honor Astronomy Professor Curtis, along with original editions of Copernicus's *De Revolutionibus* and Galileo's *Dialogue*. The Galileo manuscript in Michigan, which is the only known one in the U.S., notes at the top the military uses of the "spyglass" and sketches at the bottom the positions of the moons around Jupiter for the week of 7-15 June 1610 as if it were scrap paper. At one point, Daub noted, Galileo shifted from Italian to Latin (also noted by Gingerich in his talk at the Galileo Symposium at The Franklin), which she said was an indication of something special. The Latin, she said, could become part of a published report, in this case the eventual *Siderius Nuncius*. At that time, Daub continued, Galileo was not that well known, and a letter of support from Johannes Kepler proved helpful.

Mary Ann Hickman Classen of Swarthmore College then spoke directly about the Galileo exhibit at The Franklin Institute. She pointed out that 40 docents were trained to answer potential questions about the many Renaissance scientific instruments in the exhibit, something not typical of an exhibit at The Franklin. One of the docents, Jim Morrison, made his own astrolabe, which was exhibited to museum visitors on an "astrolabe cart."

David Zax also wrote about the exhibit at The Franklin Institute in "Galileo's Vision," *Smithsonian*, **40**(5), 58-63 (Aug 2009).

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News from Triangle Coalition

The Condition of Education 2009

Enrollment in America's elementary and secondary schools continues to rise to all-time highs, and younger learners continue to show gains in educational achievement over time. The overall achievement levels of secondary school students have not risen over time, but there are some increases in the percentages of students entering college after high school and earning a postsecondary credential, according to “The Condition of Education 2009” report released today by the National Center for Education Statistics (NCES). “The Condition of Education” is a congressionally mandated report that provides an annual portrait of education in the United States. The 46 indicators included in this year's report cover all aspects of education, from early childhood through postsecondary education and from student achievement to school environment and resources. Among the report’s other findings:

- Public elementary and secondary enrollment is projected to increase to 54 million in 2018. Over the period of 2006 to 2018, the South is projected to experience the largest increase (18 percent) in the number of students enrolled.
- Between 1972 and 2007, the percentage of public school students who were White decreased from 78 to 56 percent. This decrease largely reflects the growth in the number of students who were Hispanic, particularly in the West.
- The average reading and mathematics scores on the long-term trend National Assessment of Educational Progress (NAEP) were higher in 2008 than in the early 1970s for 9- and 13-year-olds; scores for 17-year-olds were not measurably different over the same period.
- In 2005-06, about three-quarters of the 2002-03 freshman class graduated from high school with a regular diploma.
- The rate of college enrollment immediately after high school completion increased from 49 percent in 1972 to 67 percent by 1997, but has since fluctuated between 62 and 69 percent.
- About 58 percent of first-time students seeking a bachelor's degree or its equivalent and attending a 4-year institution full time in 2000-01 completed a bachelor's degree or its equivalent at that institution within 6 years.
- Women accounted for 57 percent of the bachelor's degrees and 62 percent of all associate's degrees awarded in the 2006-07 academic year.

NCES is the statistical center of the Institute of Education Sciences in the U.S. Department of Education. The full text of “The Condition of Education 2009” (in HTML format), along with related data tables and indicators from previous years, can be viewed at <http://nces.ed.gov/programs/coe/>.

(*Editor’s Note*: The above was excerpted from the *Triangle Coalition Electronic Bulletin* for 11 June 2009 and reprinted with permission.)

High School Graduation Rate Improves Over Past Decade

A new national report from Education Week and the Editorial Projects in Education (EPE) Research Center paints a cautiously optimistic picture of high school graduation trends, finding that the national graduation rate has improved over the past decade, though a recent one-year downturn -- the first significant annual decline in that 10-year period -- raises cause for concern. Despite overall progress, three out of every 10 students in U.S. public schools still fail to finish high school with a diploma, the report finds. That amounts to 1.3 million students lost from the graduation pipeline every year, or almost 7,200 students lost every day, it adds. The report also points out that there is no firm consensus among states, schools, and policymakers on what it means to be ready for postsecondary education or how to measure college readiness.

The report, “Diplomas Count 2009: Broader Horizons: The Challenge of College Readiness for All Students,” investigates one of the most critical issues facing the nation's educational and economic future -- the challenge to prepare all students for college. As leaders at all levels of public life call for Americans to engage in some education beyond high school, “Diplomas Count” examines this growing movement by mapping the policy and reform landscape that defines the college-ready agenda, profiling one high school's efforts to nurture a college-going culture, examining how better data and accountability systems can help support readiness initiatives, and highlighting the cutting-edge efforts of a state working to put actionable information about college preparation in the hands of educators. This push for college comes amid sobering statistics on the proportion of U.S. students who currently finish high school and on the level of college preparation that comes with a high school diploma. The report -- part of a multi-year project supported by the Bill & Melinda Gates Foundation -- also tracks graduation policies for all 50 states and the District of Columbia and presents an updated analysis of graduation rates and trends for the nation, states, and the country's 50 largest school systems. The full report and supporting information for each state is available online at <www.edweek.org/ew/toc/2009/06/11/index.html>.

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Transforming Math and Science Education

The Carnegie Corporation of New York - Institute for Advanced Study Commission on Mathematics and Science Education has kicked-off a national mobilization effort to achieve much higher levels of math and science learning with the release of its report, "The Opportunity Equation: Transforming Mathematics and Science Education for Citizenship and the Global Economy." The report recommends concrete actions to a range of organizations from labor and business to federal and state government, colleges and universities, and donors who must coalesce to "do school differently" to transform math and science education. More than 65 groups have affirmed their support to work together to place math and science at the center of education innovation, improvement, and accountability. The Commission's report identifies where change is needed to transform math and science education and points to innovations that are already working on the ground. It specifies who needs to be involved and clearly illustrates the roles various sectors must play if we are to ensure all students -- no matter where they live, what educational path they pursue, or in which field they choose to work -- have the knowledge and skills they need from science, technology, engineering, and mathematics upon high school graduation. The report's detailed set of recommendations lays out a practical, coordinated plan, and describes what each constituency can do to raise mathematics and science achievement for all American students:

- Establishing new common standards in mathematics and science that are fewer, clearer, and higher, coupled with aligned high-quality assessments.
- Improving teaching and professional learning -- supported by better school and system management.
- Redesigning schools and school systems to deliver excellent, equitable math and science learning more effectively.
- Initiating a national mobilization that includes public awareness campaigns, increased public understanding about the links between effective math and science learning and the job market, and a focus on improving outcomes among historically underperforming groups through new benchmarking to evaluate school improvement efforts at all grade levels for all students.

The report can be accessed online at <www.opportunityequation.org>.

(*Editor's Note*: The above was excerpted from the *Triangle Coalition Electronic Bulletin* for 18 June 2009 and reprinted with permission.)

Report Evaluates Characteristics of Late High School Dropouts

The National Center for Education Statistics within the Institute of Education Sciences has released the report, "Late High School Dropouts: Characteristics, Experiences, and Changes Across Cohorts." The report presents information about selected characteristics and experiences of high school sophomores in 2002 who subsequently dropped out of school. It also presents comparative data about late high school dropouts in the years 1982, 1992, and 2004. The findings only address dropping out in late high school and do not cover students who dropped out before the spring of 10th grade. For this reason, the reported rates are lower than those based on the students' entire high school or earlier school career. Key findings include the following:

- Forty-eight percent of all late high school dropouts come from families in the lowest quarter (bottom 25 percent) of the socioeconomic status distribution, and 77 percent of late high school dropouts come from the lowest half of the socioeconomic status distribution.
- Most late high school dropouts (83 percent) listed a school-related (versus a family- or employment-related) reason for leaving. These reasons included missing too many school days, thinking it would be easier to get a GED, getting poor grades, and not liking school.
- The overall late high school dropout rate was lower in 2004 than in 1982 (7 percent versus 11 percent, respectively) and lower in 1992 than in 1982 (6 percent versus 11 percent), but it showed no statistically significant difference in 2004 compared with 1992.

The report can be accessed online at <nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2009307>.

New Report Sets Forth Principles of Earth Science Literacy

Earth's rocks and other materials provide a record of its history. Our solar system formed from a vast cloud of gas and dust 4.6 billion years ago. Earth's crust has two distinct types: continental and oceanic. These and other concepts are the major ideas of Earth science that all citizens should know, according to a newly released report, "Earth Science Literacy Principles: The Big Ideas and Supporting Concepts of Earth Science," funded by the National Science Foundation (NSF)-supported Earth Science Literacy Initiative (ESLI). "The Earth sciences have never been more important than they are today," says Robert Detrick, director of NSF's Division of Earth Sciences. "It's important that every citizen have knowledge of the fundamental concepts of Earth science such that he

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or she may make informed and responsible decisions about public issues--from climate change to energy, from natural resources to earthquake hazards. The Earth Science Literacy Initiative is a very important effort to convey this information about Earth science to the general public."

"Earth Science Literacy Principles" provides a summary of the major ideas in earth science for policy makers, educators, students, and the general public. The report complements the efforts of ocean, climate and atmospheric scientists, educators, and others to define the ideas and concepts essential for a geoscience-literate public. "Earth Science Literacy Principles" was developed through an online workshop held in May 2008, and a writing workshop held in July 2008. The workshops brought together scientists from across the earth sciences, including mineralogists, petrologists, sedimentologists, paleontologists, geophysicists, geomorphologists, biogeochemists, volcanologists, geohazards specialists and hydrologists, among others. To view the report, visit <www.earthscienceliteracy.org>.

Guiding Principles for Mathematics Curriculum and Assessment

Triangle Coalition member, the National Council of Teachers of Mathematics (NCTM) has released "Guiding Principles for Mathematics Curriculum and Assessment" to influence ongoing and future development of what could become uniform curriculum expectations or national standards for mathematics education. NCTM was the first organization to develop content standards and a guiding framework for curriculum development with its 1989 publication of Curriculum and Evaluation Standards for School Mathematics, which was updated in 2000 as Principles and Standards for School Mathematics. In 2006, NCTM's "Curriculum Focal Points for Prekindergarten through Grade 8 Mathematics: A Quest for Coherence" presented the three most important topics in each grade that students should learn in depth and with understanding for future learning in mathematics. The forthcoming "Focus in High School Mathematics: Reasoning and Sense Making" (2009) will address mathematics education in high school. An education based on these Standards publications will prepare students for the true workplace needs of the future: critical thinking, problem solving, and teamwork.

"The continuing discussions about common core standards or a national curriculum should be based on the work that has already been done," said NCTM President Henry S. (Hank) Kepner, Jr. "Since any discussion of true national standards relates to the fundamental issue of local control in education, effective policy should be formed by the best current information on mathematics teaching and learning. The development of any curriculum or standards should take advantage of what has already been carefully crafted by a consensus of mathematics teachers, teacher leaders, mathematics educators, mathematicians, and researchers." "Guiding Principles for Mathematics Curriculum and Assessment"" is available online at <www.nctm.org/standards/content.aspx?id=23273>. The National Council of Teachers of Mathematics has 100,000 members and 230 member Affiliates in the United States and Canada. It is the world's largest organization dedicated to improving mathematics education for all students from prekindergarten through grade 12.

(*Editor's Note*: The above was excerpted from the *Triangle Coalition Electronic Bulletin* for 25 June 2009 and reprinted with permission.)

New Engineering Alliance to Leverage Best Practices in STEM Education

Project Lead the Way (PLTW) has announced the launch of the Engineering Alliance, a new partnership between PLTW, the Technology Student Association (TSA), and SkillsUSA that will provide PLTW students with the opportunity to participate in innovative activities in science, technology, engineering, and math education – outside of the classroom. The alliance will offer STEM-related co-curricular activities for PLTW students to participate in, including online competitions and leadership development activities designed to support teachers and excite students about technology, innovation, and engineering. PLTW's critical thinking and project-based STEM curriculum is currently being implemented at over 3,000 schools and the program reaches over 300,000 students. Available this coming fall, Engineering Alliance will offer a series of classroom-level competitions and leadership development activities designed specifically for PLTW affiliated middle and high school pre-engineering instructional programs. Proposed contests include electronic gaming, solving a design problem with STEM applications, CAD design, and building an engineering model. Leadership activities will feature teamwork, communication, and time management.

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Galileo Teacher Training Program Brings Astronomy Into the Classroom

The Galileo Teacher Training Program (GTTP) has been launched, bringing training and resources to teachers around the globe. The project's aim is to improve astronomy education for children of all nations, by better equipping their tutors through a comprehensive set of resources and practical guidance. GTTP is a project of the International Year of Astronomy 2009. The International Year of Astronomy 2009 is a global effort initiated by the International Astronomical Union (IAU) and UNESCO to help the citizens of the world rediscover their place in the Universe through the day- and night-time sky, and thereby engage a personal sense of wonder and discovery. This celebration of astronomy and its contribution to science and society aims to boost the quality of education for children and young adults and GTTP is at the forefront of these efforts. The core concept is that by training teachers better, and equipping them with the right resources to tackle astronomy in the classroom, the effect will be significant and long-lasting, enduring far beyond 2009.

Astronomy education specialists have identified a critical education challenge: many teachers lack the training to understand these resources or use them effectively in their curricula. To counter this, educators are offered GTTP workshops. Teachers attending these workshops are the first Galileo Teachers and the seeds for the wider global network of future Galileo Teachers. The GTTP goal is to create a worldwide network of 3000 to 6000 certified Galileo Teachers by 2012, who will be equipped to train other teachers in these methodologies, leveraging the work begun during IYA2009 in classrooms everywhere. The project website is the initiative's central hub (URL <http://www.site.galileoteachers.org/>). This newly released site contains a wealth of resources, from training and educational materials to news and useful contacts within the astronomy communication community. Content will be added throughout the year, resulting in an impressive depository of information and activities which can be called upon as and when needed.

NASA Selects Earth System Science for Grant Funding

NASA recently awarded TERC $280,000 to develop "Earth System Science: A Key to Climate Literacy." The project is developing an Earth Systems Climate EarthLabs module that will join four existing EarthLabs modules (focused on Hurricanes, Fisheries, Corals, and Drought). This module will become part of a high school capstone Earth and Space science curriculum that uses the latest NASA data and visualization tools. The project will also develop a mechanism for teacher professional development to facilitate effective use of the module. The Earth Systems Climate EarthLabs module will be comprised of nine sequential, lab-based activities to introduce students to the topic of climate change. The activities will include a combination of fieldwork and in-classroom assignments and will integrate NASA data access and analysis tools such as NASA Earth Observations (NEO), NASA Image Composite Editor (ICE), and the Goddard Interactive Online Visualization and Analysis Infrastructure (Giovanni). The module will be available on the web and integrate professional development support.

The TERC award is one of 22 proposals that were selected for funding to organizations in the District of Columbia and 14 states: Alaska, Alabama, California, Colorado, Georgia, Illinois, Massachusetts, North Dakota, Nebraska, New York, Oregon, Pennsylvania, Texas, and Virginia. The grants are part of a program Congress began in fiscal year 2008. Winning proposals were selected through a merit-based, peer-reviewed competition. The awards have up to a three-year period of performance and range in value from $140,000 to $500,000. NASA has awarded $6.4 million in grants to institutions of higher education and not-for-profit education organizations nationwide to enhance learning through the use of NASA's Earth science resources. Both NASA and TERC are members of the Triangle Coalition.

Forty-nine States and Territories Join Common Core State Standards Initiative

The National Governors Association Center for Best Practices (NGA Center) and the Council of Chief State School Officers (CCSSO) have released the names of the states and territories that have joined the Common Core State Standards Initiative: Alabama; Arizona; Arkansas; California; Colorado; Connecticut; Delaware; District of Columbia; Florida; Georgia; Hawaii; Idaho; Illinois; Indiana; Iowa; Kansas; Kentucky; Louisiana; Maine; Maryland; Massachusetts; Michigan; Minnesota; Mississippi; Montana; Nebraska; Nevada; New Hampshire; New Jersey; New Mexico; New York; North Carolina; North Dakota; Ohio; Oklahoma; Oregon; Pennsylvania; Puerto Rico; Rhode Island; South Dakota; Tennessee; Utah; Vermont; Virgin Islands; Virginia; Washington; West Virginia; Wisconsin; and Wyoming. In the 26 years since

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the release of *A Nation at Risk*, states have made great strides in increasing the academic rigor of education standards. Yet, America's children still remain behind other nations in terms of academic achievement and preparedness to succeed. By signing on to the Common Core State Standards Initiative, governors and state commissioners of education across the country are committing to joining a state-led process to develop a common core of state standards in English-language arts and mathematics for grades K-12. These standards will be research and evidence-based, internationally benchmarked, aligned with college and work expectations and include rigorous content and skills.

The Common Core State Standards Initiative is being jointly led by the NGA Center and CCSSO in partnership with Achieve, Inc., ACT, and the College Board. It builds directly on recent efforts of leading organizations and states that have focused on developing college-and career-ready standards and ensures that these standards can be internationally benchmarked to top-performing countries around the world. The goal is to have a common core of state standards that states can voluntarily adopt. States may choose to include additional standards beyond the common core as long as the common core represents at least 85 percent of the state's standards in English-language arts and mathematics. CCSSO is a member of the Triangle Coalition. More details are at <www.ccsso.org>.

(*Editor's Note*: The above was excerpted from the *Triangle Coalition Electronic Bulletin* for 9 July 2009 and reprinted with permission.)

U.S. STEM Education Modeling Tool Available

Raytheon Company and the Business-Higher Education Forum (BHEF) have unveiled a simulation and modeling tool for the U.S. STEM (science, technology, engineering, and math) education system. The U.S. STEM Education Model was developed to enable researchers, policy-makers, and educators to explore policy scenarios that can strengthen U.S. STEM education and workforce outcomes. BHEF's STEM Research and Modeling Network (SRMN) will continue to refine the tool and develop improved versions for use in helping to understand the impact of policy scenarios, educational programs, and interventions on the U.S. education system. "BHEF seeks to double the number of U.S. students who graduate in STEM fields by 2015. Raytheon's development of this model is an excellent example of corporate and civic leadership, and we are extremely proud to help foster its use by researchers, policy-makers, educators, and the public in advancing STEM education," said Brian Fitzgerald, Executive Director of BHEF.

Many factors affect the number of students who ultimately pursue STEM careers. The model attempts to capture these factors through a series of dynamic hypotheses and more than 200 unique variables. As an open source model, this tool is available for researchers, policymakers, modelers, and other concerned stakeholders to download and adapt. Using complex algorithms, the tool simulates and assesses the impact of STEM-policy and programmatic interventions during a period of time to determine which produce favorable outcomes. Factors and variables that can be tested include: teacher-student ratios and class sizes, dropout and graduation rates, teacher attrition rates, gender differences in STEM, and teacher and STEM industry salaries. For more information on the tool, visit <www.stemnetwork.org/model>.

(*Editor's Note*: See our Fall 2007 issue for coverage of a previous report issued by the Business-Higher Education Forum, "An American Imperative: Transforming the Recruitment, Retention, and Renewal of Our Nation's Mathematics and Science Workforce.")

Role of STEM Career and Technical Education Program Discussed in New ACTE Issue Brief

During the last decade, thousands of new cutting-edge STEM-intensive career and technical education (CTE) programs have been launched or expanded in schools across the nation. CTE programs integrate high-level academics and technology into the curriculum, and the programs offer students a deeper understanding of STEM career pathways, facilitate student transitions between secondary and postsecondary education and careers, and help encourage more students from underrepresented populations to enter STEM fields. The Association for Career and Technical Education's (ACTE) new issue brief, "Career and Technical Education's Role in Science, Technology, Engineering, and Math," explores the role CTE programs and initiatives play in addressing the STEM challenge and securing America's leadership in innovation. It describes how career and technical education (CTE) can help to meet the critical need of developing a skilled, professional STEM workforce to secure America's economic future. CTE courses and programs strengthen students' understanding of STEM content and attract students to STEM careers. Founded in 1926, the Association for Career and Technical Education (ACTE) is dedicated to the advancement of education that pre-

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pares youth and adults for successful careers. The brief is available online at <http://www.acteonline.org/uploadedFiles/Publications_and_Online_Media/files/STEM_Issue_Brief.pdf>.

America's Children: Key National Indicators of Well-Being, 2009

In 1994, the Office of Management and Budget joined with six other Federal agencies to create the Federal Interagency Forum on Child and Family Statistics. The Forum, which now has participants from 22 Federal agencies as well as partners in private research organizations, fosters coordination, collaboration, and integration of Federal efforts to collect and report data on conditions and trends for children and families and calls attention to needs for new data about them. A report recently released by the Forum, "America's Children: Key National Indicators of Well-Being, 2009," is a compendium of indicators illustrating both the promises and the difficulties confronting our Nation's young people. It presents 40 key indicators on important aspects of children's lives. This year's report continues to present key indicators grouped by the seven sections identified in the restructured 10th anniversary report (2007): family and social environment, economic circumstances, health care, physical environment and safety, behavior, education, and health. With specific regard to education, the report indicates:

- At grades 4 and 8, average mathematics scores were higher in 2007 than in all previous assessments.
- At grades 4 and 8 in 2007, Asian or Pacific Islander and White, non-Hispanic students scored higher on average in mathematics than their Black, non-Hispanic, American Indian or Alaska Native, and Hispanic peers; also, Hispanic and American Indian or Alaska Native students had higher average scores than Black, non-Hispanic students.
- In mathematics, males outperformed females at grades 4 and 8 in 2007 and at grade 12 in 2005.
- In 2007, 67 percent of high school completers enrolled immediately in a 2-year or 4-year college.

The full report is available at <www.childstats.gov/americaschildren>.

(*Editor's Note*: The preceding three items were excerpted from the *Triangle Coalition Electronic Bulletin* for 23 July 2009 and reprinted with permission.)

2009 Earth Science Week Toolkits Now Available

The Earth Science Week 2009 (11-17 October 2009) Toolkit enables students, educators, and the public to fully explore this year's theme "Understanding Climate." The latest edition of this resource is now available through the American Geological Institute (AGI). It contains a 12-month school-activity calendar and classroom poster provided by AGI, its Member Societies, and other organizations. Along with these traditional Earth Science Week publications, this year's Toolkit features a variety of educational climate resources from the U.S. Geological Survey (USGS), NASA, and the National Oceanic and Atmospheric Administration (NOAA). A report on the "Ecological Impacts of Climate Change" and a new brochure outlining principles for Earth Science literacy are also included. Multimedia features this year include NASA's "Dynamic EARTH" DVD-ROM and a CD-ROM on GIS technology from ESRI. Additional informational materials within the kits include a National Park Service poster highlighting the nation's glaciers and literature on the National Wildlife Refuge System. Like years past, the 2009 Toolkit contains a genuine field notebook from Rite in the Rain. These items and much more make the Earth Science Week Toolkit ideal for engaging students and general public to explore the geosciences. The Toolkits are available for the cost of shipping and handling and bulk pricing is available. Find out more at <www.earthsciweek.org/materials>.

Earth Science Week is an annual event held the second week of October to promote an understanding and appreciation of the earth sciences. It is organized annually by Triangle Coalition member, the American Geological Institute (AGI), with support from a number of other geoscience organizations, including the U.S. Geological Survey, NASA, National Park Service, and the American Association of Petroleum Geologists Foundation. AGI is a nonprofit federation of 45 geoscientific and professional associations that represents more than 120,000 geologists, geophysicists, and other earth scientists.

"Building Policy Platforms for Resilience" Policy Brief

In conjunction with the launch of the "2020 Forecast: Creating the Future of Learning," KnowledgeWorks Foundation and Triangle Coalition member, Mid-continent Research for Education and Learning (McREL) have published "Building Policy Platforms for Resilience," a brief that examines the policy implications for two of the six drivers of change contained in the forecast:

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"A New Civic Discourse and Platforms for Resilience." A New Civic Discourse refers to new community models, communication methods, and spheres of influence that arise in a global society in which community is no longer defined geographically. The forecast makes the case that individuals will affiliate around common needs instead of common geography and will claim rights to learning that have previously been the purview of the education elite. Education will become a contested resource among those who seek a claim and demand to participate.

"Platforms for Resilience" refers to the growing need for new responses to the institutional disruptions and system shocks occurring throughout society. The forecast suggests that such disruptions require leaders to respond differently than in the past. Leaders must learn how to meet these challenges with even more flexibility, greater collaboration, and increased transparency. The brief, written by Laura Lefkowits, McREL's vice president of policy and planning services, and Dr. Carolyn Woempner, a senior researcher in policy and planning services at McREL, encourages proactive policy responses to enable organizations not only to adapt to future conditions but also to play a role in crafting the future, especially in times of great uncertainty. "Building Policy Platforms for Resilience" can be downloaded as a pdf from <www.futureofed.org/taking%2Daction/policy%2Dbrief/>.

Investing in Education: The American Graduation Initiative

Earlier this month, President Obama announced an initiative to strengthen our nation's community colleges, and called for five million additional graduates by 2020. The American Graduation Initiative is design to build on the strengths of community colleges and usher in new innovations and reforms for the 21st century economy. Among other areas, the initiative calls for 5 Million Additional Community College Graduates by 2020, including students who earn certificates and associate degrees or who continue on to graduate from four-year colleges and universities; and creates the Community College Challenge Fund to support new competitive grants which would enable community colleges and states to innovate and expand proven reforms. These efforts will be evaluated carefully, and the approaches that demonstrate improved educational and employment outcomes will receive continued federal support and become models for widespread adoption. Colleges could build partnerships with businesses and the workforce investment system to create career pathways where workers can earn new credentials and promotions step-by-step, worksite education programs to build basic skills, and curriculum coordinated with internship and job placements. They could also expand course offerings and offer dual enrollment at high schools and universities, promote the transfer of credit among colleges, and align graduation and entrance requirements of high schools, community colleges, and four-year colleges and universities.

In addition, the initiative supports a new research center with a mission to develop and implement new measures of community colleges' success so prospective students and businesses could get a clear sense of how effective schools are in helping students -- including the most disadvantaged -- learn, graduate, and secure good jobs. More details are online at <www.whitehouse.gov/the_press_office/Excerpts-of-the-Presidents-remarks-in-Warren-Michigan-and-fact-sheet-on-the-American-Graduation-Initiative>.

(*Editor's Note*: The three preceding items were excerpted from the *Triangle Coalition Electronic Bulletin* for 30 July 2009 and reprinted with permission. Note that the last two items are follow ups to items in this column in our Winter-Spring 2009 issue.)

International Supplement to "The Condition of Education 2009"

A special supplement to "The Condition of Education 2009" was recently released by the National Center for Education Statistics. The report looks closely at information gathered from international studies in which U.S. students have participated and examines the performance of U.S. students in reading, mathematics, and science compared with the performance of their peers in other countries. In response to the release of the report, Education Secretary Arne Duncan said that the "report is another wake-up call that our students are treading the waters of academic achievement while other countries' students are swimming faster and farther. Our students have stagnated educationally, putting our long-term economic security at risk. In math, our 15-year-olds' scores now lag behind those of 31 countries. In science, our eighth graders' scores now lag behind their peers in eight countries that had also participated in the original assessment. In reading, five countries have improved their performance and surpassed our 4th graders." Duncan also noted that "This is the first time that the most recent findings from the three major internationals tests have been published

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in one place. It compels us to renew our focus and reinvigorate our resolve to prepare our students to achieve to high academic standards and be ready for the global marketplace." Among the findings of "U.S. Performance Across International Assessments of Student Achievement: Special Supplement to The Condition of Education 2009," which can be accessed online at <http://nces.ed.gov/pbs2009/20009083.pdf>, are the following:

<u>Mathematics</u>: In mathematics, U.S. student scores have improved at both grades 4 and 8 since the first administration of TIMSS; however, the scores of U.S. 15-year-olds in PISA have not measurably changed. In 2007, U.S. 4th-graders improved their average score and surpassed their peers in four European countries that outperformed the United States in 1995, though England and Latvia improved more and outperformed the United States in 2003 and 2007. Also in 2007, U.S. 8th-graders gained ground relative to their European and Australian peers -- though they have not caught up with their peers in Chinese Taipei, Hong Kong, Japan, Korea, or Singapore. The most recent PISA assessments, however, suggest that U.S. 15-year-olds are not as successful in applying mathematics knowledge and skills to real-world tasks as their peers in most other OECD countries. In the 2006 PISA assessment, U.S. 15-year-olds' average scores were not measurably different than in 2003, keeping the United States in the bottom quarter of OECD countries.

<u>Science</u>: In science, results from the most recent TIMSS assessment show that U.S. 4th-graders have fallen behind their peers in several countries, even though their average scores in science have not declined since the first TIMSS assessment in 1995. At the 8th grade, U.S. scores on the most recent assessment were also not measurably different than in 1995, but they fell behind those in the Russian Federation and they continue to lag behind those in Chinese Taipei, the Czech Republic, England, Hungary, Japan, Korea, and Singapore. The most recent PISA assessment suggests that U.S. 15-year-olds are not able to apply scientific knowledge and skills to real-world tasks as well as their peers in the majority of other OECD countries: in the most recent science assessment of 15-year-olds, the United States continued to perform below the OECD average.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 27 August 2009 and reprinted with permission. Note that a story about "The Condition of Education 2009" is the subject of the first item in this column.)

K-12 Education Should Include Engineering

The introduction of K-12 engineering education has the potential to improve student learning and achievement in science and mathematics, increase awareness about what engineers do and of engineering as a potential career, and boost students' technological literacy, according to a new report from the National Academy of Engineering and the National Research Council. "Engineering in K-12 Education: Understanding the Status and Improving the Prospects" examines the status and nature of efforts to teach engineering in U.S. schools. According to the report, engineering education at the K-12 level should emphasize engineering design and a creative problem-solving process. It should include relevant concepts in mathematics, science, and technology, as well as support the development of skills many believe essential for the 21st century, including systems thinking, collaboration, and communication. While science, technology, engineering, and mathematics instruction is collectively referred to as "STEM education," the report finds that the engineering component is often absent in policy discussions and in the classroom. In fact, engineering might be called the missing letter in STEM, the report says.

Those who contributed to the report developed an in-depth analysis of 15 K-12 engineering curricula; reviewed scientific literature related to learning engineering concepts and skills; evaluated evidence on the impact of K-12 engineering education initiatives; and collected preliminary information about pre-collegiate engineering education programs in other countries. The report found that engineering education opportunities in K-12 schools have expanded considerably in the past 15 years. Since the early 1990s, for example, about 6 million children have been exposed to some formal engineering coursework. However, this number is still small compared with the overall number of students in K-12 schools (approximately 56 million in 2008). The committee noted that many challenges remain to expanding the availability and improving the quality of these programs, including the absence of content standards to guide development of instructional materials, limited pre-service education for engineering teachers, and structural and policy impediments to including this new subject in an already crowded school curriculum. Among the report's recommendations include considering a formal credentialing process for K-12 engineering teachers, continued research to determine how science inquiry and mathematical reasoning can be connected to engineering design in

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curricula and professional development, and clarifying the meaning of "STEM literacy." The report may be read online at <http://www.nap.edu/catalog.php?record_id=12635#toc>.

"Get Schooled Initiative Launches

Viacom and the Bill & Melinda Gates Foundation, along with initiative partners AT&T, Capital One Financial Corporation, and NYSE Euronext, have launched "Get Schooled," a five-year initiative which aims to generate greater awareness and engagement in addressing the nation's education crisis and to offer practical resources and support to students. "We couldn't be having this conversation at a better time," said Bill Gates, Co-chair of the Gates Foundation. "The education crisis is damaging our ability to compete in the global economy, and we need to do more to engage all Americans -- from policy-makers and corporate leaders to families and young people -- in our efforts to support students in completing their education and achieving their dreams." The "Get Schooled" initiative also released the results of a poll conducted by The Winston Group showing that an overwhelming percentage of Americans believe that the United States is lagging behind other nations when it comes to the quality of education. Eighty-one percent of survey respondents said that they do not believe that the United States has the best public education system in the world. Eighty-nine percent believe that if American students are not receiving as good of an education as their overseas counterparts, it will have a negative effect on the American economy.

From 2006 to 2016 there will be more than two million new jobs created requiring at least an associate degree or postsecondary training, according to the New Democratic Leadership Council. However, the reality is that two-thirds of American ninth graders will not be prepared for college within four years, and half of those who actually go to college will never earn a degree. As part of the "Get Schooled" mission to foster a national dialogue on education issues, AT&T is organizing "screening parties" and discussions around the premiere of the TV broadcast of Get Schooled: You Have the Right. Local events, organized with community partners, will take place in 14 cities across the nation. More information about "Get Schooled" is at <www.getschooled.com>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 17 September 2009 and reprinted with permission.)

Clearinghouse Update

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

21st Century Skills and Science Map

The National Science Teachers Association and the Partnership for 21st Century Skills released the 21st Century Skills and Science Map at their National Education Computing Conference. It is available as a 17-page pdf at <http://www.21stcenturyskills.org/documents/21stcskillsmap_science.pdf>. After two introductory pages, there are four pages on Learning and Innovation, focusing respectively on Creativity and Innovation, Critical Thinking and Problem Solving, Communication, and Collaboration. Next come three pages on Information, Media, and Technology Literacy, focusing on Information Literacy, Media Literacy, and Information and Communications Technology (ICT) Literacy. Then come five pages on Life and Career Skills, devoted to Flexibility and Adaptability, Initiative & Self-Direction, Social & Cross Cultural Skills, Productivity & Accountability, and Leadership & Responsibility. Each of these twelve pages lists outcomes and examples for grades 4, 8, and 12. The next page concerns Interdisciplinary Themes – Global Awareness; Financial, Economic, Business and Entrepreneurial Literacy; Civic Literacy; and Health Literacy – and the last two pages are devoted to Supporting Structures: 21st Century Standards, Assessment of 21st Century Skills, 21st Century Curriculum and Instruction, 21st Century Professional Development, and 21st Century Learning Environment.

DeCODE identifies another genetic cause of disease

We have previously reported how deCODE Genetics of Reykjavik, Iceland, has been able to use its database of the Icelandic people to identify genetic causes underlying risk of developing diseases: in our Winter/Spring issue (diabetes), Winter 2004 (osteoporosis, heart attack and stroke), and Fall 2003 (12 diseases). More recently, in the 10 August 2007 issue of *Science*, deCODE reported a similar genetic cause for exfoliation glaucoma, a form which has responded poorly to treatment by drops to lower pressure in the eye.

Diamond "Revisits" Easter Island

Irma Jarcho first reported in the Fall 1995 issue of this *Newsletter* on Jared Diamond's initial assessment (in

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RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Matt Palmquist, "The Key to Safe Driving?" *Miller-McCune*, **2**(2), 24-27 (Mar-Apr 09).

According to research cited in this article, "the risk [of accident] from cell phone use [while driving] is as great as that of the intoxicated driver, only in different ways." The "key" to a solution is Key 2 Safe Driving, a sleeve that fits over a car key. When the car's ignition is turned on, the sleeve signals the driver's cell phone to give the following reply to texts or calls received: "I am driving now. I will call you later when I arrive at the destination safely."

2. George W. Huber and Bruce E. Dale, "Grassoline at the Pump," *Sci. Am.*, **301**(1). 52-59 (Jul 09)..

"Grassoline" is a form of cellulosic biofuel. Unlike "first generation" biofuels, made from food products, "second generation" biofuels made from cellulosic matter that comes from plants grown on marginal land or agricultural wastes – in no case is food production jeopardized. The 1.3 billion tons per year of cellulosic biomass the U.S. can produce independent of food production could generate more than 100 billion gallons per year of "grassoline," about half current U.S. consumption of diesel and gasoline. (The world's cellulosic biomass could generate liquid biofuel in this way in excess of the world's current annual oil consumption of 30 billion barrels.)

The key to cellulosic biofuels is decomposing the cellulose into molecules which can be burned as fuel or converted to fuel molecules. Many ways have been found to do this in the laboratory, but few of them can be scaled up in commercial practice. One extreme approach is high temperature (700^{o}C), which produces syngas (carbon monoxide and hydrogen) as the Fischer-Tropsch process does from coal. Huber is pursuing "catalytic fast pyrolysis" (which heats biomass to 500^{o}C in a second in the presence of catalysts), and Dale is pursuing the ammonia fiber expansion process (AFEX), in which cellulosic biomass is cooked at 100^{o}C with concentrated ammonia under pressure. If the required biomass can be delivered to an AFEX plant for $50 per ton, ethanol equivalent to a gallon of gasoline in energy can be produced for $1.

3. Thomas R. Sinclair, "Taking Measure of Biofuel Limits," *Am. Sci.*, **97**(5), 400-407 (Sep-Oct 09).

Sinclair examines the requirement of the Energy Independence and Security Act to produce 57.6 billion liters of ethanol from corn by 2022 and 86.4 billion more gallons from nongrain biomass in terms of "three critical resource inputs: light, water, and nitrogen." For a C4 plant species like maize, each megajoule of incident solar energy can produce 1.8 grams of plant mass, and an average day brings 20 megajoules incident on each square meter, yielding 36 grams per day. For a 90-day growing season, this means 3.24 kilograms per square meter, or 32.4 tonnes per hectare, only half of which is harvested as grain. This maximum of 16.2 tonnes per hectare compares with an average U.S. yield of 10 tonnes per hectare, and meeting the goal for 2022, with an ethanol yield of 400 liters per tonne would require 15 million hectares more, about half the land currently used to grow maize in the U.S.

If the technological obstacles to producing ethanol for cellulose can be overcome (one is finding fermentation microbes to digest the five-carbon sugars yielded by cellulose), the ethanol yield is expected to be 200 liters per tonne. With a minimum viable yield of 9 tonnes per hectare, 48 million hectares would be required, "50 percent more than the area already under cultivation in the U.S. for any single crop."

The water requirements are likewise described as "a challenge" and, given that "plants and their evolutionary ancestors had hundreds of millions of years to optimize their biological machinery," it is considered unlikely that bioengineering can relax the requirements of light or water to produce biomass.

Nitrogen is needed to grow plants because nitrogen is a component of their DNA and protein, and each kilogram of biomass of maize contains 13 grams of nitrogen. For a yield of 10 tonnes per hectare, this means 130 kilograms of nitrogen per hectare, which must be provided by nitrogen recovered from the previous harvest (typically 29 kilograms per hectare) and nitrogen provided by microbes and the atmosphere (35 kilogram per hectare), with the rest required to be applied in fertilizer (only 60% of which is actually observed).

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4. Paul A. Murtaugh and Michael G. Schlax, "Reproduction and the carbon legacies of individuals," *Global Environmental Change*, **19**, 14-20 (2009), available on-line at <http://latimesblogs.latimes.com/files/study.pdf>.

This article calculates the increased carbon dioxide emissions for a child born to a woman in each of the world's eleven most populous nations ("the carbon legacy for each child produced"), which is also the reduction in carbon dioxide emissions that can be achieved by reducing the number of births by one child. Because the carbon dioxide emissions per capita are greatest among those nations in the U.S. and because U.S. life expectancy is also high, the carbon legacy of each American child is also greater than that of a child born in any other of the most populous countries, almost 170 times that of a child born in Bangladesh.

5. Eli Kintish, "Making Dirty Coal Plants Cleaner," *Science*, **317**, 184-186 (13 July 2007).

This article discusses six ways to extract carbon dioxide from power plant emissions: the integrated gas combined cycle (IGCC), monoethanolamine (MEA), ammonia or ammonium carbonate, burning coal in pure oxygen to produce a flue gas that is 100% carbon dioxide, carbonic anhydrase, and ionic liquids. Perhaps because it is most advanced, the discussion is quantitative only for MEA. A 202 megawatt plant captures 5% of its carbon dioxide emissions for sale to the beverage industry, but it uses 4 megawatts of power. A proposal to capture 96% of the carbon dioxide emissions of a 433 megawatt plant was calculated to reduce the plants power output by 40%, though this was later revised to requiring 30% of the plant's power to capture 90% of the carbon dioxide emitted. A further complication with MEA is its volatility, a property which requires a chiller onsite.

6. Renton Righelato and Dominick V. Spracklen, "Carbon Mitigation by Biofuels or by Saving and Restoring Forests?," *Science*, **317**, 902 (17 August 2007).

After calculating the avoided carbon dioxide emissions per hectare for 30 years of a particular use of land, the authors conclude that "if the prime object of policy on biofuels is mitigation of carbon dioxide-driven global warming, policy makers may be better advised in the short term (30 years or so) to focus on increasing the efficiency of fossil fuel use, to conserve the existing forests and savannahs, and to restore natural forest and grassland habitats on cropland that is not needed for food."

7. William Sims Bainbridge, "The Scientific Research Potential of Virtual Worlds," *Science*, **317**, 472-475 (27 July 2007).

Considered here by an author from the Division of Information and Intelligent Systems of the National Science Foundation (NSF) are World of Warcraft (WoW), with 8.5 million subscribers, and Second Life (SL), which has been entered by 6.5 million. WOW subscribers manage characters, and a visitor to SL is represented by an avatar. SL seems particularly well suited for conducting experiments in social science research, such as were imagined by NSF's NetLab workshop in 1997 – which would not be limited by constraints of physical space and time and involve larger numbers than are usually practical in "First Life." Already a group at the Palo Alto Research Center, armed with census data on over 200,000 WoW characters, "analyzed the factors associated with the upward status mobility of individuals and the dynamics of social groups." Given that both WoW and SL are public places and that both discourage users from using their real names, policy guidelines like NSF's *Federal Policy for the Protection of Human Subjects* might not need to be followed, though "online research involving human beings may re quire ethics scrutiny by institutional human subjects review boards." Bainbridge also observes that "scientists do not seem to be rushing into SL to find a shared virtual location. What value virtual worlds might add to the existing modes of communication between distant scientific collaborators remains to be seen."

8. Greg Miller, "The Promise of Parallel Universes," *Science*, **317**, 1341-1343 (7 September 2007).

Research of social interactions of avatars in the virtual world, Second Life, is reported (in this special section on Social Cognition), not only of encounters of individuals but also the action of crowds, including a replication of Stanley Milgram's experiment in which people were found willing to deliver shocks to a stranger for incorrect responses on a memory test. Anotehr researcher is reported using World of Warcraft to research social networking via a Sony monster-slaying game.

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9. Erik Stokstad, "New York Research Institute Hopes to Go With the Flow," *Science*, **317**, 1019 (24 August 2007).

Thanks to a new collaboration with IBM, the Hudson River will become fully monitored in real time as part of the River and Estuary Observatory Network (REON). In this collaboration, IBM will test its new System S, a "new type of computer system called stream computing," which allows real-time processing of many types of data. The real-time processing could, for example, warn a power plant of an approaching school of fish so that it could temporarily shut its intake valve. This system will also achieve a long-term goal of tracking PCB (PolyChlorinated Biphenyl)-contaminated sediment that has long plagued the river.

(*Editor's Note*: The tracking and disposition of PCBs in the Hudson River has long been a topic reported in this *Newsletter*).

10. Bob Gramling and Bill Freudenberg, "Pay, Baby, Pay," *Miller-McCune*, **2**(4), 40-46 (Jul-Aug 09).

When Interior Secretary James Watt moved from leasing blocks of territory to oil companies to leasing wide areas, only the largest companies had the resources to survey the larger areas and bid on them. Not only was more area leased for less income to the American taxpayer; the royalties received for resources extracted decreased as well. In contrast with Norway's royalty rate of 76%, the pre-Watt American royalty rate was only 16.7%, and some post-Watt leases called for only 12.5%. The authors call for the Interior Department to be involved in assessing the areas it leases, return to being more selective in the areas it offers, and institute royalty rates comparable to those elsewhere in the world. In any case, further U.S. oil development is unlikely to have a major impact on American life. Technological advances have minimized the risk of oil spills, and the ability to drill in any direction from one production facility minimizes the number of such facilities. The mobility of production facilities allows them to be built in already existing facilities, and the work schedules of those who operate drilling rigs allow them to follow the rigs wherever they go. Moreover, whatever, additional U.S. oil is produced is unlikely to be enough to affect the price of oil or the American dependence on oil imports.

11. Matt Jenkins, "Solar System," *Miller-McCune*, **2**(4), 34-39 (Jul-Aug 09).

How do you get a city to reduce its greenhouse gas emissions by installing rooftop photovoltaic cells that cost $30,000 for each house? That's the situation Francisco DeVries found himself in while working for the mayor of Berkeley, CA, and he found the answer from a Berkeley neighborhood that wanted to set up a district to fund putting its utility poles and power lines underground. This would fund the project by bonds which would be paid off by homeowners in the form of assessments over 20 years. So DeVries set up a Sustainable Energy Financing District, which would "issue bonds whose proceeds could finance the upfront costs of photovoltaic systems; participating homeowners could use the money the save on their utility bills to pay the tax assessment. That assessment stays with the property, so if a homeowner moves, the next resident picks up the repayment – and gets the solar power."

(*Editor's Note*: The lead story of our Spring 2008 issue, based on the April 2008 issue of the *MRS Bulletin*, described the California Solar Initiative (CSI), established in January 2006 to provide $3.3 billion of financial incentives to install rooftop photocells a targeted 3 gigawatts of power. According to this article, "The Berkeley City Council approved the Sustainable Energy Financing District in November 2007, and the idea immediately attracted interest from points far beyond Berkeley." Apparently the Berkeley Sustainable Energy Financing District showed the need for more than the CSI to satisfy California's solar energy needs. Both these programs, and possibly more, have contributed to make California the leader in solar energy in the United States.)

12. Eli Kintisch, "Tougher Ozone Accord Also Addresses Global Warming," *Science*, **317**, 1843 (28 September 2007).

When the Montreal Protocol was first established to eliminate the CFCs (chlorofluorocarbons) that were destroying stratospheric ozone, one of the alternatives was HCFCs (hydrochlorofluorocarbons). But, like CFCs, HCFCs are also greenhouse gases, and the Montreal Protocol has now been strengthened by reducing HCFC emissions. HCFC production by developing countries will be frozen by 2013, two years earlier than originally scheduled, and phased out by 2030, a decade earlier than originally scheduled. The phaseout of HCFCs in developed countries is due a decade earlier than in the developing countries, and the replacements for the phased out HCFCs must also be more climate-friendly.

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13. Kimberly S. Heddings and Wendy M Frazier, "Shrinking Our Footprints," *Sci. Teach.*, **76**(6), 25-28 (September 2009).

Have students go online to <http://myfootprint.org> to calculate their ecological footprint, then read and review two articles about such topics as sustainability, causes and effects of overusing natural resources, and alternatives to overuse of resources. Ask students to make lifestyle changes on the basis of what they have learned, then recalculate their ecological footprint and write an article about not only the changes they have made, the reasons for making them, and the benefits that have resulted, but also "potential counterarguments for changes they propose." After they have critiqued articles written by two of their classmates, students of these authors have completed an environmental unit in their chemistry course with an alternative assessment. But, as the authors themselves recognize, "this unit can easily be modified to work for any high school science course."

14. John Pecore, Melanie Snow, and Miyoun Lin, "What Happens to Cemetery Headstones?" *Sci. Teach.*, **76**(6), 29-34 (September 2009).

This NSTA journal frequently features project-based science (PBS), but this example cites the five features which distinguish this genre:

- an authentic context that remains central to the project
- a challenging or driving question
- student involvement in designing a constructive investigative activity
- student autonomy in decision making, and
- realistic products or presentations.

This PBS unit was developed from the "funds of knowledge" of the participants and found them learning about acids and bases from investigating deterioration of headstones in a cemetery. The complete teaching plan is presented for this 9-day unit, but not "which solutions could be implemented to prevent the exposure of the materials to acid rain," which the students were reported to have determined.

15. Steve Weinberg, "Keystone Cops at the Police Lab," *Miller-McCune*, **2**(4), 24-29 (Jul-Aug 09).

"Real science values doubt and teaches it from the start of training," Weinberg writes. "Except for DNA testing, however, forensics as practiced in many and probably most law enforcement crime laboratories places very little value on doubt." To eliminate bias in forensics that can lead to wrongful convictions, Weinberg cites the recommendations of a report from the National Academy of Sciences for 1) a uniform certification of forensic practitioners, 2) accreditation of crime laboratories, and 3) separation of crime laboratories from their "traditional police agency parents."

16. Michael Scott Moore, "Germany's Fine Failure," *Miller-McCune*, **2**(4), 15 (Jul-Aug 09).

A reversal of Germany's intent to phase out nuclear energy could obviate the need for a "feed-in" tariff which entitles producers of electricity from renewable sources to more than the market rate. Meanwhile, Gainesville, FL, has recently instituted such a tariff (which has driven the percentage of electricity from renewable sources in Germany up to 14%, more than double the percentage in the U.S.).

17. Paul Webster, "Playing Chicken With Antibiotic Resistance," *Miller-McCune*, **2**(5), 16-19 (Sep-Oct 09).

Ceftiofur is a cephalosporin antibiotic used to stem bacterial infections in sheds where chickens are raised. A Canadian study found that human resistance to ceftiofur rose and fell with the injection of this drug into chicken eggs by Quebec hatcheries. But when the U.S. Food and Drug Administration (FDA) announced a ban on "extra-label" use of cephalosporins on farms, the American Veterinary Medical Association balked that this unnecessarily constrained their ability to treat animals for pain and suffering, and the FDA (at least temporarily) withdrew the ban.

18. Timothy Ogden, "Computer Error?" *Miller-McCune*, **2**(5), 12-15 (Sep-Oct 09).

Even if the One Laptop per Child program had achieved its goal of a $100 computer for each child in the developing world, the cost-effectiveness of such an approach is being called into question. More cost-effective measures in improving Third World education include deworming and improved teacher attendance at remedial schools.

19. Nate Berg, "Faux Better or Worse," *Miller-McCune*, **2**(5), 20 (Sep-Oct 09).

Artificial turf doesn't need watering or mowing. In that respect, it saves water and fossil fuels and reduces carbon dioxide emissions. But it gets as hot as asphalt and has been linked with a potential exposure to lead

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dust. A preferred alternative is xeriscaping with native plants that require little water and no mowing.

20. Julia Griffin, "From Sewage to Artichokes," *Miller-McCune*, **2**(5), 22-25 (Sep-Oct 09).

Seventy percent of American artichokes are grown in Monterey County, CA. Obtaining two thirds of the irrigation water from the tertiary stage of sewer treatment slows seawater intrusion into Monterey County's aquifers by 30-40%.

21. Valerie Brown, "An Iodine Chaser," *Miller-McCune*, **2**(5), 26-30 (Sep-Oct 09).

Since the half life of iodine-129 is more like that of the actinides in spent nuclear reactor fuel than shorter-lived fission products, sequestering this isotope is an important part of any future American plan to reprocess this spent fuel (although France and England are dumping it into the ocean). Most promising is a zeolite whose pores have been doped with silver, leading to formation of silver iodide (which, unlike elemental iodine, is not water soluble).

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the August 1995 issue of *Discover*) of the downfall of what appeared to be a once-flourishing culture on Easter Island, and this assessment was later incorporated by Diamond into his book, *Collapse*, reviewed in our Winter/ Spring 2006 issue. A subsequent article by Terry Hunt, which took a different view, was reported in our Fall 2006 issue. Now, in "Easter Island Revisited" (*Science*, **317**, 1692-1694 (21 Sep 07)), Diamond presents his own reassessment. He notes that changes on Easter Island "included deforestation, the loss of palm sap as a food and water source; switching from wood to grasses and sedges as fuel; establishing stone mulching; ceasing to carve statues, because deforestation meant no more big logs and fiber rope for transport; abandoning upland plantations, probably used to feed workers transporting statues, and . . . increases in warfare, statue destruction by rival clans, and use of refuge caves." But in assessing the cause of these changes, he cites analysis correlating deforestation on 81 islands with nine environmental parameters determining tree growth and concludes that "all parameters were stacked against Easter: It is relatively cold, dry, low, small, and isolated, with negligible nutrient inputs from atmospheric dust and volcanic ash, relatively old-leached soils, and no uplifted-reef terrain. . . . Easter Islanders had the misfortune to inhabit one of the Pacific's most fragile environments."

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REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Hans C. Ohanian, *Einstein's Mistakes: The Human Failings of Genius* (Norton, New York, 2008). $24.95. ISBN 978-0-393-06293-9.

As I was completing this interesting and informative book, I was also reading the April 2009 issue of *Physics Today*, which is a special issue on John Archibald Wheeler. One of the articles in that periodical, titled "John Wheeler, relativity, and quantum information," includes a section detailing "Wheeler's last blackboard." This is a list of ideas which he discussed. The list includes ". . . we can make many mistakes in the search (for how the universe came into being). The main thing is to make them as fast as possible."

The Ohanian book is particularly significant to me because in the last six years, I have changed and revised the way I teach. I no longer teach high school physics and chemistry, but rather I use physics and chemistry to facilitate student learning of science. Science is about learning how nature works. This learning process involves making mistakes, learning from them and moving on to learn more. This theme runs deep throughout *Einstein's Mistakes*.

The book consists of a preface, twelve chapters, a "Postmortem," notes and a bibliography. The preface includes a list of twenty-three of Einstein's mistakes and the corresponding years when they were made. The list of course includes "Mistake in the introduction of the cosmological constant, Einstein's self-proclaimed biggest blunder." The book is enjoyable to read, with just a few typographical errors. I made numerous notations as I read. In Chapter one, "A lovely time in Berne," Ohanian discusses the notorious Einstein quote, "Then I would feel sorry for the good Lord. The theory is correct anyway," regarding the observational evidence of the bending of light predicted by his general theory of relativity. Ohanian writes, "In this occasional denial of facts and in the stubborn reliance on his own inspirations and revelations, Einstein was a kind of St. Francis of physics. . . ."

Ohanian details Einstein's self-described mathematical challenges. In chapter five, describing Einstein's work on calculating Avogadro's number, Ohanian indicates that "He was not fond of mathematics; as he once said to a French colleague: 'As for me, I do not believe in mathematics.'" Ohanian describes an abundance of mistakes. "The mistakes in physical assumptions range from oversimplifications to the outright zany." These fall in line with the well-known problem involving calculation of the milk production by a cow, where the cow is assumed to be a sphere, as described by the author.

Chapter nine, "The theory is of incomparable beauty," describes the controversy between Einstein and mathematician David Hilbert over priority in discovering the equation for the gravitational field. Ohanian's description is excellent, and very informative. In the same chapter, the author indicates that "In special relativity, Newton's Second Law is not discarded, it is merely modified. But in general relativity, the cause of gravitational accelerations is not a force, but the curvature of spacetime – mass tells spacetime how to curve, and curved spacetime tells mass how to move." There is also an interesting quote, from Einstein's autobiography, indicating that Einstein included an apology to Newton. Ohanian includes some discussion of Einstein's misconception regarding tides, and indicates that "The three greatest physicists ever known (Galileo, Newton and Einstein) all suffered from tidal dysfunction."

Chapter eleven, "Does God play dice?" includes a discussion of Einstein's use of the word "principle" to describe relativity, and the use of the word "theory" to describe it. Ohanian describes a theory as an explanation, and indicates that ". . . it would be best to replace "theory" with "explanation" in all physics textbooks (and also in textbooks in other sciences, especially in evolutionary biology). He goes on to describe the fact that Einstein used the word principle because he intended it as a prescription. "That is, he was telling us how to synchronize clocks and how to impose a time dilation on clocks . . . so that we would not be able to detect the motion of any reference frame."

Chapter twelve, "The graveyard of disappointed hopes," describes Einstein's years at Princeton and the Institute for Advanced Study. The chapter includes numerous examples of Einstein's failings. In the "Postmortem" Ohanian writes, "Einstein's mistakes . . . did not prevent him from making his groundbreaking discoveries." He continues, ". . . many of Einstein's mistakes were amazingly fruitful – they played a seminal role in leading Einstein to his revolutionary theories." He compares Einstein to Johannes Kepler, indicating ". . . Kepler later analyzed his own mistakes . . . and how he

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"unconsciously" repaired his mistakes." He quotes Kepler: "The roads that lead man to knowledge are as wondrous as that knowledge itself."

Included in the "postmortem" is a picture of the statue of Einstein at the National Academy of Sciences in Washington D.C. Ohanian indicates that the statue makes Einstein appear childlike, concluding with "And of course, children make mistakes." The book is very enjoyable to read, and I highly recommend it.

- Frank Lock

(*Editor's Note*: Frank Lock teaches physics at Lemon Bay H.S., Englewood, FL, and is a frequent contributor of book reviews to this *Newsletter*. His most recent review, of Ian Wilmut and Roger Highfield's *After Dolly: The Use and Misuses of Human Cloning*, appeared in our Fall 2008 issue.)

Andrew Robinson, *The Last Man Who Knew Everything* (Pi, New York, 2006), x +288 pp. $24.95. ISBN 0-13-134304-1.

As one who strongly resists any notion that one person can "know everything," I was very intrigued by this title – and even more so when I learned that it was a biographical work about Thomas Young. Given that it was about a person who lived two hundred years ago, when there wasn't so much to know, and realizing that, in addition to his seminal work on the interference of light, he had been a physician – and, yes, there was also Young's modulus in materials science – I figured that the title of this book might actually be legitimate.

Robinson's subtitle for his book – *Thomas Young, The Anonymous Polymath Who Proved Newton Wrong, Explained How We See, Cured the Sick, and Deciphered the Rosetta Stone, Among Other Feats of Genius* – gives further indication of the breadth of material his subject covered in one short lifetime of a little under 56 years, and even this is not completely exhaustive. Robinson uses the term "polymath" to indicate a person who has engaged himself successfully in many different fields as opposed to the more derogatory "dilettante," who merely "dabbles." Robinson suggests that Young's versatility makes him "a tough subject for a biographer" and writes that "to cover his work and life in detail and with authority is probably impossible for a single writer." Yet he seems to go ahead and do it, anyway, and successfully, too, although he claims that his book "dwells only on the highlights of [Young's] polymathic career."

In doing so, Robinson has been helped by a wealth of documents, most of them penned by Young himself. Although most of Young's journals, papers, and letters to which George Peacock had access in writing the 1855 biography requested by Young's widow have disappeared, Peacock's biography closely substituted as a quasi-primary source.

One early quotation from Young, written at age 15, seems especially telling:

> [There] is in reality very little that a person who is seriously and industriously disposed may not obtain from books with more advantage than from a living instructor. . . Masters and mistresses are very necessary to compensate for want of inclination and exertion: but whoever would arrive at excellence must be self-taught.

Perhaps it was because of the value Young found in learning from books that he left us so many for others to learn from. Two are especially comprehensive: two-volumes titled *A Course of Lectures on Natural Philosophy and the Mechanical Arts*(1807), the second volume of which contained a catalog of scientific literature through 1805 with his own commentary; and *An Introduction to Medical Literature, Including a System of Practical Nosology* (1817), which did the same for medical literature as his earlier work had done for science. ("Nosology," according to Robinson, is "the study of the classification of diseases.")

After the extensive learning from books in his early life, Young embarked on a whirlwind of activity at age 19 that was to last the rest of his short life. He began his medical training with lectures at the Hunterian School of Anatomy in London (1792) and followed this with a year of medical study at Edinburgh (1794) and Gőttingen (1795) and two years at Cambridge (though Cambridge had no medical school, earning an M.D., after a waiting period, required two years of study at the same institution). He began his eye research in 1800, became a lecturer at the Royal Institution in 1802, but did not begin his medical practice until 1807, a year before he formally received his M.D. and two years before he became a Fellow of the Royal College of Physicians.

Young's interest in deciphering the Rosetta Stone came from reviewing a German history of languages (languages had fascinated him since childhood, and he was fluent in several, both classical and modern) – this

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began in 1815. A year later Young became an author (of articles on many varied topics) for *Enclyclopaedia Britannica* and three years after that the Secretary of the Board of Longitude and Superintendent of *Nautical Almanac*. And in the final decade of his life he became "inspector of calculations" and physician to a society for life insurance. Robinson speculates that Young's actuarial involvement stemmed from his interest in and publication on mortality statistics deriving from his being a physician.

But what interested me most was the work Young did to further the understanding of the eye and light, perhaps because it relates to the eye examination I experience every year. The accommodation of the lens of the human eye to focus on objects at different distances had been known for centuries, but two famous physicists had advanced conflicting explanations for it. Kepler held that the lens moved back and forth, as does the lens in a camera, while Descartes believed that the lens changes its focal length. Young correctly sided with Descartes, and he developed an optometer to measure the range of the lens's accommodation. A card with two pinholes no farther apart than the diameter of the pupil was placed over one eye and the other eye kept closed, and the range over which the rays defined by the pinholes could provide a focused image of an object which perpendicularly bisected a line parallel to that joining the two pinholes was the range of the lens's accommodation. When Young measured the range of accommodation with the optometer oriented at different angles, he found a variation in the range of the lens's accommodation and thereby discovered astigmatism (although this term awaited coining some three decades by William Whewell, Master of Trinity Collge).

Young also originated the three-color theory of color vision, initially hypothesizing red, yellow, and blue as the three primary colors in 1801, with wavelengths in the ratio 8:7:6 – with green at 6.5, vibrating blue and yellow equally. But after Wollaston's spectroscopic work, Young revised his primary colors in 1802 to be red, green, and violet. More far reaching, though, was Young's belief in the wave theory of light and his efforts to make the case for it, against the corpuscular theory that had been the legacy of Newton. This began with Young's paper, "Sound and Light," read to the Royal Society of London (for which he was the long-term foreign secretary) in January 1800. Although most of this paper concerned sound, section X on "the analogy between light and sound" contained his basis for criticizing the corpuscular model: the constancy of light's velocity, the simultaneous reflection and refraction of light, Newton's rings, and the variability of refraction with color. Although section XI cited beats as evidence of interference of sound waves, he did not go for the optical analogy at this time.

Young's next paper on this subject, "On the Theory of Light and Colors," came a year later. In addition to his theory of color vision and acknowledging that light waves required a vibrating ether (a feature later regretted by Einstein), Young illustrated interference with water waves (which he also demonstrated with a ripple tank he invented in his 1802 Royal Institution lectures), and this time he *explained* Newton's rings by interference of light and calculated the wavelengths of different colors. But it was not until a November 1803 lecture, "Experiments and Calculations Relative to Physical Optics" that Young achieved optical two point source interference, from the portions of a narrow sunbeam (defined by a pinhole) allowed to diffract around two sides of a 1/30" card.

But even then Young had still not succeeded in the optical analog of the two point source interference of water waves. This was not to come until his *A Course of Lectures on Natural Philosophy and the Mechanical Art*, and – in spite of the drawing of double-slit interference fringes which Robinson reproduces on p. 123 – Young's lack of supporting data (which usually was included in his work) and the absence of a claim to have done the experiment have caused some to question the legitimacy of which is generally regarded as his crowning achievement in physics. Meanwhile, the arguments for a wave theory of light continued. Eventually Young realized the mistake of making an analogy between light and sound, because the longitudinal waves of sound could not explain the polarization of light, and the person who really fleshed out the wave theory of light, even to the point of winning over corpuscularist Pierre-Simon Laplace, was Augustin Fresnel.

Yet light and the elastic modulus were not Thomas Young's only contributions to physics. Robinson cites James Clerk Maxwell as attributing to Young the first use of the word "energy" – in his *Natural Philosophy* lectures – though he used an expression for kinetic energy twice the one we use today. Young was also the first to estimate molecular diameter – from the range of intermolecular force, determined from comparing surface tension (of a liquid) with tensile strength. He also agreed with Rumford in associating heat with molecular motion and recognized its transfer from radiation "by the undulations

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of an elastic medium" [ether] longer than those associated with visible light. By recognizing "blackening rays, derived from still more minute vibrations [than visible light]," Young thereby recognized the electromagnetic spectrum from infrared to ultraviolet.

Though he may not have known everything, Young's life is certainly testimony of what can come from versatile engagement in many things. And even with engagement in many things, they can usually not be engaged in all at once. For example, Young's involvement in other interests allowed Champollion to come from behind and finish deciphering the hieroglyphs on the Rosetta Stone, though Young *was* able to forge ahead and take the lead in deciphering the demotic script which paralleled the hieroglyphs and Greek. In the "Autobiographical sketch" Young wrote in the third person near the end of his life, he recognized the type of life he had chosen for himself, recognized that it differed from the choices of others, but offered no regrets:

> It is indeed so impossible to foresee the capabilities of improvement in any science, that it is idle to form any general opinion of what would be the comparative advantage of the employment of time in any one investigation rather than another, for almost all the authors of important discoveries and even of inventions, are led as much by accident as by system to their successes. He [Young] would probably not have recommended the plan of his own studies as a model for the imitation of others: and he certainly thought that many hours, and even years of his life, had been occupied in pursuits that were comparatively unprofitable. But it is probably best for mankind that the researches of some investigators should be conceived within a narrow compass, while others pass more rapidly through a more extensive sphere of research.

- John L. Roeder

John Shanebrook, *Nuclear War I and other major nuclear disasters of the 20th century* (authorHOUSE, Bloomington, IN, 2007), viii +306 pp. ISBN 978-1-4259-8511-0.

"Nuclear War I commenced on August 6, 1945 when the United States dropped a gun-type, uranium nuclear bomb on the Japanese city of Hiroshima. . . ." This is how Shanebrook defines the title of his book (p.13). On the back of his dust jacket he defines the rest of his title by enumerating 22 categories of "nuclear diasters" from which, he points out, "hundreds of thousands of people died" in the 20th century. Those categories encompass any event which released nuclear radiation to the environment, and on p. 11 he adds one more: Henry Smyth's book *Atomic Energy for Military Purposes*, better known as the "Smyth Report," which "probably helped the Russians a great deal by reducing the engineering effort needed to produce enriched Uranium-235 and plutonium." (pp. 10-11)

This book was originally published under the pen name of Samuel Upton Newtan, the initials of which would offer an alternative to nuclear energy, according a private communication from the author. Because such a use of a pen name troubled me, I was delighted to find when I searched for the book on amazon.com that the author's identity has been correctly listed. Other aspects of the book that troubled me were 1) the publication by what appears to be a vanity press (and the consequent lack of editing, which could have eliminated occasional repetition and streamlined the presentation to provide a more consistent format); 2) lack of primary sources and footnotes (just listing bibliographies of mostly secondary sources at ends of chapters, to me, is not adequate documentation); and 3) an overt anti-nuclear bias, which evaluates decisions made during World War II (when we were racing Germany to build the first nuclear weapon) and the Cold War (when we were engaged in a nuclear armaments race with the Soviet Union) by *today's* standards.

These general sources of trouble, in turn, gave rise to nine specific points of concern:

1. The necessity of attacking Japan with nuclear weapons. As I have noted in reviewing Rotter's book (in our Fall 2008 issue) and Grunow's paper (in our Winter/Spring 2009 issue), this question has concerned me deeply since I first taught a course on Galileo and J. Robert Oppenheimer in the early 1970s. In his twelfth and final chapter, which summarizes all the other eleven, Shanebook finds the nuclear attack on Japan to be an example of desperation exceeding morality; and in his second chapter, devoted to that attack, he states (without specific reference) that a 1946 intelligence study concluded Russia's entry into the war to be the deciding factor leading Japan to surrender, in contrast to Grunow's citation of opposition of Japan's military to surrender, *even after* Soviet entry into the war.

2. Attributing the nuclear attack on Japan to President Truman's lack of education. On p. 274 Shanebrook incorrectly characterizes Truman, admittedly the only President to authorize use of nuclear weapons, as "Of all the U.S. presidents . . . the only one who did not have a

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college education." Neither did Washington, Jackson, Lincoln, or several less-remembered presidents. Perhaps Shanebrook meant to qualify his statement with "in the twentieth century," though Truman is widely regarded as educating himself considerably through extensive reading.

3. *The cause of cancers later incurred by cast and crew of* The Conqueror. On pp. 87-88 Shanebrook notes that 40% of the cast and crew of this John Wayne-Susan Hayward movie, shot in the "Fallout City" of St. George, UT, in 1954, eventually contracted cancer, including its two stars. No assertion of cause-and-effect is made, but the statement leaves the reader with an implication – although the connection of radiation to cancer is harder to establish than to radiation sickness.

4. *Consequences of mutations due to human-made radiation sources*. On p. 64 Shanebrook writes that "mutations that result from man-made sources [of radiation] are always *detrimental*" (emphasis original), though on p. 286 he "corrects" this to read "almost always."

5. *"Broken Arrows" from the wikipedia*. On p. 189 Shanebrook cites the US Department of Defense definition of a "Broken Arrow" as "any unexpected event involving nuclear weapons that results in the accidental launching, firing, detonation, theft, or loss of the weapon." His list of 18 of these events comes from the wikipedia. Interestingly, they show no further events in the air after the termination of "airborne alerts," whereby there was always a nuclear bomber flying toward the U.S.S.R.

6. *"Thermal pollution" from nuclear reactors*. On p. 103 Shanebrook correctly criticizes nuclear reactors for their thermal pollution, but he does not simultaneously note that electricity produced from power plants that burn fossil fuels is accompanied by a comparable amount of thermal pollution.

7. *Amount of uranium dust emitted into the air*. On p. 234 Shanebrook states that 100 tons of uranium dust escaped into the air at the Fernald, OH, uranium enrichment plant. This is the same as the amount of weapons grade plutonium he cites as being produced on p. 230. Might he have meant kilograms rather than tons in referring to the uranium?

8. *The mission of the WIPP (Waste Isolation Pilot Plant)*. When Shanebrook describes this plant on p. 232, he does not distinguish that it is dedicated to storing military radioactive waste. In spite of the report of its success in resource #11 of our Winter/Spring 2009 issue, Shanebrook implies the existence of problems there.

9. *"Uncertainty" as a negative argument*. Just as David Michaels in *Doubt is their Product* (reviewed in our Winter/Spring 2009 issue) reports the use of doubt by stakeholders in the *status quo* to oppose proposed solutions to problems, Shanebrook more than once criticizes vitrifaction of nuclear waste because of the uncertainty about how vitrified nuclear waste will hold up at the high temperatures it will generate.

In addition to these nine points of concern, there are two errors which I found surprising: an incorrect symbol (St) is used consistently (on pp. 73, 74, 90, 91, and 92) for strontium (should be Sr), and the location of the Yucca Mountain site for nuclear waste storage is mistakenly given as New Mexico (rather than Nevada) on p. 171.

Yet, in spite of all the concerns I have registered about this book, I also found a great deal of justification for this book. In spite of its author's bias, it presents a history of nuclear weaponry and nuclear energy in the twentieth century that enabled me to gain a better perspective on the relationship of events I have lived through. For example, I learned that, among the consequences of the Kemeny Report following the accident at Three Mile Island on 28 March 1979, college degrees are now required of nuclear reactor operators, evacuation plans are required for the licensing of nuclear power plants (this is what brought an end to the Shoreham nuclear power plant on Long Island), and the Federal Emergency Management Agency (better known as FEMA) was established.

More importantly, Shanebrook has framed several issues in new, more enlightening, perspectives:

1. *Radiation danger potential from power plants*. On p. 139 Shanebrook points out that the radiation released by the accident at Chernobyl on 26 April 1986 is 50 times that from Hiroshima and Nagasaki combined, in agreement with the statement of Sergiy Komisarenko at the United Nations, as reported in our Spring 2001 issue. That this is so can be calculated from comparing the amount of fission required to produce energy for a power plant with the fissions required to produce the energy released in a nuclear explosion – although the energy released in an explosion is confined to a very short interval of time, the energy released by a nuclear power plant in a

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year is about 300 times that released by a 20 kiloton (TNT) nuclear weapon.

The cleanup costs of Chernobyl are reported on p. 144 to be about half the TARP funds approved by the U.S. Congress in 2008. Yet Shanebrook also points out that the 50 million curies of radiation unloosed at Chernobyl is dwarfed by the 122 million curies released by a *chemical* explosion at the U.S.S.R. Mayak reprocessing site on 29 September 1957 (p. 241).

2. Vulnerability of nuclear power plants to attack in war could bring about a nuclear war without nuclear weapons. Repeatedly in his book Shanebrook expresses concern that nuclear power plants could be targeted in the style of attacks on 11 September 2001, and on p. 252 he cites an Al Jazeera interview with Khalid Sheik Mohammed that Al Qaeda rejected the Indian Point reactors (40 miles north of New York City) because "things would get out of control." Yet, as Shanebrook notes on p. 253, Israel crossed "a new *threshold* in warfare" (emphasis original) by bombing an Iraqi reactor on 7 June 1981.

Shanebrook also quotes former Energy Secretary James Schlesinger (p. 259) that nuclear power plant containment domes are limited in their ability to withstand a collision impact equivalent to that of a 200,000 pound plane traveling at 150 miles per hour. Fortunately, Shanebrook notes (p. 265) that India and Pakistan have realized the consequences of their nuclear power plants as military targets and reached an agreement in 1991 that forbids attacks on each other's civilian nuclear facilities.

3. Lack of regulation transforming nuclear submarine technology as a pathway for nuclear proliferation. International control of nuclear weapons technology does not apply to the reactor technology applicable to nuclear propulsion, Shanebrook notes on page 163. He is a strong believer in the linkage between reactor and weapons technology, noting (on p. 169) that plutonium produced in reactors was the fissionable material used in the first nuclear test conducted by all the world's nuclear powers except China.

4. Unlike a "burner" a runaway reaction in a "breeder" reactor caused by core meltdown can explode. Although no reason is given for this statement on p. 175, I would expect that it is a consequence of the fact that there is no moderator in a breeder reactor. In a "burner" reactor, which depends on the fission of U-235 for the bulk of its energy, sustenance of the chain reaction requires a moderator to slow the neutrons released in fission so that they can cause additional U-235 fissions more efficiently. In American "burner" reactors, water acts as both coolant and moderator. Therefore, a loss of coolant, which is needed to bring about a core meltdown, also means a loss of moderator, and this acts to end the chain reaction. This is not the case in a "breeder" reactor, which relies on absorption of U-238 by neutrons and two subsequent beta decays to produce fissionable Pu-239 fuel, which does not require slow neutrons to fission. Therefore, loss of coolant (which Shanebrook cites as a problem common to development of "breeder" reactors in Japan, France, and the former Soviet Union, pp. 185-186) in a "breeder" reactor would allow the fissioning of the critical mass of reactor fuel melted down on the reactor floor to continue without control.

This issue would become more critical in the future as Earth's finite supplies of U-235 in mined uranium are fissioned and the future viability of electricity from nuclear power becomes dependent on converting the unfissionable but more abundant U-238 to fissionable Pu-239.

5. Increased background radiation levels from increased use of nuclear energy. As Shanebrook correctly points out on p. 212, each stage of the nuclear fuel cycle produces nuclear wastes, and each nuclear waste is a source of radiation in our environment. At the current level of producing electricity from nuclear energy, this has not been a problem, but what if this level were multiplied by, say, a factor of ten?

In addition to this list of issues which I have described, Shanebrook closes his book with his *own* list of "five nuclear issues [which] will probably require considerable attention in the future:

1) The continued global use of nuclear reactors to generate electricity, heat energy, and plutonium.

2) Proliferation of nuclear weapons, including 'dirty bombs,' and the commerce of sensitive nuclear materials (fissile materials and fission products) to produce these weapons.

3) Nuclear waste management (storage; reprocessing).

4) Acts of War on nuclear facilities (e.g., preemptive attacks to impede production of nuclear weapons).

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5) Nuclear reactors and nuclear weapons in space (satellites, battle stations, and space vehicles)." (pp. 284-285)

Of this list, Shanebrook singles out #2, #3, and #4 as three issues "that escaped resolution in the 20th century." (p. 287) "These issues," he writes, "can not be ignored if nuclear technology is to continue into the future as a viable source of energy or the world."

- John L. Roeder

(*Editor's Note*: Shanebrook is a retired engineering professor from Union College. His article on "A Nuclear Tech Course" in our February 1985 issue seems to have been the basis for this book, and a further article on "Putting Counterforce into the Curriculum" in our Fall 1988 issue described the last unit of his course on "Modern Nuclear Weapons and Delivery Systems." In our Fall 1996 issue he wrote about "A New Energy/ Environment Course.")

Michael D. Gordin, *Five Days in August: How World War II Became a Nuclear War* (Princeton, Princeton, 2007), xiv +209 pp. $24.95. ISBN 978-0-691-12818-4.

The five days that are the focus of this book are 6-10 August 1945. On 6 August the United States dropped a nuclear weapon nicknamed "Little Boy," which derived the energy of its explosion from uranium-235, on Hiroshima, Japan. On 8 August the Soviet Union entered the World War II against Japan (although the yearlong grace period following its 5 April 1945 abrogation of a Neutrality Pact with Japan had not expired). On 9 August the United States dropped a nuclear weapon nicknamed "Fat Man," which derived the energy of its explosion from plutonium-239, on Nagasaki, Japan. On 10 August, the Japanese offered a conditional surrender, which led to the final surrender on 15 August.

The result is a detailed examination of what happened during the period between the Manhattan Project and the Potsdam Declaration and the post-World War II world. Although this amounts to putting a magnifying glass over a very small piece of the calendar, it is done fully within the context of the grand scale of events which preceded it. But it is also done with the author's own "spin" on the story. In his introductory chapter, titled "Endings," Gordin writes – without any documentary documentation – that "because so many military planners and influential politicians considered the atomic bomb to be, at least in some degree, an 'ordinary' weapon . . . dropping one or several of them merited no more justification than the inception of firebombing campaigns. . . ." (p. 7) Gordin's other "spin" is that just because the Japanese surrendered after two nuclear weapons were dropped, there was no *à priori* reason to believe that this would be the case.

When I read Gordin's assertion that "many in the field perceived the atomic bomb as a quantitatively different firebomb (it was much more explosive, more efficient, and required fewer B-29 bombers to deliver), but not as a qualitative change in warfare" on pp. 10-11, I was reminded of the argument that the reactor in a nuclear power plant is just another way to boil water. But I was also reminded of President Truman's telling Josef Stalin at Potsdam that the U.S. had "a new weapon of unusual destructive force." Never mind. Gordin finishes his sentence atop page 11 with a discounting of the President's opinion: "however epochal Truman and his advisers at times considered it to be."

When Gordin does seek to marshal evidence to support his case, it seems rather silly. He cites the ultimate decision to use the bomb as based on the absence of a justification *not* to use it (p. 40), General Groves's insistence that nuclear weapons be dropped on targets spared conventional bombing so that the difference would be noticed (p. 44), and the fact that not until the third paragraph of the radio announcement of the Hiroshima bombing was it announced to be "atomic." (p. 86)

In fact, in the same paragraph citing Groves's criteria for targeting, Gordin himself admits that the bomb which Secretary of War Henry Stimson called S-1, with the "S" for "special," was "on its face . . . *not* [ordinary]." (p. 44, Gordin's emphasis). And though, after the Hiroshima drop, Stimson took his cue from Army Chief of Staff George C. Marshall by characterizing the bomb as "merely another weapon much more powerful than any of its predecessors," could it be that General Marshall was trying to put a "business as usual" spin on the situation?

Not until nuclear weapons were found to fit the need for the "shock" that was deemed needed to move the Japanese to surrender does Gordin feel that they became "special." Perhaps Gordin feels this way because the radioactive aftermath of nuclear weapons was not taken into account – the region of exposure to radiation was believed to be smaller than the region which wrought destruction by blast. We first learned about radiation sickness from Tokyo Rose, and it became known that

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"the real horror of The Bomb is not blast but radioactivity." (p. 55)

Regarding the number of bombs believed to be needed to move the Japanese to surrender, Gordin seeks to deflate the "two-bomb myth" based on the post-war writings of MIT President Karl T. Compton and Groves, although Groves is also quoted as writing J. Robert Oppenheimer after the Trinity test (at Alamogordo, NM) on the possible need for a third plutonium bomb (the first was tested at Alamogordo, the second dropped over Nagasaki). But much of what Gordin writes in this regard is actually referring to a need for a second bomb as a harbinger of more to come, lest Japan regard the first as a fluke (pp. 47-48). The third bomb sought by Groves was scheduled to be available in late August, with additional bombs after that on a more accelerated schedule. The target list was extended, with Tokyo suggested for the third drop, for psychological reasons, even though it violated Groves's target criteria (pp. 97-98). Col. Paul Tibbets, who piloted the *Enola Gay* over Hiroshima, believed that five bombs would be needed, and Norman Ramsey believed that up to 50 would be needed. So confident was Ramsey that the war would not be over soon, that he failed to buy health insurance to cover his wife's current pregnancy (p. 76). Only William S. "Deak" Parsons, the weaponeer on the *Enola Gay*, believed that only one bomb was needed (p. 83). In any case, when you're fighting a war, you have to plan the future as if it will continue indefinitely.

Once one gets past Gordin's "spin" on the story of the closing days of World War II, one finds some very interesting insights in this book that are rarely seen elsewhere. Gordin comes up rather empty-handed when it comes to two fundamental questions he raises in his "Coda": "What was President Harry S. Truman's intent in using the bomb" and "What ended World War II," because he feels that reliable answers must come from contemporary documents, not memoirs. The "traditionalist" answer to the first question is represented by Stimson's 1947 article in *Harper's Magazine*, but there are several "revisionist" alternatives, one of which was authored by British physicist P.M.S. Blackett.

Since the Japanese burned all their records prior to the American occupation lest they be used in war crimes trials, there is essentially nothing to go on other than public oral statements concerning their offer to surrender – and Emperor Hirohito's allusion to the effect of the bombs in his surrender announcement is noted twice (pp. 16-17, 36). Incidentally, Gordin, citing "the diary of Keeper of the Privy Seal Kido," which "does not depict an emperor actively intervening to generate peace" (p. 37), disbelieves the traditional description of Hirohito's encouraging Japan's surrender after the Hiroshima bombing – which spared him from a war crimes trial – and this, Gordin believes, tainted the postwar monarchy with guilt.

Gordin opines his own uncertainty about the effect of the Soviet entry into the war on p. 28. Elsewhere (p. 27) he notes the Soviet Union's need to enter the war late enough to avoid excessive toll on its troops but early enough to claim what had been ceded at Yalta. This was originally planned for 9-10 August but moved up to 8 August after the bomb was dropped on Hiroshima on 6 August. In the end, Truman "flatly refused" the Soviets the same occupation rights in Japan they had in Germany – he ceded to them only the Kurile Islands (pp. 104-105).

What is especially valuable about Gordin's book are the questions he *does* answer, and these largely focus around the events on the island of Tinian, which, he states in two places (pp. 8-9 and 59) "was the only site where people ever confronted a fully assembled, predetonation, deliverable atomic bomb." This comprises two of the inner chapters of the book's total of seven. Tinian was taken after the U.S. captured neighboring Saipan, which Gordin notes was the first conquest within the Japanese Absolute National Defense Sphere (p. 63). Tinian under American control allowed B-29s to fire bomb mainland Japanese cities and later served as the base dispatching the B-29s carrying the nuclear weapons destined for Hiroshima and Nagasaki. Although the firebombing inevitably killed noncombatants, it was officially designated for the military targets in the area that was bombed, and Gordin notes (p. 22) that this type of area bombing was excluded from war crimes in both World Wars. The Army Air Force (as it was known then) hoped that its performance in World War II would earn it an autonomous position along the then two other armed forces (p. 18), and it saw its wish come true on 18 September 1947 (p. 120).

One of the curiosities about winding down World War II is why the peace-seeking Japanese faction made overtures through the Soviet Union, which had abrogated its Neutrality Pact on 5 April 1945. In spite of all this, Gordin points out that the Soviet Union was the only nearby power with which Japan was not at war at the time (p. 25).

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Lastly, Gordin provides an answer to one of the four rhetorical questions posed by Andrew Rotter in *Hiroshima* (reviewed in our Fall 2008 issue): "Were both bombs needed?" Since the second bomb hit when the Japanese cabinet was still deciding what to do in view of the first one, a related question might be more logical to ask – and one which Gordin notes is more debated than why the first bomb was dropped on Hiroshima: Why was the interval between the dropping of the two bombs so short?

The answer, in a nutshell, was weather. Little Boy was ready for delivery on 2 August 1945, but weather didn't allow dropping it until 6 August (p. 80). Gordin writes on p. 90 that "According to Groves's diary, the original plan had been to drop the second bomb five days after the first one: close enough to establish that there was in fact a mass production of these weapons, but far enough apart so that the Japanese government and people had time to ponder the implications of the weapon." Ramsey reported to Oppenheimer that the original schedule called for delivering the second bomb on 11 August 1945 but could have it ready by 10 August. When Tibbets observed that good weather was forecast for 9 August but that bad weather was forecast for five days after that, they arranged to ready Fat Man for a 9 August delivery, if it could be done without sacrificing safety or reliability.

- John L. Roeder

William Low, *Machines Go to Work* (Holt, New York, 2009), 40 pp. $14.95.

"Here is a fine picture book for little boys who have an innate love of machinery and the noises that big machines make. In fact, the richly colored pages of *Machines Go to Work* probably could not be more exactly calibrated to entrance the vehicle oriented, 2-to-6-year-old male demographic."

The above is the opening excerpt of a book review that was written in *The Wall Street Journal* in May 2009. The author was Meghan Cox Gurdon, one of the *Journal*'s regularly-assigned reviewers of children's books, who unfortunately opined that *Machines Go to Work* is a boy's book. In fact her next sentence in the review states, "Gzzzzzzzk! the text begins as if the narrator is himself a small boy." Okay, fair enough.

Why am I bringing this to the attention of *Clearinghouse* readers? It is because this fine writer has unwittingly succumbed to stereotyping this enthralling book as being appropriate only for boys. Instead of opening up the opportunity for all children – and for all girls – throughout this world to explore machines in this realistically fashioned and beautifully illustrated book, she narrowed the playing field and reinforced a bias that enlightened educators are constantly battling. It is as if we were back in the 1950s world of Dick and Jane.

Yet I am not dismissive of all the latest research on brain development that has taken place in the last ten years. I work at Horace Mann School with esteemed colleagues who have shared with me the latest research on brain formation which indeed cites documented differences in the developing brains of boys and girls – how they approach problem-solving, their early language development, their spatial acuity, decision-making, and risk taking. So if it is a given that boys do have an innate predilection and interest in tools, trucks and cars, block building, machines, do we, in an enlightened society, then pander to their interests and exclude all females from exploring a realm that they may or may not find comfortable or stimulating? Why would young girls not want to read such an outstanding new book on machines? Consider the reviewer's own words: ". . . But what makes William Low's contribution a standout is his skillful matching of dramatic oil paintings with fine-tuned, age appropriate, gentle surprising text. . . . At one point we find ourselves, as if in the sky, looking down upon a helicopter that is hovering above a row of cars. 'The traffic has stopped. Is there an accident ahead?' When we unfold the next page, there is a tiny line of bright yellow dots on the distant asphalt and the charming explanation 'No, a family of ducks is crossing the road.'" What young child would not find such a book both informative and engrossing?

What a missed opportunity! Need I say more? All of us must be vigilant and confront our own biases and misconceptions plus those in the media and elsewhere that are so destructive to our producing a literate, well-informed inclusive population now and in the future.

- Bernice Hauser
Primary Education Correspondent

Deborah Cramer, *Smithsonian Ocean: Our Water, Our World* (Smithsonian/HarperCollins, 2008), 296 pp. $39.95.

This attractively-published companion volume to the exhibit which opened in the Sant Ocean Hall at the National Museum of Natural History in Washington, DC, on

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27 September 2008 would be a welcome addition to anyone's coffee table. But don't put it there for your guests to leaf through to enjoy the awesome photography of what covers two thirds the surface of our planet. Read it! The pictures are gorgeous, but my main concern about this book is that they will distract perusers from the really poignant message Deborah Cramer has written to accompany them.

In the first half of the book, which operates under the supertitles of "Beginnings" and "Touched by the Sea," by tracing out the origins of life – in the ocean, of course – Cramer enables us to realize that all life is ultimately dependent on the ocean for its existence. The first photosynthesis came from green bacteria, and descendants of those bacteria continue to photosynthesize today and are responsible for almost half of Earth's photosynthesis (this is noted twice – on pp. 66 and 103). More advanced forms of life evolved when "a cell evolved with its DNA contained in a nucleus [that] . . . swallowed a photosynthesizing bacterium . . . [which] became the chloroplast. . . ." (p. 143) and "after single cells containing chlorophyll had pumped enough life-giving oxygen into atmosphere and ocean to sustain the metabolism of a large animal." (p. 138)

Then, in the bridge to the second half, titled "The Anthropocene," Cramer observes, "Only one species in the genus *Homo* remains. On this last human species, the health of the earth depends." (p. 154) Five pages later she ponders, "Only as we begin to understand the richness of the sea do we realize how much we are at the risk of losing." "The Anthropocene" is Paul Crutzen's title of "our chapter in earth's biography," which he characterizes as beginning with the Industrial Revolution (p. 156). But, notes Cramer, E. O. Wilson's "Anthropocene" began much earlier – "when *Homo sapiens* settled the continents and hunted large animals to extinction." (p. 157) Adds Cramer: Humans are now "powerful enough to restructure marine food webs, powerful enough to alter the chemistry and temperatue of sea water. . . . Today characterization of . . . the sea . . . is incomplete without considering the contribution of humans, and considering how, in the grand sweep of time, that contribution might matter to humanity, to our fellow inhabitants on earth, and to the sea itself. We hold earth's life-giving waters in our hands." (p. 158)

The extent to which this is true is made clear in the second half of the book, supertitled "Touching the Sea." We read how human forays into all parts of the biosphere, both land and sea, have been accompanied by hunting and fishing of species to the points of extinction or near-extinction. The mass extinctions of the Permean and Cretacious periods took place over periods of 100,000 years or more, but the extinction rate since humans have arrived is 100 times as great and threatens to go higher. Furthermore, extinctions are only part of the story. Temperature increases accompanying increased carbon dioxide emissions from fossil fuel combustion threaten ice sheets over Greenland and Antarctica, resulting in higher sea level and loss of habitat for polar species, and phosphorus and nitrogen from agricultural runoff threaten aquatic ecology through pollution. "Farmers tending fields in Kansas and Nebraska also tend to the lives of shrimp in the Gulf of Mexico," Cramer observes (p. 239).

"Four out of five of earth's major mass extinctions were associated with rises in atmospheric carbon doxide," Cramer cautions. "Our fossil fuel emissions, habitat destruction, overfishing, introduction of invasive species, and pollution may be triggering earth's largest extinction since the death of the dinosaurs." (p. 248) Yet, she points out, "Unlike the animals that came before us, we can choose the legacy we leave. Our choices will be felt for generations to come, and by all who dwell on earth." (p. 250) "We can choose a legacy of stewardship," she concludes, "choose to live by an ocean ethic, whose principles, derived from the nature of the sea itself, are these:

That the sea is the source and sustainer of all life, including ours;
That we are but one species among many;
That earth history recorded in ancient seafloor illuminates our present and intimates a future;
That earth's ocean waters are joined in a single, flowing sea;
That wherever we live, however we live, we touch the sea and therefore share responsibility for its health and well-being." (p. 251)

An atlas of the world's oceans followed by small world maps showing features affecting the world's oceans complement the book, in addition to maps within the text which show the configuration of the continents at critical times in the past.

- John L. Roeder

Stephen C. Meyer, Scott Minnich, Jonathan Moneymaker, Paul A. Nelson, and Ralph Seelke, *Explore Evolution: The Arguments For and Against Neo-Darwinism*

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(Hill House, Melbourne, 2008), 160 pp. ISBN 0-947352-47-3 (hard), 0-947352-48-1 (soft).

This book is a supplement for high school science students by five authors, all of which have close connections with Intelligent Design activism and the Discovery Institute (which is also distributes the book). These authors use many old and new creationist ploys to wedge their religious views into the high school science curriculum.

One old ploy being used is the name-changing game. When biblical creationism no longer could be taught directly, the term "scientific creationism" was substituted. When it was also disallowed, the term "Intelligent Design" was used – until Judge John E. Jones decreed that it was a form of creationism in the 2006 *Kitzmiller v. Dover* case. *Explore Evolution* is a post-Kitzmiller text, so once again there is name changing. In this book the presumed "sudden appearance" of fossils of never-before-seen animal species is presented as a *new* "polyphyletic," or "orchard" view of life that is contrasted to the old-fashioned, Darwinist branching tree "theory" that is illustrated in this book with images including those that are more than 100 years old.

This name changing is linked to the argument that evolution is an unproven theory that many scientists support, but others do not. Starting with this premise – that evolution is a debatable concept – the central part of the book is a series of nine debates focusing on what are described as the evidences of evolution. On page four the authors write: "We gather as much evidence as possible and look at it carefully. Then we compare the competing theories in light of how well they explain the evidence." At the end of each debate students are asked to decide whether the evidence supports evolution.

The first debate is on fossils, and it's centered on a distorted rendition of the Cambrian "explosion" as it's called in this text. It's accompanied with illustrations contrasting a single evolutionary tree with an "orchard of trees" and a text that questions the existence of transitional fossils. At the end of the "debate" students are asked, "Are the Darwinists right? Or, . . . are the critics of Universal Common Descent right when they say that transitional forms have not been discovered because they never existed? Scientists disagree, and the issue is far from settled." (p. 35).

The issue is settled. Descent with modification from common ancestors has been a scientific fact for 100 years. However, there are multiple unsolved problems about the factors that cause evolution. Is punctuated equilibrium a viable concept, for instance? In *Explore Evolution* these issues are falsely presented as arguments against evolution itself. Snippets are culled from scientific exchanges, lifted out of context and presented as antievolutionary data. As a result, many scientists working to further evolutionary understanding find their words being used to support creationism. Steven J. Gould is one scientist whose views repeatedly have been misused.

After fossils, the debates that follow are on homology (structural similarities among species) embryology, biogeography (different species in different parts of the world), natural selection, and mutation. In each of these areas, so-called anti-evolutionary "scientists" claim that there are scientific alternatives to each kind of evolutionary arguments.

As one example, in the homology section, the authors claim that the one-bone, two-bone limb arrangement found in mammals can be explained without evolution. Their alternative explanation? Usefulness. Two pages are used to describe an experiment students can conduct to show that the two lower bone/one upper bone system in mammals works better than the reverse—two up and one down. Then, it's "Time for discussion." Are mammalian similarities due to common descent, or can they be explained by usefulness? No God or Intelligent Designer is mentioned, but the usefulness argument is nonsensical without one. The authors assume that teachers and students at the local levels will fill in this blank. And by saying nothing – as well as using a debate format – the people responsible hope to protect the text from suffering the fate of its predecessor, *Of Pandas and People*.

Consider next the example of biogeography. Unlike biblical creationists who try to understand how animal species populated the world once they came off the ark, these authors have no problem. Remember the "orchard" concept. If kangaroos are found in Australia, this is where the kangaroo "kind" popped up, then branched out to became many kangaroo species. This microevolution evolution – change within a kind – is accepted. But, the authors claim, there are barriers that constrain evolution. The original kangaroo could evolve into various kinds of kangaroos, but no line of kangaroos could ever become a koala bear. That would be macroevolution. In the debate students are asked to decide the following question: "How much creative power do evolutionary mechanisms possess?" (pp. 79-80)

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The answer for which these authors are looking is "not much." As explained to students, when a species originally pops up – say the kangaroo kind – it has all of the genetic potential for every kind of kangaroo that's ever existed. But as the kangaroos diverged, "each daughter population will have lost genetic information necessary for building certain other traits. The total biological information in the gene pool will have decreased . . . . Some would argue that it's illogical to claim that a process that loses information can explain the origin of a new type of animal." (p. 95)

And so students go from rigged debate to rigged debate. The last one is on Michael Behe's creationist concept of irreducible complexity, and it ends with students being asked these questions: "Will scientists find an adequate, mechanistic explanation for irreducibly complex systems? Have they already? Or will researchers conclude that the neo-Darwinian mechanism ultimately comes up short?" (p. 122)

Through all of these debates, teachers and students do not necessarily know that creationists have selected the topics. They are not told that it's creationists who have written both sides of each debate and formulated the questions since only their academic credentials are found in the text and at the text website. There is no hint that all five authors have long histories of religious activism and Intelligent Design promotion.

Nonetheless, the authors claim the book is fair, encourages critical thinking, and is inquiry-based learning on undecided scientific questions, The text isn't fair and it doesn't foster critical thinking or inquiry-based learning. These terms are just used as propagandistic "glory words." Then, the book's authors go on the offensive say that it's the evolutionary scientists who are less than honest.

Much of the "evidence" for the presumed scientific dishonesty revolves around errors in high school science texts – as if scientists are responsible for what goes into these commercial products, often written by non-scientists. As examples, some textbooks are condemned because large and small fossils appear similar in size. Another charge is that transitional fossils of a certain type were not found in the same geographical location – as if rock layers are of no significance. Ernst Haekel's generalized embryo drawings from the late 1800s (with large illustrations) also are used to undermine student confidence in modern evolutionary science.

At the end of the text the authors don't even bother to make a case for evolution. There is a 12-page "Special Study" (with lavish illustrations) in which students are asked in a rather derisive way how a reptile's heart with three chambers could ever be transformed into a mammal's four-chambered organ or how a reptile's diaphragm breathing system ever could become a bird's flow-through system. In regard to the last idea, the authors unfortunately (for them) selected a problem that's been solved. It's now known that some dinosaurs—the Aerosteons—had bird-style breathing systems.

On the very last page the book's creationist agenda is made clear – as it was in Kansas. "Practicing science should be about making a vigorous effort to make true statements about the natural world, using all the evidence we have gathered, whatever its source, wherever it leads." (p. 143) We know where this kind of thinking leads – to supernatural explanations – miracles – being taught as science.

Brant Abrahamson

(*Editor's Note*: Brant Abrahamson, recently retired from teaching, runs The Teachers' Press in Brookfield, IL, and speaks to as many groups as he can to heighten awareness of efforts of Intelligent Design advocates to subvert the teaching of evolution. In our Spring 2008 issue Abrahamson provided biographical information about the authors of *Explore Evolution*.)

Chris Mooney and Sheril Kirshenbaum, *Unscientific America: How Scientific Illiteracy Threatens Our Future* (Basic Books, New York, 2009). 132 pages of text plus 66 pages of notes. ISBN 978-0-465001305-0.

The rift between science and mainstream American culture is growing ever wider, says this book. Chris Mooney should know; his 2005 book *The Republican War on Science* analyzed an important and blatant example of this rift. The opening pages of *Unscientific America* note the nation's historical disdain of intellect as documented in Richard Hofstadter's classic 1962 book *Anti-Intellectualism in American Life,* a problem that's especially acute when it comes to science. The book notes the science-society rift in politics, the media, entertainment, and, most importantly, religion.

The authors largely blame scientists themselves for this rift, and look to scientists to lead us out of it. But scientists today tend to step out of their labs only long enough to blame the problem on others such as education or the media. The authors share C. P. Snow's concern, as expressed in Snow's much-quoted essay *The Two Cultures,*

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that science isn't being translated broadly into relevant social and cultural terms, and that this stems from compartmentalization of knowledge in science and in other fields. Today, science is walled off not only from the humanities (Snow's chief concern) but also from politics, the media, entertainment, and religion.

Unscientific America offers Carl Sagan as a foremost example of the kind of scientist that's needed. A successful researcher early in his career, Sagan quickly turned to broader issues of public education and scientific literacy. One of Sagan's more successful projects, for example, was the PBS television series *Cosmos,* called by Sagan's friend Stephen Jay Gould "the greatest media work in popular science of all time." Although Sagan won a goodly share of praise from scientists, the authors fault the scientific and academic community for failing to award him tenure at Harvard and failing to admit him to the National Academy of Sciences after he was nominated for membership in 1992. He was criticized for "oversimplification" in his scientific writings. Speaking as one who has read a lot of Sagan's writings, I find that he wrote with skillful and powerful accuracy, using non-technical language without mathematics. Unfortunately, for some scientists this kind of writing is synonymous with "oversimplification," and therein lies much of the cause of the science-society rift of which *Unscientific America* speaks.

One of Sagan's best known warnings comes from his final published book, *The Demon-Haunted World:*

> We've arranged a global civilization in which most crucial elements profoundly depend on science and technology. We have also arranged things so that almost no one understands science and technology. This is a prescription for disaster. We might get away with it for a while, but sooner or later this combustible mixture of ignorance and power is going to blow up in our faces.

In fact, what with global warming, superstition-driven terrorism, *etc.*, it's blowing up now.

The book wisely remains focused on the dumbing down of American culture by anti-intellectual, conservative, and religious forces. As evidence, the authors cite their experience as participants in "ScienceDebate2008," a nonpartisan grassroots call for presidential candidates to debate science and technology policy on national television. But the project found its invitation declined by Clinton and Obama and ignored entirely by McCain. Meanwhile, political journalists nearly ignored science throughout the campaign, and the candidates managed to debate religious issues in religious forums.

The demise of the Congressional Office of Technology Assessment at the hands of the partisan Gingrich Congress in 1995 is another example. In the words of a 2008 report on how members of Congress think about science, "most members seem to have little care about, interest in, or attention to technical and scientific matters, and to credible sources of information to guide Congress on [scientific] issues."

Another tragically important example is how the media bungled the most important science-related story of our time: global warming. The media mostly ignored the story until 2005, although scientists had been sounding the alarm since at least the first Intergovernmental Panel on Climate Change report in 1990. When the media did report on global warming, it was always in the "he said, she said" mode that bowed to industry and media interests by maintaining the fiction that science was seriously divided on this issue. It remains true today that, on global warming science, "the press is AWOL."

In Chapter 8, "Bruising Their Religion," the authors criticize the actions of the "new atheists," *i.e.*, those such as Sam Harris, Richard Dawkins, and Christopher Hitchens who forthrightly criticize religion for maintaining America's superstitions and anti-intellectual attitudes. The authors argue that "America is a very religious nation, and if forced to choose between faith and science, vast numbers of Americans will select the former." Furthermore, "Atheism is not the logically inevitable outcome of scientific reasoning." Although I agree with these two quotations, I part company with the book on this issue. It seems to me that religion, or at least fundamentalist religion, is a major cause of the science-society split. This isn't the place for me to debate this point, but I don't see how the problem with fundamentalist religion can be resolved without direct confrontation.

The 2005 National Academy of Sciences report *Rising Above the Gathering Storm* noted a U.S. failure to produce enough scientists and engineers to keep us competitive for the long haul, and recommended dramatically bulking up K-12 science education. But *Unscientific America* notes that this recommendation is narrowly rooted. "Simply producing more scientists won't solve our cultural problems." The book laments the equations and formulas that public school students memorize, while these science students don't look at how science will transform the future world they will inhabit, never learn-

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ing that science's most profound implications reach far beyond the scientific technicalities that science students are required to master, never becoming *scientifically literate*.

The solution, says this book, is that scientific and educational institutions, including universities, must redefine the scientists' role by rewarding endeavors that these institutions have long undervalued: public outreach, education of non-scientists, communication, and interdisciplinary education.

The authors document the trials and tribulations of U.S. science students in traversing undergraduate school, graduate school, and post-doc labor, only to find that, contrary to what one would expect from *Gathering Storm's* analysis, they are overeducated and have few job prospects. The proposed solution to both this "pipeline" problem and the scientific illiteracy problem is obvious: broaden the scientific mandate to include scientific literacy for all. Arm all science students with the skills to teach and otherwise communicate publicly relevant science, broaden public school science to emphasize scientific literacy for all non-scientists and all scientists (since scientists are not really scientifically literate today), and encourage public policy makers to create public-interest fellowships and jobs whose purpose is to connect science with society. In other words, instill in scientists the notion of *public service.*

Summarizing its prescription, the book's final chapter states "We must fundamentally change the way we think and talk about science education," and this means rethinking the education of *scientists* as well as the public school and college education of non-scientists. "We don't simply need a bigger scientific workforce: We need a more cultured one, capable of bridging the divides that have led to science's declining influence. . . . We must invest in a sweeping project to make science relevant to the whole of America's citizenry." I couldn't agree more.

Art Hobson

(*Editor's* Note: Art Hobson (ahobson@uark.edu) is Professor Emeritus of Physics at the University of Arkansas and a frequent contributor to this *Newsletter*. This review was previously accepted for publication in the APS Forum on Education *Newsletter* and is reprinted here with permission.)

Your book review here!

Have you recently read a book that would interest other readers of this *Newsletter*? If so, why don't you write a review of it to appear in a future issue! Just e-mail it, preferably in a Microsoft Word file, to editor John Roeder at <JLRoeder@aol.com>.

Rutherford

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sociation Conference in Dallas in 2005 (which was reported in our Fall 2006 issue). There he said "we have not achieved what we *should* have, what we *could* have," in regretting that we have not "sustained improvements in the quality of K-12 science education in America." To this he adds, four years later, "not yet." Then he continues, "After all, 2061 is still some way off."

In my coverage of the April 2008 *MRS Bulletin* in our Spring 2008 issue, I closed by suggesting that a "disruptive innovation" is "needed on many fronts to meet the energy needs in a world filled with more people but less of the cheap fossil fuels on which we have become too dependent," and the report in this issue on MacKay's *Sustainable Energy* makes this all too clear. In our Fall 2008 issue I editorialized that a similar "disruptive innovation" is also needed in STEM education. It strikes me that such a "disruptive innovation" is what Project 2061 is calling for. Rutherford is right that "2061 is still some way off" – but only 52 years remain.

(*Editor's Note*: Other Project 2061 documents cited or reviewed in previous issues of this *Newsletter* are *Blueprints for Reform: Science, Mathematics and Technology Education* (Fall 1998), *Resources for Science Literacy* (Spring 1996), *Dialogue in Early Childhood Education in Science, Mathematics, and Technology* (Spring 1999), and *Designs for Science Literacy* (Fall 2000).

Rutherford recalls beginning of Project 2061

by John L. Roeder

Having directed such reform projects in science education as the Carnegie Science-Humanities Project in California, Harvard Project Physics, and Project City Science in New York, Jim Rutherford served as Assistant Director of the National Science Foundation and Assistant Secretary of Education in the Carter Administration. Then the election of Ronald Reagan to the presidency in 1980 took away all the wind that Rutherford had felt in the sails for science education reform, and, according to Rutherford's reminiscences about "The Birth of *Science for All Americans*," his future services on behalf of science education might have been lost had not the late William Carey, then executive officer of the American Association for the Advancement of Science (AAAS) tapped him to head a new AAAS "desire to engage the scientific community energetically and knowledgeably in a sustained K-12 science education reform effort" that eventually became known as Project 2061. His earlier efforts may have been failures, in the sense of not surviving, he recalls, "but it is from those experiences that I acquired a set of beliefs about science education reform – some fortifying my existing conviction, others changing them – that eventually led me to my role in the creation of Project 2061 and its first product, *Science for All Americans*.

The purpose of the first of two projected phases of Project 2061, which Rutherford describes as "tactical," "was to create and launch some activities that would increase the AAAS presence and capabilities in science education reform nationally and provide a rationale for recruiting a staff of talented individuals eager to be involved in innovative undertakings . . . while garnering up-to-date information on the status of science education, reestablishing connections with school, university, and state leaders in science education, and impressing the scientific community of the crucial importance of its informed participation in the reform of K-12 science education in America." This in itself was a tall order, given many previous attempts at science education reform, which Rutherford and his team criticized as being piecemeal and fragmented, unfocused, and short-sighted and impatient. In contrast, they sought "lasting reforms that make possible the attainment of science literacy by all K-12 students by the time they graduate from high school," with "science literacy" broadened to "include the physical, biological, and social sciences, and the interrelationships among those sciences and mathematics and technology." They sought to define science literacy in terms of "explicit learning goals that are compelling and challenging yet attainable . . . without involvement of or financial support from the federal government." And they sought to focus on the *long term*, because "lasting changes cannot be brought about in a hurry," hence the name Project 2061: it was then 1985, the last year for Comet Halley to pass the Earth's orbit, and the 76 years until the comet's next passage should suffice to bring about the desired reform in science education.

With funding from the Carnegie Corporation of New York and the Andrew W. Mellon Foundation, Project 2061 set to work. Five panels were charged with coming up with recommendations in five respective domains, respectively: "the biological and health sciences; mathematics; the physical and information sciences and engineering; the social and behavioral sciences; and technology." Their "statement of literacy learning goals must encompass science . . . mathematics, and technology, and their interdependencies, the nature of science as well as its conclusions, and both knowledge and skills" and must "be expressed in language that is both scientifically sound and illustrative of the language sufficient for science literate citizens." They were to "steer clear of developing goals to accommodate current materials and practices, but rather set goals that will eventually become the basis for the creation of better materials and practices by others in the future." "This meant favoring content that has had great influence on what is worth knowing now and what will still be worth knowing decades hence . . . that could serve as a lasting foundation on which to build more knowledge over a lifetime."

Science for All Americans, which expressed the vision of Project 2061, and the reports of the five panels were reviewed in our Fall 1989 issue, and what they said then remains valid today. These documents in turn laid the foundation for the second phase of Project 2061, which Rutherford terms "strategic." This phase saw publication of such supporting publications as *Benchmarks for Science Literacy* (reviewed in our Winter 1994 issue) and, most recently, *Atlas of Science Literacy*. The goal of these documents is to flesh out curriculum models which will enable implementation of Project 2061's vision. It is the *Atlas* that really grapples with the nitty gritty of mapping curricula so that all the *Benchmarks* are met, and Project 2061 regularly offers workshops to introduce teachers to *Atlas* and how they can use it.

At the end of his reminiscences about "The Birth of *Science for All Americans*," Rutherford recalls his Paul F-Brandwein lecture at the National Science Teachers As-

(continued on page 54)

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What Your Mother Never Told You About Physics Teaching

1. Physics is for everyone – but this was not always.

2. The best physics understanding is conceptual understanding. This was not realized when we emphasized solving problems and wondered why students had trouble solving them.

3. There is real merit in covering topics out of their order in the book.

4. Learning occurs with frustration.

5. The art of physics teaching is managing the struggle.

6. The role of physics teaching is facilitation.

7. The role of students is active engagement.

8. It is impossible to write the perfect lab instructions:

a. Given the materials . . . find a relationship . . . .

b. What do you know based on the evidence?

c. How close is close enough? (Half the variability is a good +/-.)

9. Teacher intervention best occurs when the students are ready to hear the suggestions.

10. Homogeneous grouping works best (grouped by gender if possible).

11. If the conceptual understanding is in place, the mathematics happens.

12. If most students miss the problem, the conceptual understanding is not there. (The answer is *not* to work out more examples.)

13. The best measure of identifying student understanding is to ask them to explain.

14. The heart of successful physics teaching is to like kids.

15. The soul of successful physics teaching is to see each student as an individual.

16. The goal of physics teaching is to help students see that physics is everywhere.

17. Find a mentoring group – don't do it alone!

(*Editor's Note*: The above is excerpted from the talk given by Deborah Roudebush, Physics Teacher at Oakton High School (VA), upon receiving the Excellence in Pre-College Teaching Award from the American Association of Physics Teachers in Ann Arbor, MI, on 28 July 2009.)