TEACHERS CLEARINGHOUSE
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Innovation – the only key to the future
Gathering Storm Revisited sees Category 5

Five years ago the National Academies (of Science, Engineering, and the Institute of Medicine) published *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, in response to a Congressional charge to respond to the following questions:

> What are the top 10 actions, in priority order, that federal policymakers could take to enhance the science and technology enterprise so that the United States can successfully compete, prosper, and be secure in the global community of the 21st century? What strategy, with several concrete steps, could be used to implement each of those actions?

The report produced "four overarching recommendations, underpinned by twenty specific implementing actions. . . . The National Academies *Gathering Storm* committee concluded that a primary driver of the future economy and concomitant creation of jobs will be *innovation,* largely derived from advances in science and engineering." The Executive Summary of the *Gathering Storm* report took "deserved pride" in the American system but cautioned that "without a renewed effort to bolster the foundations of our competitiveness, we can expect to lose our privileged position."

The *Gathering Storm* report stimulated more than 100 editorials and op-eds and was heralded by this *Newsletter* as a prescription for "*doing* something to improve science education" rather merely a statement of "what *should* be done to improve science education," as had been the case with a long line of reports issued in the two preceding decades. It was also heralded in his 2006 State of the Union Address by former President Bush, who on 9 Au-

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PCAST emphasizes Preparation and Inspiration

While the writers of *Rising Above the Gathering Storm* were revisiting and revising their 2005 report to Congress, the President's Council of Advisors on Science and Technology (PCAST) were addressing the same topic for President Obama. They titled their report *Prepare and Inspire: K-12 Science, Technology, Engineering, and Math (STEM) Education for America's Future*, because they wanted to emphasize the importance of preparing American students to succeed in STEM subjects and inspiring American students to achieve this success.

The reason for this is the reason for every other report calling for improved STEM education since this *Newsletter* has been published: scientific progress is "an increasingly important driver of innovation-based growth" (p. v), accounting for more than half of the growth of American per capita income. *Preparation* needs greater emphasis because "African Americans, Hispanics, Native Americans, and women are seriously underrepresented in many STEM fields," and *inspiration* is needed because "there is also a lack of *interest* in STEM fields among many students." (p. vi)

In assessing the present situation, PCAST cites four great lacks and three great strengths. "Schools often lack teachers who know how to teach science and mathematics effectively, and who know and love their subject well enough to inspire their students. Teachers lack adequate support, including appropriate professional development as well as interesting and intriguing curricula. School systems lack tools for assessing progress and rewarding success. The Nation lacks clear, shared standards for science and math that would help all actors in the system set and achieve goals." (p. vi) "Despite these troubling

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An EDITORIAL: A Tale of Five Reports on STEM Ed

We were just about ready to put this issue together two months ago, with the front page covered by what had been learned over the summer about revising science education standards in terms of the NRC Draft of "A Framework for Science Education" and what Pat Heller had said about physics education standards. Then the reports started coming in. First was *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*. When *Rising Above the Gathering Storm* was published five years ago, it was heralded in our Fall 2005 issue, and in other quarters as well, as *the* report which was going to cause something to be *done* about improving American science education, after two decades of science education reports that got no farther than what *should* be done. After all, *Rising Above the Gathering Storm* had been requested by none other than the U. S. Congress itself. That was sign enough that when they asked what action they should take, that action would be taken.

One of the other reports calling for action on U. S. science education, issued in the same year as *Rising Above the Gathering Storm*, was *Tapping America's Potential: The Education for Innovation Initiative*, from 15 representatives of the business community. Its hopes were riding on the outcome from *Rising Above the Gathering Storm*, but the early hopes generated from authorizing the provisions recommended by *Rising Above the Gathering Storm* were dimmed when most of the required appropriations failed to follow. The authors of *Tapping America's Potential* recognized this when they took the unprecedented step of reconvening three years later to evaluate the progress to date. As reported in our Fall 2008 issue, they emerged "frustrated that while governments around the world are building their national innovation capacity through investments in research and STEM education, the United States is standing still."

When the Presidents of the National Academies, which had been asked by Congress to develop *Rising Above the Gathering Storm*, asked the authors of that report to review their work five years later, the three-year review of *Tapping America's Potential* was already the handwriting on the wall. In turn, the original authors of *Rising Above the Gathering Storm* issued their own damning of Congressional inaction, and it has been more than noticed in the science education community.

But that's not the only report we received. Close behind was a report of the President's Council of Advisors on Science and Technology (PCAST) on how to prepare and inspire more young people in STEM education. The National Science Board also weighed in – with *Preparing the Next Generation of Stem Innovators*. In the course of reading these documents, we also were able to locate the document that underlay the assertion in a letter to the *Wall Street Journal*, to which Bernice Hauser had called our attention, that the U. S. ranked last in a field of 40 nations in rate of improvement in its competitiveness. This was *The Atlantic Century: Benchmarking EU and U.S. Innovation and Competitiveness*, published by The Information Technology and Innovation Foundation (ITIF).

Two months later, we've managed to read and digest these reports and report on them for you. The thrust of *Rising Above the Gathering Storm* was overall competitiveness, with strength in STEM education seen as a factor to spur innovation, seen to be the key to competitiveness. PCAST's *Prepare and Inspire* is more focused on STEM education, but it calls for 10 times the

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

NSB addresses STEM Innovation

"Innovation is the complex process of introducing novel ideas into use or practice in order to develop cutting-edge breakthroughs in emergent fields . . . as well as novel solutions to age-old problems. . . .," writes the National Science Board in its latest report, *Preparing the Next Generation of STEM Innovators: Identifying and Developing Our Nation's Human Capital*. It "requires highly able, determined, and creative leaders and thinkers," they continue, noting that "we are now living in what the Council on Competitiveness calls the 'conceptual economy,' where competitive advantage and value creation rely on 'insight, imagination, and ingenuity.'" (pp. 7-8) Thus, "scientific and technological innovation continues to play an essential role in catalyzing the creation of new industries, spawning job growth, and improving the quality of life in the United States and throughout the world."

Noting that their report was motivated by "two mutually reinforcing reasons" – that "the long-term prosperity of our Nation will increasingly rely on talented and motivated individuals who will comprise the vanguard of scientific and technological innovation" and that "every student in America deserves the opportunity to achieve his or her full potential" – the Board presents recommendations "detailing how our Nation might foster the identification and development of future STEM innovators" that "will engender a renewed aspiration towards equity *and* excellence in U.S. STEM education."

The Board conducted a two-year examination of STEM innovation in conjunction with the National Science Foundation and the U.S. Department of Education (the two greatest funders of STEM education at the Federal level) and defines STEM "innovators" as "individuals who have developed the expertise to become leading STEM professionals and perhaps the creators of significant breakthroughs or advances in scientific and technological understanding" (pp. vii, 1). Its first "keystone recommendation" is to "provide opportunities for excellence," and the two that follow are to reach out to make sure that these opportunities are available to all students and to support the attainment of excellence by all students.

Thus, the theme of "equity *and* excellence" plays a major role in the recommendations of the National Sci-

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"America's Growing Innovation Gap"

by Bernice Hauser and John L. Roeder

In the 9 July 2010 issue of the *Wall Street Journal* John C. Lechleiter, Chairman/President /CEO of Eli Lilly and Co., wrote an article, "America's Growing Innovation Gap," in which he stated that

> America is the inventing nation. A stream of inventions helped make the 20th century the American Century. . . A recent study ranked the US sixth among the top 40 industrialized nations in innovative competitiveness, but 40th out of 40 in the rate of change in innovative capacity over the past decade. The ranking, published . . . by the Information [Technology] and Innovation Foundation measured what countries are doing — in higher education, investment in research and development, corporate tax rates and more — to become more innovative in the future. The US ranked dead last.

Continuing on, Lechleiter suggested various strategies that he said would enable our country to reclaim our edge. One of these dealt with the education issue: "First, with our kids falling further behind on international comparisons in education, we've got to get serious about broad improvement in science and math instruction in our grade schools and high schools."

The study to which Lechleiter referred was *The Atlantic Century: Benchmarking EU and U.S. Innovation and Competitiveness*, published by The Information Technology and Innovation Foundation (ITIF) in February 2009 and authored by Robert D. Atkinson, President of the Foundation, and Scott M. Andes. It is available online at <www.itif.org/files/2009-atlanatic-century.pdf>. The basis of their study was to "assess nations' innovation-based, global competitiveness" of 36 nations plus four nation-groups (NAFTA, EU-25, EU-15, and EU-10) by a weighted average of sixteen categories, distributed among six categories as follows:

A. Human Capital
   1. Higher Education Attainment (% age 25-34 with college degrees)
   2. Science and Technology Researchers (# researchers/1000 employed)

B. Innovation Capacity
   3. Corporate Investment in R&D (corp R&D/ GDP)

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National Science Board

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ence Board. In effect, the Board is saying that top-notch STEM education to nurture our best STEM students is good for *all* students and that we need to cast a wider net with top-notch STEM education in order to not to fail to identify all future STEM innovators. This is especially true, given that "longitudinal data show that intellectually talented individuals who can be identified at an early age (and then supported in their learning) generate a disproportionate number of Fortune 500 patents, peer-reviewed STEM publications, and other creative achievements." (p. 8) Casting this wider net is also important to ward off overdependence on foreign talent: "Ideally, foreign talent should augment a robust domestic STEM talent pipeline, not compensate for its deficiencies." (p. 9)

More than once the Board writes that "the United States is faced with a clear and profound choice between action and complacency." (pp. 4, 6, 9) Yet, in contrast with its call to provide opportunities for excellence, it finds that No Child Left Behind has schools "focused on getting children across the basic proficiency threshold" to the exclusion of finding opportunities for the most talented students to exceed the standards. Like the President's Council of Advisors on Science and Technology (PCAST) in their *Prepare and Inspire* report, the National Science Board advocates opportunities for future STEM innovators to be continually challenged to developed their STEM abilities. And because future STEM innovators are exceeding the standards at their grade level, their abilities can be best identified by giving them tests designed for a level above their grade. Finally, future STEM innovators need to be supported by their teachers, school administrations, families, and peers in their development of STEM abilities.

The National Science Board accompanies its recommendations with a research agenda. "In a climate where education resources are scarce, it is essential to provide policy-makers with empirical evaluation data to aid their funding decisions," they write. "Therefore, a key component of a research agenda must be a candid analysis of which educational and enrichment interventions work . . . and which do not, in the short-run and long-term." (p.18) Further research is also needed because "much is still unknown about the various forms of ability and their relationship to future innovation." (p. 21) What, for example, is important beyond cognitive ability, motivation, and hard work? One such factor which needs further study is spatial ability, because it has already been noted that "90 percent of STEM doctorate holders scored in the top quartile of spatial ability during adolescence." (p. 9)

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4. Government Investment in R&D (gov't R&D/GDP)
5. Share and Quality of World's Scientific and Technical Publications (#pub/million people)

C. Entrepreneurship

6. Venture Capital ($/GDP)
7. New Firms (% new firms of total #)

D. Information Technology and Infrastructure

8. E-Government (2008 index of gov't use of digital technology)
9. Broadband Telecommunications (quality and #subscribers/cap.)
10. Corporate Investment in Information Technology (bus. investment in IT/GDP)

E. Economic Policy Factors

11. Effective Corporate Tax Rates (avg. 5-yr. effective marginal rate)
12. Ease of Doing Business (regulation and business climate)

F. Economic Performance

13. Trade Balance (trade balance/GDP)
14. Foreign Direct Investment Inflows (foreign investment/GDP)
15. GDP per Working-Age Adult (GDP/adult(25-64))
16. Productivity (GDP/hr)

The study tabulated values for each nation and nation-group in each category for a recent year (between 2005 and 2008, apparently according to the most recent year for which figures were available) and the change for each nation and nation-group in each category for a period of four to seven years preceding before calculating the overall weighted average. Although the U.S. ranks 6^{th} in terms of overall score, its "change score" is the lowest of all: "ITIF finds that all of the 39 other countries and regions studied have made faster progress toward the new knowledge-based innovation economy in recent years than the United States. . . . If the EU-15 region as a whole continues to improve at this faster rate than the United States, it would surpass the United States in innovation-based competitiveness by 2020." (p. 1)

In addition to North American and European nations, the ITIF "list of 40" includes the Asian nations of South Korea, Japan, China, Singapore, and India, and the study observes that "East Asian nations, in particular, are making rapid strides. Perhaps not surprisingly, China comes in first in terms of progress, as they have aggressively promoted modernization and technology development."

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It goes on to add that "East Asia's central challenge will be to transition in the next decade away from an export-led model of growth, much of it based on mercantilist policies like currency manipulation, to policies that spur innovation, IT use, and productivity growth through all sectors of their economy – not just a few select export industries. . . . absent concerted public sector efforts by the United States and Europe to boost innovation and competitiveness . . . this century will not be the Atlantic century, but rather the Pacific century, or perhaps more accurately the Southeastern Asian century." (p. 4)

National Science Teachers Association President Alan McCormack noted a related document, also from The Information Technology and Innovation Foundation, *ICT R&D Policies: An International Perspective*, in the September 2010 issue of *NSTA Reports*. It is a five-page article in *IEEE Internet Computing*, available online at <http://www.itif.org/files/ICTRandD.pdf>, written by Stephen Ezell and Scott Andes. They begin by making the case that information and communication technology (ICT) is "a crucial driver behind innovations in Internet computing and drives economic growth and citizen's quality of life." Although ICT constitutes only 3% of the US GDP, they write that it "has accounted for 25 percent of US economic growth since 1995" and "more than half of US productivity growth over the past 15 years." Moreover, "US ICT employment grew four times faster than US employment as a whole" between 1999 and 2008.

Ezell and Andes culled data for ICT industrial R&D expenditures for 2005 for six key nations from the Organization for Economic Cooperation and Development's (OECD's) "Information Technology Outlook 2008" and a 2007 report commissioned by the French Ministry for Education, Higher Education, and tabulated the information in the accompanying table.

Although The US is at the top of the list in ICT R&D for 2005, Ezell and Andes are appalled that its growth rate is so much less than other global competitors. And when it comes to government funding for ICT R&D, things get worse. The European Union's $3.5 billion in 2005 almost doubles the $1.8 billion invested by the US government. Japan's public investment of $2.7 billion falls in between, but this is six times the percentage of Japan's GDP as the US investment is of US GDP. It is because "the economies that accrue the greatest benefits will be those that continue to aggressively support ICT R&D to keep their firms and industries at the cutting edge of innovation and application" that Ezell and Andes conclude the heading of their article by saying "Although the US still performs the most ICT R&D globally, competition has intensified as US ICT R&D investment as a percentage of GDP has fallen noticeably – and has been surpassed by competitors – in the past decade."

Realizing that they are writing in a recession, Ezell and Andes note that "Robust tax credits are especially important in countering economic recessions, as businesses tend to cut R&D during downturns" and recommend a broad program of tax credits they feel Congress should enact.

Country	ICT industrial R&D (billion $), 2005	% growth in industrial ICT R&D
United States	59.6	6 (1996-2005)
China	38.7	22 (business, 1997-2007)
European Union (EU-15)	34.6	37 (1996-2005)
Japan	31.6	41 (1996-2005)
Korea	10.7	71 (1996-2005)
India	7.3	

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10,000 STEM teachers advocated in *Rising Above the Gathering Storm*. Most importantly, it considers teachers to be the most important factor in STEM education.

PCAST cites four "National Needs," and the National Science Board report addresses the third and fourth of these. Like *Rising Above the Gathering Storm*, the National Science Board advocates a key role for innovation in America's future. And *The Atlantic Century* assesses innovation trends globally. We've put our reports of these documents at the front of this issue for your reading convenience, but after reading them, we hope you'll move on to see what else is new in the world of science and society education.

\- John L. Roeder

CORRECTION

The reference to "mega-e" in resource #7 of our Spring 2010 issue should have been "omega-3."

Preparation and Inspiration

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signs," PCAST continues, "the United States has the most vibrant and productive STEM community in the world," which includes many foreign scientists who stayed on after being attracted to complete their studies here. We also have "a growing body of research [that] illuminate[s] how children learn about STEM," including active learning, avoidance of breadth without depth, and learning progressions. Lastly "a clear bipartisan consensus has emerged on the need for education reform in general and the importance of STEM education in particular." (p. vi)

In view of the above, PCAST sees four "National Needs for STEM Education": 1) "Ensure a STEM-capable citizenry" (knowledge of STEM subjects and facility with STEM skills is important in everyday life and in a wide variety of occupations), 2) "Build a STEM-proficient workforce" (STEM proficiency is needed in an increasing number of occupations, and employment is increasing more in STEM fields more than in non-STEM fields), 3) "Cultivate future STEM experts" (they are needed to spur scientific and technological innovation), and 4) "Close the achievement and participation gap" (women and minorities underrepresented in STEM fields must join the "STEM-capable citizenry").

To meet these needs, PCAST feels that Federal funding needs to be more strategic for its billion dollars (8% of total education expenditures) to have a stronger effect in achieving national educational goals. Moreover, "Federally-funded programs and initiatives in STEM education have not historically been researched and evaluated in a manner that contributes to effective program development and policymaking." (p. 32) The key to achieving this is coordination of STEM education efforts across Federal agencies, principally the US Department of Education (USDofEd) and the National Science Foundation (NSF), which are "complementary in their expertise." "The Department of Education," PCAST notes, "has lacked the strong ties to the STEM community that would allow it to incorporate scientific expertise into its projects. The National Science Foundation possesses the required staff expertise and the ties to the scientific community while lacking the systemic focus and levers for large-scale change that will be required to catalyze major changes in STEM education. A high-level partnership between the agencies could bridge this gap, driving systemic reform through innovative research and data-driven program evaluation." (p. 34) Thus, PCAST recommends, among other things, that "the Department of Education and the National Science Foundation should enter into a high-level partnership to improve STEM education, using their complementary expertise to engage the education community and STEM communities."

"Teachers are the single most important factor in the K-12 education system," the PCAST report states (p. 57), and their emphasis is on the recruitment, training, support, and retention of *great* STEM teachers. It is noted that 25,000 of the nation's 477,000 STEM teachers leave annually, and that 28% of grade 7-12 science teachers have neither a science major or minor. Moreover, a science major or minor doesn't guarantee the deep content knowledge that, along with strong pedagogical skills, characterize *great* teachers. PCAST laments the lack of professional respect and consistent teacher preparation programs which, along with salary disparities, have kept too many potentially great teachers from STEM classrooms. To offset this, PCAST recommends that the Federal government help recruit and train 100,000 new STEM teachers over the next decade with the attributes to become *great* (this is ten times the quota targeted by *Rising Above the Gathering Storm*).

In determining how to achieve this, PCAST acknowledges that we know much about how students learn and something about effective teaching but regrets that we know little about how to produce effective teachers: "there is little solid research about precisely *how* and *why* teachers influence student outcomes and about *how* teacher programs should be designed to train great teachers." (p. 58) The former requires "finer grain measures of the attributes of teachers," and the latter requires evaluating a variety of different ways of preparing teachers. PCAST observes that this research will require 10 to 20 years, while we need to act now – "act and learn at the same time." (p. 59) "Without substantial and immediate knowledge of the outcomes of a broad range of teacher preparation programs, it makes sense to expand programs that have a high likelihood of preparing great teachers, while simultaneously improving the research enterprise so that data drives the evaluation and selection of such programs in the future" (p. 63), a decision likely to be made by the envisioned partnership between the Department of Education and the National Science Foundation.

In addition to preparing *new* STEM teachers, it is also "important for current STEM teachers to be able to improve their knowledge and skills." To this end, the highest-quality and most cost-effective professional development programs for STEM teachers need to be identified, also presumably by the USDofEd-NSF partnership. Because lifting the salaries of STEM teachers to the level of

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salaries of comparable STEM professionals is not presently economically feasible and present financial incentives for STEM teachers reach only a minority of them, PCAST recommends creating a STEM Master Teacher Corps, selected on the basis of criteria broader than only improvements in standardized test scores – for a specific term, to encompass from an initial 5% to an eventual 20% of all STEM teachers, with responsibilities for mentoring, leadership, and liaison to the public, and a recommended $15,000 salary supplement.

Although "technology cannot replace the need for great teachers" (p. 75), "PCAST believes that one of the most powerful tools to propel innovation in education is computation and information technology" (p. 73), consistent with the USDofEd's National Education Technology Plan. Although technological support of innovation allows "continuous evaluation and improvement based on data," "rapid and inexpensive dissemination of successful solutions," and customization to meet the needs of all users, PCAST notes that "technology has *not* played a major role in K-12 education to date" (p. 74) and lists nine reasons for this, ranging from insufficient training to insufficient equipment.

PCAST's "Vision for Technology-Driven Innovation in K-12 Education" includes 1) "Deeply digital, whole-course instructional materials with several alternative versions for all major STEM courses" (these could provide alternative paths for different types of learners and supplementary supports for students with special needs), 2) "Modular components for use in instructional materials," 3) "Testing systems and test materials," 4) "Personalized tutoring that extends beyond the classroom," and 5) "Automated systems and software to aid teachers" (which should facilitate development of online learning communities for students and networks to other teachers). (p. 82)

This will cost money, but PCAST notes that "while the provision of education is the province of the states, only the Federal Government has the ability to fund the basic R&D necessary to develop truly transforming platforms and instructional materials for education." (p. 75) This, combined with the adoption by several states of Common Core State Standards (see below), could create the market demand leading to the creation of "a vibrant ecosystem of technology-based education." (p. 81) But PCAST feels that neither the National Science Digital Library, Digital Promise, nor grants from the USDofEd or NSF is able to achieve this. They feel that an agency "driven by a mission to improve educational technology and to spread innovations into schools and classrooms" is needed. PCAST refers to it as "ARPA-ED," modeled after the Department of Defense's "DARPA" (Defense Advanced Research Products Agency). Funded initially at more than $200 million per year, it would work with both the USDofEd and NSF.

PCAST notes that the lack of "shared standards for science and math" which they lament at the beginning of their report is being remedied by the Common Core State Standards Initiative, which published its K-12 standards for English-language arts and mathematics earlier this year, as reported in "Triangle Coalition News" in our Spring 2010 issue. According to a separate article in this issue on the National Research Council's *Framework for Science Education*, made available in draft form this year and scheduled for completion in early 2011, this document will form the basis of shared K-12 science standards later in the same year. PCAST applauds the shared state standards, which have now been adopted by 36 states and the District of Columbia, because they will facilitate providing improved teaching materials and professional development for a broader range of school districts.

Standards require assessments to make sure that they are met, and PCAST notes that "the true meaning of a standard is often unclear until the corresponding assessment has been defined." (p. 47) Here, too, shared standards play an important role. Because of the tendency to "teach to the test," the quality of instruction, in effect, depends on the quality of the assessment (does it address higher-level thinking skills or only factual recall?). High quality assessments are more expensive, but their cost can be brought down if developing them is done jointly by the states adopting the Common Core State Standards.

Standards-based assessments can insure that standards are met, but PCAST notes that students who will become leaders in STEM fields need educational experience beyond that specified by the shared state standards. They therefore call for Federal Government funding of two types of supplements to K-12 STEM courses: out-of-class enrichment activities and programs, and advanced courses. Types of out-of-class enrichment activities and programs would include competitions (like FIRST robotics, described in our Fall 2009 issue), field trips, after school, weekend or summer programs, internships, and websites. Adding STEM personnel to all 21st Century Community Learning Centers could reorganize these centers to provide out-of-class STEM educational experiences with a coherent strategy and expertise lacking in presently-sponsored programs. This program would be

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part of a coordinated initiative which could be called INSPIRE (Individualized STEM Programs to Interest, Reengage, and Educate), with special attention paid to the needs of underrepresented groups.

Three categories of advanced STEM courses are noted: college and online courses, the International Baccalaureate (IB) program, and Advanced Placement (AP) courses. Although AP STEM courses are known for their concept density and not for promoting inquiry, PCAST notes that passing an AP exam correlates with success in college. The number of students passing an AP exam has quintupled from 1990 to 2008 for math and quadrupled for science in the same time period, and PCAST adds that even more students from underrepresented groups could do so with proper preparation. PCAST also notes that the College Board is restructuring AP science curricula to foster inquiry (as described in our Fall 2008 issue) and urges that the Federal Government commit to doubling the overall number of students (6% of all seniors) passing an AP exam and triple this number for underrepresented groups (2% of all seniors) in the next five years.

Increasing the number of students in STEM courses requires persuading them of the problems in STEM-related areas that they can help solve. Currently about 100 public high schools in the U.S., enrolling about 47,000 students, have a special focus on STEM subjects, but few middle or elementary schools target STEM. One way to do this is would be to target the Knowledge is Power Program (KIPP) to STEM. Using science as a vehicle for teaching reading and writing could increase the time spent on both subjects. Given the success of STEM-focused schools like High Tech High (San Diego), Illinois Math and Science Academy (Aurora, IL), and Thomas Jefferson High School for Science and Technology (Alexandria, VA), the U.S. should establish 1000 new STEM-focused schools, 800 of them at the elementary and middle level, with USDofEd leadership and NSF collaboration. These additional STEM-focused schools will not only educate more students with strong STEM backgrounds but also serve as "testing grounds for approaches to STEM-focused education." (p. 101) School leaders with greater awareness of STEM subjects would be more likely and more able to cultivate rich STEM learning experiences and expertise in their schools." (p. 103)

PCAST notes "there have been a number of important reports related to STEM education over the past two decades" (p. vii), among them *Rising Above the Gathering Storm*, which they have relied on. Rather than redo these reports, PCAST sought to "translate [their] ideas into a coherent program of Federal action to support STEM education in the United States that responds to current opportunities" (which was the intended mission of *Rising Above the Gathering Storm*). (p. vii)

ITEEA produces Engineering by Design

The International Technology and Engineering Educators Association (ITEEA), through its STEM Center for Teaching and Learning, has developed Engineering by Design, a model program to provide technological literacy for students at all grade levels, K-16. Based upon ITEEA's Standards for Technological Literacy, The National Council for the Teaching of Mathematics (NCTM) Principles and Standards for School Mathematics, and Project 2061's *Benchmarks for Science Literacy*, this program uses constructivism for students to learn concepts and principles in an authentic, problem-based environment.

Based on the belief that "citizens of today must have a basic understanding of how technology affects their world and how they exist both within and around technology," Engineering by Design offers integrated concepts and lessons for students in grade levels K-2 and 3-5, 18-week units on "Exploring Technology" for grade 6, "Invention and Innovation" for grade 7, and "Technological Systems" for grade 8. There are five 36-week high school courses – "Foundations of Technology" for grade 9, "Technological Issues and Impacts" and Technological Design" for grades 10-12 and "Advanced Design Applications," "Advanced Technological Applications," and "Engineering Design" for grade 11-12, the last being a capstone course. A semester-long "Engineering Design" course for college students is also available.

This program is organized around seven organizing principles, listed in the following order of importance:

1. Engineering through design improves life.
2. Technology has and continues to affect everyday life.
3. Technology drives invention and innovation and is a thinking and doing process.
4. Technologies are combined to make technological systems.
5. Technology creates issues that change the way people live and interact.

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Gathering Storm Revisited

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gust 2007 signed into law the America COMPETES Act, which passed both houses of Congress by wide bipartisan majorities and authorized many of the provisions of the *Gathering Storm* report.

Alas, the authorizations of America COMPETES were never matched by the needed Congressional appropriations, and now the Presidents of the National Academies have thoughtfully asked the original writers of the *Gathering Storm* report to revisit what has happened in the five years since their original report was issued, an action not requested of the writers of any of the many similar reports preceding it. All, save the since-deceased Joshua Lederberg and Secretaries Gates and Chu now serving in President Obama's Cabinet, graciously participated in producing the five-year "post mortem," *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5*.

The picture of the future they paint is not rosy, and the five years past are portrayed as a time of missed opportunities. They lament that most enabling financial resources to implement their recommendations came from the American Recovery and Reinvestment Act ("Stimulus Legislation"), a one-time initiative, and that authorization to implement many *Gathering Storm* recommendations (America COMPETES) is set to expire in fiscal year 2010. ". . . addressing America's competitiveness challenge . . . will require many years if not decades," they write (p. 1). Sustaining the progress that has begun requires reauthorization of the America COMPETES Act and "institutionalizing" the funding and oversight of *Gathering Storm* recommendations or the equivalent. One of them is doubling the research budget, which should be regarded as an investment.

In contrast to a doubled research budget, they point to a 60% reduction in federal funding of research and development in the past 40 years (except for a one-time two-year infusion under the American Recovery and Reinvestment Act for the health sciences), with more than two thirds of U.S. engineering doctorates granted to non-citizens, and U.S. firms spending twice as much on litigation as on research. Although the past five years have brought about ARPA-E (Advanced Research Projects Agency-Energy), they write that "the latitude to fix the problems being confronted has been severely diminished by the growth of the national debt over this period from $8 trillion to $13 trillion," and U.S. public school systems have shown little improvement, especially in math and science, while other nations have been forging ahead. The only way out continues to be *innovation*, they stress, noting that America in the past has shown innovative prowess, but "it has increasingly placed shackles on that prowess such that, if not relieved, the nation's ability to provide financially and personally rewarding jobs for its own citizens can be expected to decline at an accelerating pace. . . ."

The main body of *Rising Above the Gathering Storm, Revisited* basically reaffirms the premises and recommendations of the original *Gathering Storm* report. Defining the "fundamental measure of competitiveness" as "*quality jobs*," which generate the tax revenues that support government benefits, they lament that "*the United States appears to be on a course that will lead to a declining, not growing, standard of living for our children and grandchildren.* The likelihood of a more promising outcome can be enhanced by implementing the four overarching recommendations (via twenty specific actions) offered in the original *Gathering Storm* report . . . and to sustain the effort needed to reach fruition. It is noteworthy that America's current predicament was not generated in a decade, nor will it be resolved in a decade." (p. 19)

After reiterating the four recommendations of the *Gathering Storm* report – to 1) "move the United States K-12 education system in science and mathematics to a leading position *by global standards*," 2) "double the real federal investment in basic research in mathematics, the physical sciences, and engineering over the next seven years . . .," 3) "encourage more United States citizens to pursue careers in mathematics, science, and engineering," and 4) "rebuild the competitive ecosystem by introducing reforms in the nation's tax, patent, immigration and litigation policies" – and the twenty specific implementing actions, *Rising Above the Gathering Storm, Revisited* presents a five-page table comparing the "recommendations and action steps" recommended by *Gathering Storm* and "congressional actions."

The writers of *Above the Gathering Storm, Revisited* then move on to describe "Changing Circumstances" in the rest of the world in the past five years. Saudi Arabia has established a new research university with a ten billion dollar endowment, China is sending more than 200,000 students to study abroad, Russia is building a new "innovation city" for 40,000, and India is establishing 14 new "world-class" universities to establish itself as a nanotechnology hub. At the same time, the U.S. has spent $2 trillion more on K-12 public education, while six million more students have dropped out of high school and National Assessment of Environmental Progress (NAEP) scores in reading and math have essentially not changed. As the American share of high-tech exports dropped from 21% to 14%, China's grew from 7% to 20%. "Even given these and other recent events, the United States remains relatively strong in comparative economic terms," the authors write, "based in large part on investments made in decades past . . . ." and this "is

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backed by a government characterized by a remarkable degree of stability and operating under the rule of law. But the continued existence of such assets is not guaranteed . . ." and ". . . in recent years most competitiveness measures have trended in a flat or negative direction insofar as the United States ability to compete for jobs is concerned." (p. 35) This difficulty is further compounded by the current global financial crisis, which has threatened the endowments and governmental support of American universities, which, along with other publicly-supported organizations, produced more than 70% of the top 100 innovations of 2006, as opposed to more than 70% from private firms in 1975. The concurrent GDP growth rates in China (11% in 2005-2008) and in India (8.6%) belie the economic crises these countries have faced for years, being based on their smaller GDP in the past, the authors of *Rising Above the Gathering Storm, Revisited* note. The contrasting 2% GDP growth rate in the U.S. reflects the higher standard of living to which Americans have been accustomed, and the fact that they must work that much harder to sustain it.

The primary ingredients of the innovation by which America is "to maintain, or preferably enhance, the future standard of living of its citizenry," (p. 43) are characterized in *Rising Above the Gathering Storm, Revisited* as 1) knowledge capital, 2) human capital, and 3) a supportive environment.

The value of knowledge capital is epitomized by a quotation from former British Prime Minister Margaret Thatcher that ". . . the value of Faraday's work today must be higher than the capitalization of all shares on the stock exchange." Yet, with 80% of U.S. CFOs willing to cut research and development to meet profit projections, the writers of *Rising Above the Gathering Storm, Revisited* acknowledge that ". . . pressures of today's financial markets make it difficult for corporations to invest in fundamental research" (p. 44) and that "in this environment the great United States corporate research laboratories of the past are increasingly becoming a thing of the past." (p. 45) With reduced corporate investment in fundamental research, they recognize that it falls to government to pick up the slack. Yet, the U.S. currently ranks eighth in its ratio of research and development funding to GDP, with government funding recently decreasing from two thirds of the total to less than one third (and over half of that defense-related). The comparable Chinese ratio has more than doubled in the past decade.

Rising Above the Gathering Storm, Revisited also observes that scientific research is increasingly globalized, "with the percentage of internationally co-authored research articles almost tripling between 1998 and 2008." (p. 46) Also noted is an increasing number of partnerships between American universities and universities overseas, especially those in China, with more Americans going to China than the other way around, due to lower costs. The same applies to U.S. companies, which "now have 23 percent of their R&D employment located abroad." (p. 46)

An indication that other nations are catching up with the U.S. in terms of human capital is that only 14% of the world's college students are now in the U.S., as opposed to 30% 30 years ago. Twenty years ago the leader in percentage of high school and college graduates, the U.S. has now been overtaken by eight and six other nations, respectively. Because "jobs performing relatively routine functions of science and engineering have been lost to nations with lower cost structures and a well educated citizenry" (*e.g.*, China and India), education in itself is not enough, although statistics on p. 50 show that the July 2010 unemployment rate was lower (4.5%) for holders of bachelor's degrees than for non-high school graduates (13.8%). "What must be preserved in the United States, if the nation is to compete, is an adequate supply of scientists and engineers who can perform creative, imaginative, leading-edge work . . . ." (p. 48) that is the basis for the innovation that is the key to America's future. Cited examples of innovative American companies are Microsoft, Netscape, Apple, and Google.

"The principal focus of the *Gathering Storm* review was on mathematics, science, and engineering, not simply because of their critical importance in creating jobs but also because these are the disciplines in which American education is failing most convincingly," the authors of *Rising Above the Gathering Storm, Revisited* write on p. 48, and they follow this statement with examples of American scientific illiteracy. In spite of increasing American population and knowledge, they lament, the number of U.S. bachelor's degrees in physical science, math, and engineering has virtually unchanged; and while only 16% of U.S. students major in natural science or engineering, the corresponding percentage is 47 in China, 38 in South Korea, and 27 in France. The number of PhDs in physical science and math has also held steady, but there has been an increase in engineering doctorates in the past five years, mostly due to foreign student enrollment. The 8000 U.S. engineering doctorates per year, meanwhile, pale in comparison to 150,000 MBAs.

The authors of *Rising Above the Gathering Storm, Revisited* acknowledge the present surplus of post-doctoral researchers in science but note that these researchers must realize that an academic position is not the sole purpose of a PhD in science. The authors also note that the attraction of scientists and engineers into other fields "is simply reflective of the value placed on education in

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these disciplines" (p. 50). The doubling of federal investment in scientific research sought by the *Gathering Storm* report, they write, should double employment for PhDs in science, and shortages can be expected to lead companies to move their research elsewhere. Moreover, America's present dependence on foreign and immigrant science students and scientists could be undermined by the real possibility that they could choose to return to their country of ancestral origin.

When the authors of *Rising Above the Gathering Storm, Revisited* speak of a supportive environment for innovation, they speak of an "innovation ecosystem," factors which affect the innovative process, including the cost of labor, tort policy, tax policy, regulatory barriers, cost and availability of capital, protection of intellectual capital, freedom from corruption, sanctity of law, cost of benefits, export control laws, visa policy, availability of markets, employment policy, stability and predictability of government and markets, availability of transportation and telecommunications, and market growth potential. Here the U.S. is disadvantaged in its cost of labor, tort policy (businesses can grow, prosper, and perhaps fail in less time than some litigation requires, not to mention the cost, already noted to be twice expenditures on research), tax policy (only Japan has a higher corporate tax rate), and regulatory barriers. The U.S. ranks high in freedom from corruption, sanctity of law, stability and predictability of government and markets, and availability of transportation, but it is exceeded by 21 other nations in broadband communication. Although the U.S. patent system is viewed as the world's protector of intellectual property, its lack of staffing by sufficiently knowledgeable people makes it "ponderous and glacial." (p. 57) U.S. export control laws need to be rewritten to eliminate constraints once required by the Cold War, and U.S. visa policy still makes it difficult to attract the foreign scientific talent that it needs. In cost of benefits and employment policy requirements the U.S. is more restrictive than developing countries but less so than Europe. Although the U.S. presently is a large market for goods, it is expected to become a less important market as developing nations grow their own middle classes, and saving transportation costs motivates setting up manufacturing facilities near customers.

The authors of *Rising Above the Gathering Storm, Revisited* quote their original report as stating that "Market forces are *already at work* moving jobs to countries with less costly, often better-educated and highly motivated workforces, and more friendly tax policies," then add that "From a shareholder's perspective, a solution to America's competitiveness shortfall has already been found — but it is at the expense of those seeking employment here at home." They also quote former IBM Vice President Ralph Gomory saying, ". . . what is good for America's global corporations is no longer necessarily good for the American people."

Noting that "the basic nature of the competitiveness challenge does not lend itself to any sudden 'wake-up call' — such as was provided by Pearl Harbor, Sputnik or 9/11," the authors of *Rising Above the Gathering Storm, Revisited* lament that "*In balance, it would appear that overall the United States long-term competitiveness outlook (read jobs) has further deteriorated since the publication of the* Gathering Storm *report five years ago.* Today, for the first time in history, America's younger generation is less well-educated than its parents. For the first time in the nation's history, the health of the younger generation has the potential to be inferior to that of its parents."

"The *Gathering Storm* is looking ominously like a Category 5," they conclude, "and, as the nation has so vividly observed, rebuilding from such an event is far more difficult than preparing in advance to withstand it."

(*Editor's Note*: *Rising Above the Gathering Storm, Revisited* is available online at <http://www.nap.edu/catalog/12999.html>. Norman Augustine, Chair of the *Gathering Storm* report and three fellow authors of that report, Craig Barrett, Charles Holliday, Jr., and C. D. (Dan) Mote testified about *Rising Above the Gathering Storm, Revisited* before the U.S. House Committee on Science and Technology the last week of September 2010, just before the authorizations of America COMPETES expired. As this issue was going to press, word was received from Rep. Bart Gordon (D-TN), Chair of the House Science and Technology Committee, that "absent objections from a Senator, the Senate is preparing a Unanimous Consent agreement that would send H.R. 5116, the America COMPETES Reauthorization Act of 2010, back to the House with an amendment. The amendment is a compromise final COMPETES bill. Though no legislation is ever all you want, I believe the compromise being sent over from the Senate is a fair and reasonable proposal that maintains the broader goals of the COMPETES Act – increasing our investment in research, improving STEM education, and harnessing the spirit of American innovation to ensure our economic competitiveness now and in the future.")

EASIER ACCESS TO THE *NEWSLETTER* ONLINE is at <http://www.holtonsworld.com/TCNL.php>. This link is provided courtesy of Brian Holton, New Jersey physics teacher. Tell your friends about it!

Heller speaks out on standards

Pat Heller of the University of Minnesota recognizes that standards are here to stay, that the physics that is taught is increasingly driven by standards, and that colleges will need to prepare teachers to teach to those standards. But she is unhappy that the standards for teaching physics have been blended in with standards for other physical sciences – in Project 2061's *Benchmarks for Science Literacy*, the *National Science Education Standards*, and, most recently, in the recent National Research Council's draft of "A Framework for Science Education" (see separate story, page 13, this issue).

Heller spoke to this in speaking on "Guiding the Future: Developing Research-based Physics Standards" after accepting the Millikan Medal from the American Association of Physics Teachers (AAPT) on 20 July in Portland (OR). In addition to calling for separate standards for physics education, she also called for reforming state science education standards, which, she said, are too often merely lists of textbook topics. Here she noted work done by the Pacific Research institute, the Thomas Fordham Institute, and the American Federation of Teachers to develop criteria for standards, and the recent *Science College Board Standards for College Success*.

In addition to calling for separate standards for physics education, Heller, with Gay Stewart of the University of Arkansas, has prepared her own version, *College Ready Physics Standards: A Look to the Future*, which is available online at <http://groups.physics.umn.edu/physed/Talks/Standards_Document.pdf>. Guided by the revision of the AP Physics B syllabus, they have developed five standards, each supplemented by three to five objectives. Because their standards are drawn from the revised AP Physics B syllabus, they point out that students taking a high school physics course based on these standards could complete the revised AP Physics B course, slated to require two years, in one year.

Heller and Stewart's standards and objectives, with applicable grade levels, are listed in Figure 1. In their document, each objective for each standard is described as follows: After statement of the objective comes a list of Elementary Foundations (expectations by the end of grade 4), then, separately for grades 5-8 and grades 9-12 a statement of Clarification, a listing of Essential Knowledge (key concepts for student learning), and Learning Outcomes (what students should know). Dispersed throughout as needed are Boundary statements, spelling out the scope and restrictions of the respective objective.

1. Interactions, Models, and Scales
   - 1.1 Interactions, Systems, and Scale (5-8)
   - 1.2 Interactions and Properties (5-8)
   - 1.3 Interactions and Atomic and Subatomic Models (5-8 and 9-12)
   - 1.4 Interactions and Objects Moving Very Fast (9-12)
2. Conservation Principles
   - 2.1 Conservation of Mass, Energy, and Charge (5-8 and 9-12)
   - 2.2 Conservation of Linear Momentum (9-12)
   - 2.3 Nuclear Interactions and The Conservation of Mass-Energy (9-12)
3. Newton's Laws of Motion
   - 3.1 Constant and Changing Linear Motions (5-8 and 9-12)
   - 3.2 Forces and Changes in Motion (5-8 and 9-12)
   - 3.3 Contact Interactions and Forces (5-8 and 9-12)
   - 3.4 Gravitational Interactions and Forces (5-8 and 9-12)
   - 3.5 Magnetic and Electrical Interactions and Forces (5-8 and 9-12)
4. Energy Transfer and Storage
   - 4.1 Contact Interactions and Energy (5-8 and 9-12)
   - 4.2 Circuit Interactions and Energy (5-8 and 9-12)
   - 4.3 Mechanical Wave Interactions and Energy (5-8 and 9-12)
   - 4.4 Radiant Energy Interactions (5-8 and 9-12)
   - 4.5 Heating and Cooling Interactions and Energy (5-8 and 9-12)
5. Forces, Energy, and Fields
   - 5.1 Forces and Fields (5-8 and 9-12)
   - 5.2 Energy and Fields (5-8 and 9-12)
   - 5.3 Electromagnetic Interactions and Fields (5-8 and 9-12)

Fig, 1: Heller and Stewart's Standards and Objectives

Later in *College Ready Physics Standards* Heller and Stewart provide Instructional Guidance for each objective, in the following format: A short background essay

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NRC drafts new Framework

From 1992 until the *National Science Education Standards* were published by the National Research Council in 1996, this *Newsletter* reported regularly on their evolution into their final form. Given "a large and growing body of research on teaching and learning science," the Council has decided that it's time to go through the process again. The Council feels that its efforts are also timely because of the movement toward common state standards (see "Triangle Coalition News" in our Spring 2010 issue) and away from long lists of topics that previously characterized state standards and made the curriculum "a mile wide and an inch deep," leaving students with fragmentary knowledge that obscures the "need for students to develop an understanding of the practices of science and engineering which is as important as knowledge of its content." (p. 1-2)

The National Research Council has produced a Preliminary Public Draft of what they call "A Framework for Science Education," with comment from the public invited through 2 August 2010. This draft points out that it is a *framework*, not a set of standards (that will be subsequently developed from it). As a framework, it is a broad description of content and sequencing, intended to help standards developers, curriculum designers, science education administrators, and informal education educators. It seeks to foster an approach to science education leading to a more coherent vision of the world around us and does so in three ways: 1) through the focus on a "limited number of core ideas" to allow exploration of them in greater depth, 2) commitment to "learning as an ongoing developmental progression" to develop "students' knowledge about a more scientifically based and coherent view of the natural sciences and engineering," and 3) integration of scientific explanation with practices of scientific inquiry and engineering design. "Engineering and technology are featured alongside the natural sciences in recognition of the importance of understanding the designed world and of the need to better integrate the teaching and learning of science, technology, engineering and mathematics." (p. 1-1)

The Framework is based on the following guiding principles of how students learn science:

<u>Children are born investigators</u>. Children enter school with their own model of how the world around them works based on their experience, although this model may be underdeveloped because of lack of knowledge.

<u>Understanding develops over time</u>. Curriculum to build on what students already know to develop the core ideas should provide continuity across the years to accommodate student development of understanding over time. Experts differ from novices in the organization of their knowledge, and teaching science with greater emphasis on the connectedness of ideas will foster understanding at the "expert" level. This can best be done with a series of steps called "learning progressions," which can extend from K to 12 and beyond.

<u>Science is more than a body of knowledge</u>. In addition to what is known about the natural world, science is also the process by which it has been learned, and it is important that students learn both content and process.

It is structured in terms of three "dimensions": 1) core ideas from the specific disciplines, 2) elements that cut across the specific disciplines, and 3) science and engineering practices. The intent is "to prepare students with enough core knowledge, and to develop their ability to interpret claims and evidence so that they can begin to be informed consumers of information that is of interest to them." (p. 1-13) Each standard that is based on this Framework "should be defined as the intersection of scientific knowledge and practices" (dimensions 1 and 3) and also incorporate a cross-cutting element.

The Framework's commitment to emphasize connected depth rather than unconnected breadth makes the choice of core ideas and practices very critical. The criteria used to select core ideas and practices looked for ideas important across multiple science and engineering disciplines or key organizing concepts of a single discipline, key tools for pursuing more complex ideas and solving problems, relevance to students' lives or societal concerns requiring scientific and technical knowledge, and applicability to multiple grades with increasing sophistication and depth.

In its integration of science and engineering, the Framework notes that science and engineering both use reasoning processes to solve problems and test their outcomes. But it notes that engineering outcomes are products and processes while those of science are theories. While the approach of engineering is designing systems to solve specific problems, that of science is inquiry to learn how natural systems work and to develop theories with the broadest possible applicability. Engineering also differs from science in having more than one solution to a problem, and the one eventually chosen can be due to budgetary and other constraints. The four strands describing proficiencies in learning science from *Taking*

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NRC Framework

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Science to School (one of many documents reviewed in the preparation of this Framework and reported on page 21 of our Fall 2006 issue) were modified for target proficiencies in engineering as follows [the first word(s) bracketed refer to science/the last word(s) bracketed refer to engineering] (pp. 2-10,11):

1. "Knowing, using, and interpreting scientific explanations [of/in] the [natural/designed] world."
2. "Generating and evaluating [scientific evidence and explanations/technological solutions]."
3. "Understanding the nature and development of [scientific/technical] knowledge [/and capabilities]."
4. "Participating productively in [scientific/] practices and discourse [/of science or engineering]."

But these strands do not suffice to develop standards. All three dimensions are needed to do that.

The Three Dimensions

As noted above, the first dimension is core ideas from specific disciplines, and these are enumerated by category in Chapter 3 of the Framework. Because engineering and technology are included along with the natural sciences, the specific disciplines include technology, engineering, and mathematics (ET) along with physical sciences (PS), life sciences (LS), and earth and space sciences (ESS). Each core idea is expressed as a sentence, with a topic following in parentheses that could be used as a "big idea" in a curriculum following the principles of Wiggins and McTighe's *Understanding by Design*, plus a question the core idea would answer and a one to two paragraph description. (Some of the core ideas are divided into subcomponents.) (See box on page 15.)

Cross-cutting elements are highlighted as the second dimension to "elevate their significance in the development of standards, curriculum, and assessment," (p. 4-1) because, as the Framework states, "students are often expected to build . . . knowledge [of the cross-cutting elements] without any explicit instructional support." (p. 4-1) Some of them are the unifying concepts and processes of the *National Science Education Standards*, the common themes in *Benchmarks for Science Literacy*, and unifying concepts in *Science College Board Standards for College Success*: 1) patterns, similarity, diversity; 2) cause and effect: mechanism and prediction; 3) scale, proportion, and quantity; 4) systems and system models; 5) energy and matter: flows, cycles and conservation; 6) form and function; and 7) stability and change. The other cross-cutting elements are based on the statement that "Science, engineering, and technology do not exist in isolation from society" (p. 4-19): 1) history and cultural roles of science, engineering, and technology; 2) impacts of science, engineering, and technology on society; 3) impacts of societal norms and values on the practices of science and engineering; 4) professional responsibilities of scientists and engineers; 5) roles of scientific and technical knowledge in personal decisions; and 6) careers and professions related to science and engineering.

The Framework notes that although "one focus of science education has been to develop scientific habits of mind," ". . . production of curricula that provide a coherent account of science and of the range of practices that support and enable the construction of reliable knowledge has been a challenge. The intent of Dimension 3, therefore, is to provide a guide that would give science and engineering practices a more complete realization and a more central place in the next generation of science standards, curricula, and assessment." (p. 5-1) "Any science education which focuses predominantly on . . . the 'facts' of science . . . without developing an understanding of how those facts were established, or which ignores the many important applications of science in the world, misrepresents science and marginalizes the importance of engineering." (p. 5-2) From a list of three practices of "How Scientists and Engineers Work" – 1) Investigation, Hypothesis, and Coordination; 2) Models; and 3) Communication and Discourse – seven "Practices for Science Classrooms" are derived: 1) Asking Questions; 2) Modeling; 3) Devising Testable Hypotheses; 4) Collecting, Analyzing, and Interpreting Data; 5) Constructing and Critiquing Arguments; 6) Communicating and Interpreting Scientific and Technical Texts; and 7) Applying and Using Scientific Knowledge. Practices are noted to require *both knowledge and skill* and are thus seen as an amalgam of the two. The Framework notes that "practices" replaces "inquiry" in the *National Science Education Standards* as a term pertaining to how science is done, because "inquiry" has become associated with hands-on activities in science classrooms.

In the last chapter, prototype learning progressions are laid out for each of the core ideas and their subcomponents, with the following criteria for each grade level: phenomena which can be directly experienced in grades K-2, macroscopic phenomena which cannot be seen directly but which can be modeled by pictures in grades 3-5, explanations in terms of atoms and cells (but without their inner workings) in grades 6-8, and subatomic and subcellular explanations in grades 9-12. All the core ideas are treated in tabular form, and an accompanying

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	Core Idea sentence	Core Idea topic
LS 1	Organisms have structures and functions that facilitate their life processes, growth, and reproduction.	From Molecules to Organisms – Structure and Process
LS 2	Organisms have mechanisms and processes for passing traits and variations of traits from one generation to the next.	Heredity – Inheritance and Variation of Traits
LS 3	Organisms and populations of organisms obtain necessary resources from their environment which includes other organisms and physical factors.	Ecosystems: Interactions, Energy, and Dynamics
LS 4	Biological evolution explains the unity and diversity of systems.	Biological Evolution: Unity and Diversity
ESS 1	Humans are a small part of a vast Universe; planet Earth is part of the Solar System, which is part of the Milky Way galaxy, which is one of hundreds of billions of galaxies in the Universe.	The Solar System, Galaxy, and Universe
ESS 2	Earth is a complex and dynamic 4.6 billion-year-old system of rock, water, air, and life.	Earth's Planet-sized Structures, Processes and History
ESS 3	Earth's surface continually changes from the cycling of water and rock driven by sunlight and gravity.	Earth's Surface Process and Changes
ESS 4	Human activities are constrained by and, in turn, affect all other processes at Earth's surface.	Human Interactions with Earth
PS 1	Macroscopic states and characteristic properties of matter depend on the type, arrangement, and motion of particles at the molecular and atomic scales.	Structure and Properties of Matter
PS 2	Forces due to fundamental interactions underlie all matter, structures and transformations; balance or imbalance of forces determines stability and change within all systems.	Interactions, Stability, and Change
PS 3	Transfers of energy within and between systems never change the total amount of energy, but energy tends to become more dispersed; energy availability regulates what can occur in any process	Energy and its Transformations
PS 4	Our understanding of wave properties, together with appropriate instrumentation, allows us to use waves, particularly electromagnetic and sound waves, to investigate nature on all scales, far beyond our direct sense perception.	Waves as Carriers of Energy and Information
ET 1	The study of the designed world is the study of designed systems, processes, materials, and products and of the technologies and the scientific principles by which they function.	The Designed World
ET 2	Engineering design is a creative and iterative process for identifying and solving problems in the fact of various constraints.	Engineering Design
ET 3	People are surrounded and supported by technological systems. Effectively using and improving these systems is essential for long-term survival and prosperity.	Technological Systems
ET 4	In today's modern world everyone makes technological decisions that affect or are affected by technology on a daily basis. Consequently, it is essential for all citizens to understand the risks and responsibilities that accompany such decisions.	Technology and Society

Core Ideas in NRC's Draft "Framework for Science Education"

Heller on standards

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is followed by a Table of Common Student Difficulties, indexed by Essential Knowledge and Learning Objective, and a Table of Content Boundaries, listing Phenomena, Representations and Models for each grade level (5-8 and 9-12). This is rounded out by examples and ancillary diagrams. An appendix provides a discussion of "Five Principles of How Students Learn" (see Figure 2).

1. Learning with understanding is facilitated when new and existing knowledge is structured around the major concepts and principles of the discipline.
2. Learners use what they already know to construct new understandings.
3. Learning is facilitated through the use of metacognitive strategies that identify, monitor, and regulate cognitive processes.
4. Learners have different strategies, approaches, patterns of abilities, and learning styles that are a function of the interaction between their heredity and their prior experiences.
5. The practices and activities in which people engage while learning shape what is learned.

Fig. 2: Heller and Stewart's Five Principles of How Students Learn

New STS Monograph

At a time that the National Research Council is drafting a new Framework for Science Education, Robert Yager, who has probably done more than any other educator to further the infusion of societal topics in science courses, addresses "two aspects of the [current *National Science Education Standards* (*NSES*)] that too often are ignored" in a book, *Exemplary Science for Resolving Societal Challenges*, which he has edited for the National Science Teachers Association.

In his foreword to the books 15 chapters, Yager writes that one of these aspects "concerns two of the four goals that should frame reform efforts designed in science for preK-12 schools," namely to prepare students to "use appropriate scientific processes and principles in making personal decisions" and "engage intelligently in public discourse and debate about matters of scientific and technological concerns." The other aspect of the *NSES* which is emphasized in this book is the seventh of eight categories of content standards: "science in personal and social perspectives."

He states that "this monograph was conceived to illustrate the centrality and importance" of both of these goals and "illustrates how personal and social contexts have been approached in ways not found in mainline curricula or in the most-used science textbooks." In this way the content standard category of "science in personal and social perspectives" serves as a vehicle to meet the goals of using scientific processes and principles in decision making and engaging intelligently in public discourse.

NRC Framework

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narrative is provided for one of them. The sample narrative consists of two columns, one headed "Motivating Questions and Contexts" (featuring an overall question, subquestions, and a brief overview), the other headed "Ideas" (with a detailed description of the experiences students need but not the fully developed curriculum to provide them). The tables list only the overall question from the "Motivating Questions and Contexts" column of the narrative and an abbreviated version of the text in the "idea" column. But even this abbreviated list shows that each core idea contains a large number of sub-ideas, all related to the core idea, at each grade level.

These prototype learning progressions, however, deal only with the first of the three dimensions of the Framework. It is curiously in the penultimate chapter that it puts the dimensions together, and it does so for two core ideas: LS1.C and PS1.A. The content of each core idea, taken from the learning progressions of the last chapter, is listed as "Science Idea" for LS1.C and as "Content" for PS1.A for each of the grade levels (K-2, 3-5, 6-8, 9-12), followed by a "Scientific Practice" and "Performance" combining the two, plus "Criteria" by which to evaluate the performance. If standards are to be defined as the intersection of the dimensions, perhaps as points on a three-dimensional graph, one axis for each of the three dimensions, then the penultimate chapter has provided two prototype points. Many more of these points need to be fleshed out before the Framework is translated into meaningful standards and a curriculum to achieve them.

(*Editor's Note*: A 17 December 2010 letter from Helen Quinn, chair of the committee at the National Research Council working to develop the Framework, anticipates releasing the Framework in final form in spring 2011. After that, "Achieve, Inc., an independent, bipartisan, nonprofit education reform organization that works closely with states will develop a full set of internationally-benchmarked standards based on the Framework.")

New STS Statement from NSTA

The Board of Directors of the National Science Teachers Association (NSTA) recently voted to adopt a newly revised position statement advocating the provision of K–16 science instruction within the context of personal and societal issues. The statement recognizes the influence that science and technology have on our lives, and how these issues provide a rich and motivating context in which students can learn the principles and practices of science and technology. The statement gives recommendations on what students should know and be able to do and how science instruction should occur within the context of societal and personal issues. The panel developing the statement was chaired by former NSTA President Harold Pratt, who has been instrumental in promoting the infusion of societal and technological issues in science teaching. Panel members were Denise Antrim, Pat Barron, Norman Lederman, Kathy Prophet, Troy Sadler, William Smith, Cary Sneider, and Robert Yager (also a past NSTA president and a strong proponent of STS education).

Teaching Science and Technology in the Context of Societal and Personal Issues

Introduction. From health to climate change and from bioethics to energy, a myriad of personal and societal issues requires citizens to make informed decisions based on science and technology. These issues provide a rich and motivating context in which students can learn the principles and practices of science and technology. Science and technology influence every aspect of our lives, and in turn, we influence the direction and use of scientific and technological endeavors (Roberts 2007). In addition, science and technology are central to our well-being and success as individuals, as members of society, and as members of the global community. Therefore, NSTA advocates that K–16 science and technology instruction be provided within the context of personal and societal issues.

NSTA strongly promotes the education of a citizenry that is scientifically and technologically literate as defined in the National Science Education Standards (NRC 1996). This requires that we not only know, understand, and value scientific and technological concepts, processes, and outcomes, but that we are able to use and apply science and technology in our personal and social lives (Zeidler 2003). While both science and technology are human endeavors and involve similar basic procedures, science involves exploration of the *natural world* seeking explanations – based on evidence – for objects and events encountered, and technology focuses on the *human-made world*.

There is a national consensus about the central role that science and technology play in our society and its connection to our nation's competitiveness and future economic prosperity (Business Roundtable 2005). However, we have yet to ensure all students have the ability to use what they have learned when making decisions about what is appropriate in personal, societal, and global situations involving science and technology, and to value these endeavors (Abd-El-Khalick 2003).

The purpose of understanding science and technology is not solely for the sake of learning, but rather to enable and motivate citizens to contribute to and engage in society (DeBoer 2000). Therefore, NSTA sets forth the following declarations to promote the teaching of science and technology within the context of personal and societal issues.

Declarations. Regarding what students should be able to know and do in science within the context of societal and personal issues, NSTA recommends that students

- know the major concepts, hypotheses, and theories of science and be able to use them;
- include knowledge of science concepts and practices of science in making responsible everyday decisions;
- understand that the generation of scientific knowledge depends upon inquiry processes and upon conceptual theories;
- understand that the invention and improvement of technologies depends on the technological design process;
- understand that science and technology are products of human creativity and imagination, subject to verification and rigorous tests;
- recognize that scientific understanding is subject to change as evidence accumulates, or old evidence is re-evaluated;
- distinguish between scientific evidence and personal opinion;

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New STS Statement from NSTA

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- understand how society influences science and technology and how science and technology influence society;
- understand and weigh both the benefits and burdens of scientific and technological developments;
- be able to consider the trade-offs among alternative solutions when considering decisions that involve competing priorities;
- recognize that scientific and technologic advances may have unanticipated consequences, which only become apparent over time as the application or technology becomes more pervasive or more powerful;
- recognize that many decisions are global in nature and that people in other parts of the world are affected by our decisions and faced with similar decisions and issues themselves;
- understand how sustainable solutions to societal issues are those that meet the needs of the present without compromising the ability of future generations to meet their own needs;
- recognize how scientific and technologic advances may affect the environment positively or negatively;
- appreciate the value and role of research and processes of technological design; and
- know reliable sources of scientific and technological information, how to access them, and how to use these sources in the process of decision making.

Regarding how science instruction should occur within the context of societal and personal issues, NSTA recommends that science instruction

- incorporate scientific issues that are personally and socially relevant, and developmentally appropriate, as a way to generate interest in and motivation to engage in relating science to personal and societal issues;
- focus as much as possible on scientific and technological issues that are identified by students;
- incorporate the practices and understanding of scientific inquiry and technological design;
- provide multiple learning opportunities that encourage the study of science in personal and societal contexts;
- provide an authentic learning context by examining the societal dimensions of scientific issue, such as political, economic, and ethical considerations;
- approach decisions in an open unbiased way, respecting and acknowledging different perspectives, views, beliefs, and other ways of knowing;
- prepare students to become future citizens who are scientifically and technologically literate and willing to engage in making responsible and informed decisions.

—Adopted by the NSTA Board of Directors
November 2010

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Engineering by Design

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6. Technology impacts society and must be assessed to determine if it is good or bad.
7. Technology is the basis for improving on the past and creating the future.

The Standards for Technological Literacy, originally developed by ITEA were reported in our Fall 2001 issue (before Engineering was added to its name to become the ITEEA, reported in our Winter 2010 issue). Preliminary information about the Engineering by Design program is reported in our Spring 2010 issue. More information can be obtained by visiting ITEEA's website, <http://www.iteea.org>.

AAPT addresses Science and Religion

by John L. Roeder

The "Science and Religion" session organized by Olga Livanis on 21 July for the meeting of the American Association of Physics Teachers in Portland (OR) featured a rather varied set of perspectives on religion from four different professors of physics: Herbert Levine of the University of California, San Diego; Matthew Koss of the College of the Holy Cross (Worcester, MA); Paul Nienaber of Saint Mary's University of Minnesota (Winona); and Stamatis Vokos of Seattle Pacific University.

Noting that recent popular books on science and religion have focused on Christianity or at best treat Jewish views in passing, Levine, in his talk titled "Science and Observance: Must Traditional Judaism be Fundamentalist?" observed that Orthodox Jews have been more concerned about their religious observances than issues with science. The practices of Orthodox Judaism, he said, have historical validity but serve social and ethical rather than metaphysical needs (though he indicated that the prohibition of mixing milk with meat might have originally been prohibiting fat rather than milk).

Yet, Levine added, a book written by a Jew ten years ago claims that Copernicanism is heresy, and a survey of 176 orthodox college students in New York City showed answers to questions similar to those of creationists. He also cited a rabbi who was denounced by other rabbis for writing books to reconcile scriptures with science.

Levine went on to say that the main source text for Judaism is the Babylonian Talmud (500 C.E.) rather than the Bible. Jewish fundamentalism, he said, considers the Talmud to be infallible, although the rabbis writing it did not consider themselves to be infallible. In fact, Levine observed, the Talmud appealed to experimental observation in its discussion of the motion of the Sun. It also authorized killing lice on the Sabbath, because at the time lice were believed to be spontaneously generated. Levine cited the observation of Maimonidies (1135-1204) in his *Guide for the Perplexed* that science in Biblical times was insufficient to be taken seriously. Yet, Jewish fundamentalism, by its adherence to those scientific views of Biblical times, is regarded by Levine as more extreme than Christian fundamentalism. A greater attendance of Orthodox Jews at sectarian schools with curricular controls exerted by rabbis is giving Levine concern.

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When Scientists Should Step In

by John L. Roeder

When should scientists involve themselves in discussing or debating public issues on which their science has a bearing? This was the issue raised at a panel session which I organized, "When Scientists Should Step In: Media, Politics, and Science," on 19 July 2010 at the meeting of the American Association of Physics Teachers in Portland (OR). Addressing the issue were panelists representing all three areas in the session title: Peter Bhatia, Editor of *The Oregonian*, representing media; Willie Smith, Director of the District Office of Rep. Earl Blumenauer (D-OR), representing politics; and Gordon Aubrecht of The Ohio State University, representing science.

"Right away!" Aubrecht chimed in, wasting no time as the leadoff responder to the question. He continued by acknowledging that communication is difficult and conceded that maybe we don't educate our students or the public about how science works and the fact that nothing can be conclusively proved (this is something not learned in specialized science courses). Journalism practices treating both sides of an issue, Aubrecht noted, but he went on to point out that science doesn't have two sides – and evolution hasn't been disproved yet. Scientists, Aubrecht said, find it difficult to understand why people don't understand that nothing can be proved. By pointing this out, opponents of a scientific theory can seed doubt and distract public attention.

Aubrecht also emphasized that the ultimate authority in science is data. Scientists are skeptics, he said, but they can't deny data – it's "denialists" who manufacture their own. But data have uncertainty, he recognized, and scientists frequently act toward the public as if the uncertainty in their data don't exist. Specifically, Aubrecht noted that the IPCC (Intergovernmental Panel for Climate Change) statement was one of *likelihood* of human cause of global warming.

The next panelist to speak, Bhatia observed that science has been hijacked by politics. He added that he receives much mail from those skeptical about global warming and sees this as reason enough for scientists to speak out, even if the public has difficulty understanding. But as far as the media go, in their search for understanding, they find themselves looking at *multiple* points of

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Science and Religion

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The next two talks were a pair by two professors who earlier at the meeting had presented a workshop titled "Applied Critical Thinking: Science and Religion." They both surveyed what they called the "Science-Religion Landscape" from their respective religious views, Koss being an atheist and Nienaber a religious physicist. Picturing himself as an acceptor of methodological and metaphysical naturalism, Koss sought to place scientists who had expressed their religious views in writing on a spherical landscape like that of the Earth. At the North Pole he placed what he characterized "new" atheists Richard Dawkins, Daniel Dennett, Christopher Hitchens, and Victor Stenger. At the South Pole he placed R. Terrance Egolf, author of *Physics for Christian Schools*, which cautions that in areas of conflict, the word of the Bible must take precedence. Intelligent design adherents Michael Behe and William Dembski were placed just north of the South Pole, because, Koss said, they accept science's age of the universe but insist that God had a hand in the evolution of life. Other scientists Koss placed in the southern hemisphere included Francis Collins, Michael Guillen, Owen Gingerich, and Ken Miller (Catholic biology text author who testified on behalf of evolution at the Dover, PA, trial which rejected intelligent design as creationism redisguised and therefore not science). Meriting places in the northern hemisphere of Koss's science-religion landscape were such scientists as Michael Shermer, Ursula Goodenough, and Stephen Jay Gould; and, just south of the North Pole, John Allen Paulos, Carl Sagan, and Steven Weinberg.

Nienaber stated that in his teaching he relies on statement 99.6 of the American Physical Society for "What is science?" and for his own belief in an extraphysical being, with a corresponding guide to personal ethics, for "What is religion?" He noted that while only 4% of Americans profess not to believe in God or a higher power, this number shoots up to 41% if only scientists are polled. The methodological (but not metaphysical) naturalism to which Nienaber adheres (and in doing so is in partial agreement as well as partial disagreement with Koss) requires that material effects have material causes. But Nienaber offered that material effects could lead to extramaterial consequences in the nature of human feelings. The demographics of belief need thoughtful consideration, he added. Whether faith or reason can trump each other, Nienaber suggested, appears to be an irreconcilable argument. Therefore, he is opposed to presenting science and religion on an "either-or" basis, for fear that it would shut down the entire dialog.

Taking a different tack, Vokos began his talk on "Using Students' Metaphysical Beliefs as Resources in the Physics Classroom" by observing that physics teachers want students to see physics as a way of knowing that they can apply in their lives, also to think to learn (as opposed to "learn to think"). Teaching physics, he went on, therefore involves participation in a thinking-to-learn community, apprenticeship, and enculturation. He urged teachers to interact with their students in all aspects of their belief and went on to relate how he has taught physics courses in this way to large numbers of Tibetan Buddhist monks. Vokos reported that the Dalai Lama finds relevance in modern science and maintains that Buddhism has something to offer the study of science as well. He found that the Buddhist monks had the same methods of reasoning as their Western cohorts, also that all religions have *Mythos* and *Logos*. But he found that neither modern inquiry nor lecture was effective in teaching the Buddhist monks. What *was* effective was debating.

Vokos closed by advocating that we ascertain our students' metaphysical beliefs and use them without trespassing on their rights to their beliefs. It is important, he cautioned, to talk with rigor without rancor.

Vehicle competition in Reno

How to increase the number of students participating in extracurricular STEM (science, technology, engineering, and math) projects? Truckee Meadows Community College in Reno, NV, staged a lighter-than-air vehicle competition, as Daniel Loranz reported on 19 July at the American Association of Physics Teachers meeting in Portland (OR). Mylar and helium were provided; students had to provide the rest. The final vehicles were tested visibly in the student center, under the watchful eye of campus daycare students. Laranz reported that students learned much from the experience, including the development of skills in project management, teamwork, and critical thinking.

SCIENCE & SOCIETY EDUCATION MEETINGS

8-12 Jan 11, American Association of Physics Teachers: "Fifty Years of Nuclear Physics," Jacksonville, FL. Visit <www.aapt.org>.
5-7 Apr 11, World Nuclear Fuel Cycle 2011, Chicago, IL. Visit <www.world-nuclear.org>.
25-29 Apr 11, Materials Research Society Spring Meeting, San Francisco, CA. Visit <www.mrs.org/spring2011>.

Step In

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view (there are *more* than two sides!). Bhatia stated that in his search for answers, he looks for expertise, while also realizing that there are disbelievers such as those who believe that we never went to the Moon. This dependence on experts, Bhatia said, is necessary because news reporters don't have the background to check scientific facts.

Representing politics, Smith acknowledged that, while the Congressman he serves chairs the committee that hears testimony on global warming, he himself doesn't understand it. Yet he also expressed concern about how scientists can get their message across. Right now, Smith said, credibility is high for teachers, nurses, firefighters, and small business owners – low for corporations and media. Scientists, he added, can "go either way."

Right now, Smith went on, people are more concerned about their personal economic welfare than scientific issues. He urged scientists not to use words of more than three syllables, so that their message can be more clearly understood. He also inserted a parenthetical remark about an issue particularly sensitive to him: After Rep. Blumenauer wrote a section into the national health care bill that would allow a conversation with a doctor about "death with dignity" options, Sarah Palin labeled it a "death panel" on her website.

Following the brief initial presentations of the panelists, there was an extended time period for questions and comments from the audience. Several suggestions for things scientists can and should do emerged:

a. Be aggressive about writing op-eds. This was a suggestion from Bhatia, who also urged the development of writing skills.
b. Establish good relations with the district staff of your Congressional Representative (Smith).
c. Give talks to civic organizations (Aubrecht acknowledged that he has done this).
d. Be a "go to" person for the media (a suggestion by Erik Hendrickson in the audience, which dovetailed with Bhatia's cited need for the media to seek scientists for expertise).
e. Be a part of the community (Smith).
f. Speak out when you see something wrong (scientists need to overcome their introversion, Bhatia said, while pointing out that most journalists are introverts, too).
g. Include the way science works in their courses in order to teach students about science's inability to prove anything conclusively (to remedy the deficiency cited by Aubrecht above).
h. Have students write letters to Congressional Representatives (from Bernard Fishman in the audience).

Bhatia took note of the effect of electronic media on the coverage of science by print media. The Internet's growth and influence on media have made a difference, he said. The influence of a newspaper pales in comparison with what Sarah Palin can achieve by what she posts to her Facebook page. Moreover, the economy has reduced the number of science writers in the news media, and most of them focus on health, which is the science topic of greatest interest to the public. This makes it all the more important for scientists to reach out to the media to make their expertise available.

Well-established in the tradition of journalism, Bhatia said that he doesn't worry whether he's in the news business or education business, because he feels that they mostly overlap. Most importantly, he feels that he's in the truth-telling business, but laments that there seem to be many versions of truth. Donna Peterson made a relevant comment from the audience: it often turns out to be a matter of truth versus belief. "Beliefs are implacable," Aubrecht responded. One needs to be respectful of others' beliefs, he stated, noting that his approach is to ask people to articulate their beliefs, after which he cites countervailing evidence.

As presider over the session, I used my prerogative to ask the last question. It was based on a situation described in Robert Park's *Voodoo Science*, in which the inventor of an "energy machine" invited a Ph.D. physicist to debate him. "How do you respond to the homespun humor from the inventor of such a machine?" I asked. Acknowledging that people respond better to anecdotes than to hard numbers, Smith said, "Learn to tell jokes!"

As I later reflected on this session and one I had attended earlier the same day on outreach to the public, I couldn't help but think that the "bottom line" of both sessions was the same: It is important to communicate at a level that can be understood but without being "dumbed down."

AN EASIER WAY TO ACCESS THE *NEWSLETTER* ONLINE

is to go to <http://www.holtonsworld.com/TCNL.php>. This link is provided courtesy of Brian Holton, New Jersey physics teacher.

Riendeau highlights importance of mentoring

The 2010 recipient of the Excellence in Pre-College Physics Teaching Award from the American Association of Physics Teachers (AAPT) on 20 July at its meeting in Portland (OR) was Diane Riendeau, physics teacher at Deerfield (IL) High School. Her acceptance talk on "Who's In?" focused on the importance of the role of mentoring in her career, asking, in effect, "Who's into mentoring?"

"What was your mentor?" and "Whom are you mentoring?" Riendeau asked at the outset. Noting that she was originally a math major, she recalled how she sought help when she was asked to teach physics. A new teacher doesn't like to feel left out, she said, prompting her to ask her listeners, "Do you welcome new ideas from new teachers?" Going on to the subject of retaining teachers, she urged her listeners to train those teachers to become stars. And, to develop a team, she added, you need to develop loyalty in those stars.

She then went on to cite her two particular mentors: Chris Chiaverina and Jim Hicks (whose mantra, she said, is "You can't do alone what you can do together"). Riendeau reported getting her vision from Hicks and her encouragement from Chiaverina, who encouraged her to write for *The Physics Teacher* and to join an AAPT committee.

But, Riendeau continued, she really didn't appreciate mentoring until she mentored Shannon Mandel. Shannon "shook it up" and introduced her to project-based learning and portfolios, she pointed out, and this further broadened the horizons of her own teaching. Probably not realizing that she was paraphrasing Kathryn Murray at the end of every *Arthur Murray Party*, Riendeau left her listeners with the following advice: "To rejuvenate your teaching, try mentoring!"

One teacher's incentive to improve grades

Chris D'Amato has completed his fourth year at Pequannock Township High School after an earlier career in computer science. He uses ISLE (developed by Eugenia Etkina of Rutgers University), Active Learning, whiteboards, and a daily quiz based on yesterday's lesson. He seeks to cultivate learners rather than students and recognizes the tension between learning and grading. The former is flexible and supportive, he notes, since everybody learns *something* and the teacher is viewed as a supporter. On the other hand, grading is rigid and impersonal – failure *is* an option, and the teacher is viewed as the authority.

On 20 July at the American Association of Physics Teachers meeting in Portland (OR), D'Amato reported how he has developed a mastery approach to resolve this tension, based upon his master's work at Rutgers. It is based on the concept that improving one's work is normal. Any grade can be improved at any time – and a student may work with other students and use any reference. Daily quizzes count for four points and are returned without comment. To recover missed points, students must fix mistakes and explain why they made them and what they learned from fixing them. This, D'Amato said, involves him more with work he likes than what he doesn't.

D'Amato displays student grades by student number online. Most of his students get Bs, an almost equal number of As and Cs, with a smattering of Ds and Fs. He reported that 19 of his students did not seek to recover points, while 34 did. When he asked his students to retake a kinematics exam two weeks later, he found that the students who recovered points increased their exam scores more and had a low correlation (0.06) with their original exam scores. The correlation for students *not* recovering points was much higher (> 0.6).

Hogan's core beliefs of teaching

(*Editor's Note*: Upon accepting the Excellence in Undergraduate Physics Teaching Award from the American Association of Physics Teachers on 20 July in Portland (OR), William Hogan of Joliet Junior College (IL) gave a comedic yet humble monolog about his teaching and those to whom he is indebted. He closed with the following three core beliefs which have formed the basis of his teaching.)

1. Care deeply about your students. It means more work, but the work becomes more rewarding.
2. Get students actively involved in the learning process.
3. Be sincere in who you are and in what you're doing.

Teaching Young Children about Houses

by Bernice Hauser, Primary Education Correspondent

As a result of activities that grew out of teachers reading "The Three Little Pigs" to a combined kindergarten-first grade class, I have found that a holistic and interdisciplinary approach works best with young children. To teach them about architecture, I would immerse them in the subject of houses and buildings and focus on their experiments and explorations. For example, would a breeze blow a wolf-proof house down, would a stronger wind blow it down, would a hurricane blow it down? When and where might it be appropriate to build a house of straw, of wood, of brick, of other materials? Videotape the children's experiments, discuss every aspect of their experiments, record their comments on bulletin boards or smart boards or capture their remarks with new technology to plan future activities and to dispel misconceptions they may still harbor. Always encourage young children to share *why they did what they did* and also have them *critique their work*. But do not stop there – share books, videos/DVDs and literature on the subject of houses — take them on tours of different kinds of houses, collectively draw up a questionnaire regarding the house or apartment house they live in and have them fill it out and share their findings. If permitted, use a data base of parents as a resource and invite engineers, scientists, inventors, and programmers into the classroom to talk about their work.

In addition, working with Lego or working with blocks, young children can create and design their ideal homes. Other children, working with different materials such as clay, could also build their ideal house. Mapping their designs might culminate out of their questions and this very activity. And why not include topics in technology – tools, materials, elevators, skyscrapers, heating, lighting, the cell phone, the computer – what impacts are they having on our homes? The topic of houses seamlessly lends itself to making global connections to how people live in other kinds of houses such as yurts, igloos, sampans (Chinese boat house), caves, tents and adobe homes. But always remember that good questions both from the children and adults are integral to enlarging the scope of a discussion and stretching the children's creative and cognitive abilities. By the way — myths, stories and fairy tales have inspired wonderful scientific experiments and ethical dilemmas down through the ages. *Goldilocks and the Three Bears* is a linchpin for countless experiments and discussions about mattresses and even includes an ethical dilemma; *The Three Billy Goats Gruff* inspires a year's study into bridges — but that will have to await another article.

Resources

Ann Morris, *House and Homes* with photographs by Ken Heyman (Lothrop, 1992). ISBN 0688101682.
Grades PreK – 4. Here's a book for browsing and learning for children of many ages. It has limited text and exquisite and informative photographs show buildings from Buckingham Palace to a simple house of straw in various places around the world. A map and afterword add to the information.

Sue Tarsky, *The Busy Building Book* (Putnam, 1997). ISBN 0399231374.
Grades PreK – 2. The various steps involved in constructing a building are clearly laid out here for the youngest reader. The explanations are simple and the various workers and tools are identified.

Martin Waddell, *The Hidden House,* with illustrations byAngela Barrett (Candlewick Press, 1997). ISBN 076360335X.
Grades K – 4. This gentle book with its intricate illustrations has just the right amount of whimsy. An old man lives in a tiny house in the woods and, for company, makes three wooden dolls, which he places in the front window so that they can watch him work. We're told that he talks to them sometimes, but not very often. Then the old man leaves never to return and vines and other plants grow up and around the house until they conceal it. Insects and other tiny creatures take it over and years go by. Waddell thinks the dolls are lonely. Then a man, his wife, and child find the hidden house, clean it up, repair the damage of years of neglect and do the same for the dolls. Of course, they still can't talk, but I think they're happy again.

Bonnie Pryor, *The House on Maple Street*, with illustrations by Beth Peck (Mulberry Books). ISBN 0688120318.
Grades K – 4. As in *Borning Room* for older kids (see below), we view the passage of time throughout the existence of a house. Two girls find an arrowhead. They go back in their imaginations to a time when there was no house in this spot and then travel forward through time as the house develops and changes.

Ezra Jack Keats, *Apt. 3* (Puffin Books, 1999). ISBN 0140565078.
Grades PreK – 2. Although the title of the book is a building, the concentration here is on the sounds within it. Sam and his friend must hear through the sounds of other tenants eating, talking and snoring before they find the source of the harmonica music.

Megan McDonald, *My House Has Stars*, with illustrations by Peter Catalanotto (Orchard Books, 2001). ISBN 0531071812.
Grades 1 – 4. Here's a book that surveys the homes in eight different cultures as the children in them get ready for bed.

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Houses

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Glen Rounds, *Sod Houses on the Great Plains* (Holiday House, 1995). ISBN 0823411621.
Grades 1 – 6. This simple picture book gives a surprising amount of information about the reasons why sod houses were used, the way in which they were constructed and the advantages and disadvantages of these unique buildings.

Barbara Cooney, *Island Boy* (Puffin Books, 1991). ISBN 0140507566.
Grades 2 – 4. There are many buildings on this tiny island but not at first. A young man settles on the island off the coast of Maine and we watch the buildings there change as the generations build.

Chris Van Allsburg, *Two Bad Ants* (Houghton Mifflin, 1988). ISBN 0395486688.
Grades 1 – 5. Here we get an ant's eye view of the interior of a house. The perspectives are mind-boggling.

David Macaulay, *Rome Antics* (Houghton, 1997). ISBN 0395822793.
Grades 2 – 8. Macaulay has done so many books on various kinds of buildings that they could fill their own newsletter. For our purposes, however, *Rome Antics* is both more fun and more useful in its coverage of many types of buildings. The scene is modern Rome and we follow a pigeon's flight throughout the city, getting a pigeon's eye view of it all.
A few of the Building Books by David Macaulay:
Building Big (Houghton Mifflin,2000). ISBN 0395963311.
Castle (Houghton Mifflin,1982). ISBN 0395329205.
Cathedral (Houghton Mifflin, 1981). ISBN 0395316685.
Pyramid (Houghton Mifflin, 1982). ISBN 0395321212.

Raymond Bial, *Frontier Home (*Houghton Mifflin, 1993). ISBN 0395640466.
Grades 1 – 6. A poetic text and interesting color photographs combine to recreate the experience of a covered wagon trip and the establishment of a prairie home.

Ann Turner, *Dakota Dugout*, with illustrations by Ronald Himler (Simon and Schuster, 1985). ISBN 0027897001.
Grades 2 – 9. In this picture book a stylishly dressed woman tells a child of her early life in a sod house on the prairie. This is a good look at the harsh life there.

Philip M. Isaacson, *Round Buildings, Square Buildings, and Buildings That Wiggle Like a Fish* (Knopf, 2001). ISBN 0394893824.
Grades 3 – 9. Actually, even the youngest browser might enjoy this book of photographs on buildings. The text, however, is poetic and mind-expanding as the author takes a look at the various buildings humans have devised. He takes us from famous structures like the Taj Mahal to echoes of their motifs and structures throughout the world.

Ann Turner, *Finding Walter* (Harcourt, 1997). ISBN 015200212X.
Grades 3 – 6. This time it's a dollhouse as the building in question. Rose and Emily find an old dollhouse in their grandmother's attic and it becomes the focus of their rivalry and concern as they restore it to its former glory. As they do so, they begin to hear the residents of the dollhouse talk.

Avi, *The Barn* (Camelot, 1996). ISBN 0380725622.
Grades 4 – 9. In this brief but challenging novel, Ben, the youngest boy in a motherless family, has been called home, together with his siblings, to deal with their father's recent stroke. Ben becomes convinced that their building of a barn will help to heal his father. It's a story of persistence, acceptance and love.

Elizabeth Winthrop, *The Castle in the Attic* (Dell, 1988). ISBN 0440409411
Grades 3 – 7. William's friend and housekeeper, Mrs. Phillips, has given him the castle as a parting gift. The miniature building has been in Mrs. Phillips' family for generations. Bored and disappointed at first by the gift, William soon finds that his touch brings the Silver Knight to life and William finds a way to keep Mrs. Phillips a prisoner within the castle.

Paul Fleischman, *The Borning Room* (HarperCollins, 1991). ISBN 0785707980.
Grades 5 – 9. This short novel focuses on one room in a house built in Ohio in 1820. Our narrator is Georgina, whose grandfather built the house. The sense of life and death permeates this beautiful book.

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. Paul Webster in "The AIDS Funding Dilemma" (*Miller-McCune*, **3**(4), 58-65 (Jul-Aug 10), resource #20, this issue) describes the success of George W. Bush's President's Emergency Plan For AIDS Relief (PEPFAR) in Africa and how it has prompted drives toward similar treatment programs targeting malnutrition and diseases preventable by vaccines. The concern is that addressing these additional medical problems could be at the expense of efforts to combat AIDS. In contrast to a peak of $18 billion per year for PEPFAR, $10 billion per year could treat malnutrition, and an additional $1 billion per year could provide necessary immunization to the 72 poorest countries. If financial resources are limited to current expenditures, should the present drive to

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Scherrer contrasts science and science fiction

The recipient of the Klopsteg Award from the American Association of Physics Teachers at its meeting in Portland (OR) was Robert Scherrer of Vanderbilt University, a practicing physicist who has written science fiction. Accordingly, when he addressed the Association after receiving his award on 21 July, he chose the topic "Science and Science Fiction."

Scherrer began his contrast between the writing of science fiction and doing theoretical physics by observing that both are what he called "disciplined daydreaming." The closest aspect of theoretical physics to science fiction, he noted, is "What if?" Such "what ifs," he said, led to the special theory of relativity, quantum theory, and the inflationary universe. The acceptance of new theories, he went on, requires that they both fit into the established framework of existing theories and also go beyond what is already known. This, in turn, means that theoretical physics must be "exciting," which Scherrer considered to be a fine line between "boring" and "crazy"; to avoid the latter, theoretical physics cannot get "too far ahead" of experimental data, a problem he said currently besets string theory.

Science fiction operates similarly in terms of "what if," Scherrer went on, introducing plausible ideas that have naturalistic explanations, although speeds greater than that of light and time travel have become accepted. Some science fiction predicts some future developments correctly (a 1944 story predicting the atomic bomb caused the FBI to visit the offices of *Analog*, Scherrer said), but others make predictions that are only partially correct or totally incorrect.

Further contrasting physics and science fiction, Scherrer observed that in physics the idea is primary, and writing about it is secondary. These priorities are reversed in science fiction, he said. Moreover, he added, the introduction of new ideas in science fiction cannot interrupt the flow of the story. Here, he stated, the balance must be between "boring" and "incomprehensible."

Some science fiction writers have science backgrounds, Scherrer went on, but only Fred Hoyle, Gregory Benford, and Carl Sagan among high-profile research scientists have written significant science fiction. Scientists have advantages writing science fiction, he added, but not the advantages most people think. Scherrer said that he finds it most difficult to write science fiction about his own field of research. But, he continued, most scientists do have writing skills; all they need to do to write science fiction is to change from the style of writing science, with its passive voice, parenthetical phrases, and compound nouns.

Infusion Tips

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combat AIDS continue as it is? If some of the resources presently used to combat AIDS are to be diverted to fight other diseases, how much would you divert?

2. Vince Beiser in "Resurrecting the Dead Sea" (*Miller-McCune*, **32**(5), 50-61 (Sep-Oct 10), resource #21, this issue) explains that the Jordan River drains into the Dead Sea, 420 meters below sea level but that withdrawal of water from the Jordan, mostly for agricultural purposes, is causing the Dead Sea to shrink and that water subsidence has pocked the area with dangerous sinkholes. There are environmental concerns about a plan developed by the Israelis, Palestinians, and Jordanians to reverse this trend by replenishing the Dead Sea with water flowing through a channel from the Red Sea, and, at the same time, generate hydroelectric power to run desalination plants: 1) the effect of the rate of water withdrawal from the Red Sea on conditions in the Gulf of Aqaba, which could adversely affect its ecology, 2) the fact that the Arava Valley, through whch the channel would run, straddles two tectonic plates, and 3) the creation of gypsum when sulfate-rich Red Sea water meets calcium-rich Dead Sea water. If you had the authority to decide whether to complete the Red-to-Dead project, what would your decision be? What factors did you take into account? Which factors were most important in determining your decision?

3. Social epidemiologist Paula Lantz is quoted in the September/October 2010 issue of *Miller-McCune* that taxing tobacco has been an important factor in the reduction of smoking. Noting that "the rise of obesity among kids is highly correlated with the increase in consumption of soda and other sugared beverages," Lantz observes that "taxing sugared beverages . . . could make a huge difference" and "could also generate revenue for states that are struggling fiscally right now."

   If a bill to tax sugared beverages were brought up in your state legislature, what would you tell your legislator? If you were a state legislator, how would you vote? How much tax would have to be levied on a 12 fl. oz. can of soda to give people second thoughts about purchasing it?

Enabling life with lab-designed parts

Princeton University Chemistry Professor Michael Hecht has replaced a gene without which an *E. Coli* cannot live by a gene coding for another protein he artificially designed, and he found that the resultant organism continued to live. Moreover, the artificially-designed replacement protein was less complex than the protein coded for by the deleted gene. Hecht reported this in a lecture, "Synthetic Biology: Designing New Proteins and Building Artificial Genomes," to Princeton University alumni on 16 October 2010.

In achieving this, Hecht felt that he was enabling life with molecular parts designed in the laboratory and had found the beginnings of an ability to create a living system from a genome that doesn't already exist, in contrast with J. Craig Venter's April 2010 report of rebuilding an already known bacterial genome, then inserting it into another bacterium whose genome had been removed.

Hecht related how he began by considering what is necessary to sustain life. To him, three things are important:

1. Information storage and transmission (DNA → genes → genome)
2. Molecular machinery – for structure and function (amino acids → proteins → proteomes)
3. Boundaries (membranes, cell walls, skin)

If #2 can be achieved, he said, it's easy to figure out what is required to get #1. He considered proteins of the size of 100 amino acids chained together and noted that, given 20 possible choices for each amino acid, there are $20^{100} = 10^{130}$ possible proteins. There is no way to construct all these proteins in any laboratory, and no way that all of them could have appeared on Earth in the course of evolution. Yet the course of evolution on Earth has led to the proteins that are the basis of life. Designing new life-supporting proteins requires consideration of *quality* as well as *diversity*, Hecht concluded. He reasoned that a focused (designed) library of proteins, that fold properly in water, is needed, with non-polar amino acid bases on the interior. (Triplets in genetic coding with "T" in the middle code for non-polar amino acids, he said, and most triplets with an "A" in the middle code for polar amino acids.)

Hecht obtained such a library of proteins with the structure of four alpha helices by creating genomes with codes for polar and non-polar bases always in the same respective position, then inserting the respective genomes into *E. Coli* to make the respective proteins. He found that these proteins folded into stable structures, each characterized by four alpha helices, and tested them for their biochemical activity. Of the two million possible proteins of this structure, he tested a thousand, by means of 96-well plates, then substituted genes for the proteins exhibiting the greatest biochemical activity in the genome of *E. Coli* in place of one of the 400 genes (of a total of 4000) that is absolutely essential for *E. Coli* to live. He marveled not only that the genetically-modified *E. Coli* lived but that the replacement protein was less complex than the protein it replaced. If *E. Coli* could live with the simpler protein, Hecht wondered, why did nature "bother" to evolve more complex proteins?

"Race to the End of the Earth" at AMNH

The race between Roald Amundsen and Robert Falcon Scott to reach the South Pole is a study of contrasts. With a background of exploring, Amundsen was intent on reaching the Pole as soon as he could, to the exclusion of everything else. With a background in the British Navy, Scott saw his expedition as an opportunity to make scientific observations in addition to "being first." To this end, Scott brought a team of 16, including Edward Wilson, MD, who wanted to investigate how birds and reptiles were related, geologist George Simpson, and parasitologist Edward Atkinson, though only five made the trip to the Pole from their base camp. Amundsen brought only his party of five that would make the trek to the Pole.

This was related at an evening for teachers on 15 October 2010 at the American Museum of Natural History in New York City by Ross D. E. MacPhee, curator of the new exhibit, "Race to the End of the Earth" and author of the companion book, *Race to the End*. In addition to the contrast between Amundsen and Scott described by MacPhee, a tour of the exhibit showed further differences between the two leaders and their expeditions. Amundsen used fur to clothe his men, while Scott used wool. Amundsen depended solely on dogs for his transportation, 52 of them. In contrast, Scott brought only 22 dogs and did not use them as extensively as did Amundsen. In addition, he planned to use Manchurian ponies, which would be shot for food *en route*, and motorized sledges. With the failure of the motorized sledges, Scott's men had to pull them across the cold Antarctic ice themselves (and one part of the exhibit showed how the friction between the sledges and the ice at the temperatures they encountered was much greater than we associate with icy roads).

"Race to the End of the Earth" can be visited at the American Museum of Natural History through 12 January 2011.

News from Triangle Coalition

Unaware of Possibilities, Many High School-Age Students Do Not Plan to Pursue Healthcare and Science Jobs

Despite the projected need for healthcare practitioners at all levels in a challenging job market, nearly half of high school-age students (45 percent of 13 to 18 year-olds) are not considering pursuing a career in healthcare and science fields. The news comes as a result of a recent survey conducted online by Harris Interactive for University of the Sciences in Philadelphia, PA. Of the students who are not interested in pursuing a career in healthcare and the sciences, about one in five (22 percent) feel they "do not know enough about careers in healthcare and the sciences" to pursue them. This includes 19 percent of teenagers between the ages of 16 to 18, a critical juncture for making decisions that impact their career options. The survey, conducted between 20-25 May among 604 high school-age students, also suggests that the disinterest in healthcare and science jobs is partly due to students feeling intimidated by the field. Specifically, among high school age students who express disinterest, 21% feel they are not good at healthcare and science subjects in school; 19% do not feel ready to study healthcare or science in college; 12% feel getting a healthcare degree would be too difficult.

Triangle Coalition member, the Sloan Career Cornerstone Center, provides in-depth resources that compare over 185 career paths in science, technology, education, mathematics, and medicine (STEMM). The extensive website provides exactly the type of objective career planning resources needed by middle and high school students considering STEMM degrees and careers. There are also broad resources for the teachers, counselors, and parents who advise precollege students. In addition to salary and employment data, Cornerstone provides a snapshot of what it is like to work in each field, what educational requirements exist, profiles of individuals currently working in the area, and a career path forecast. Many of the fields covered on Cornerstone can be entered via an associate's degree. Cornerstone also has recently updated its precollege resources which include ideas for programs, projects, summer camps, and courses that students might consider taking to ensure that they keep their career options open when they enter college. There are many steps that can be taken as early as middle school to avoid discovering that career options have been narrowed by the time they reach college. Find out more at <www.careercornerstone.org>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 15 July 2010 and reprinted with permission.)

New National Governors Association Chair Unveils College Competition Initiative

West Virginia Governor Joe Manchin III officially became chair of the National Governors Association (NGA) during the recent NGA Annual Meeting in Boston. He announced his chair's initiative, "Complete to Compete," which focuses on increasing the number of students in the United States who complete college degrees and certificates and improving the productivity of the country's higher education institutions. "The nation has fallen from first to twelfth in the world in the number of students who complete degrees. Now, we're faced with a generation of students that is projected to have lower educational attainment than their parents," said Gov. Manchin. "This slide continues at a time when the economy demands more educated workers and Americans increasingly look to higher education as the path to economic success," continued Gov. Manchin. "My initiative will bring together governors, higher education executive officers, campus leaders, and corporate CEOs to make marked improvements in college completion and productivity and get our country back on track to produce a successful workforce for the future."

In addition to raising awareness about the need to increase college completion and productivity, "Complete to Compete" aims to create a set of common higher education completion and productivity measures that governors and higher education leaders can utilize to monitor state progress and compare performance to other states and between institutions. A report, "Complete to Compete: Common College Completion Metrics," was released during the session. It will be followed in the coming weeks by a technical guide for states. The initiative will also develop a series of best practices and a list of policy actions governors can take to achieve increased college completion; provide support to states to design policies and programs that increase college completion and improve higher education productivity and serve as models for other states around the country; and hold a learning institute for governors' senior advisors in education, workforce, and economic development focusing on successful state strategies to graduate more students and meet workforce demands. The report is available online

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at <http://www.nga.org/Files/pdf/1007COMMONCOLLEGEMETRICS.PDF>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 22 July 2010 and reprinted with permission.)

Push for New Standards Described at NSF/AAAS Education Conference

With growing concern that U.S. students are falling behind global competitors in science and math, education leaders are developing a new generation of standards to help cultivate a skilled and innovative workforce. Attendees at the annual meeting of the Robert Noyce Teacher Scholarship Program, organized by AAAS, got an early look at the standards in mathematics and the process for developing a conceptual framework and aligned next-generation science standards. Funded by the National Science Foundation, the Noyce program aims to improve K-12 education by improving the quality of teachers. Institutions -- mostly universities -- receive grants to recruit students and professionals in science, technology, engineering and mathematics and train them to be K-12 teachers in high-need school districts. Since the program began in 2002, it has trained 7700 teachers.

New mathematics standards were introduced this spring and have already been adopted by 25 states as of mid-July. New science standards are under development and are slated for release in late 2011, and will for the first time include a component on engineering education, speakers said. In a keynote speech at the Noyce conference, Bruce Alberts -- editor-in-chief of *Science* and a long-time advocate for improved science education -- stressed the importance of new, voluntary national science education standards. He told attendees that the term "science education" needs to be redefined, because it currently focuses far too often on memorization of science words. "We're losing lots of potential scientists, because science is much more exciting than it seems in the textbooks," he said.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 29 July 2010 and reprinted with permission. A digest of the Framework for Science Education currently drafted by the National Research Council appears on page 13 of this issue.)

New McREL Report: *Changing the Odds for Student Success: What Matters Most*

A new McREL report concludes that changing the odds for student success does not necessarily demand a wholesale reinvention of the system nor technology-driven innovation, but rather, a clear focus on simply doing what matters most for raising student achievement. According to the report, the odds stacked against many students, especially those born into poverty, are sobering:

- Nationwide, nearly one-third of all students fail to graduate with their peers.
- One-third of those who do graduate are ill-prepared for either employment or college.
- Only one-half of African American, Latino, and Native American students graduate on time from high school.
- In some urban communities, graduation rates are as low as 17 percent.

The report examines thousands of studies of education and calls out those practices that demonstrate the largest effects on student achievement. It goes beyond merely identifying what works and instead identifies what matters most -- those influences and approaches that clearly stand above the rest. It distills these influences into five "high-leverage, high pay-off" areas for improving students' chances for life success: 1. Guarantee challenging, engaging, and intentional instruction; 2. Ensure curricular pathways for success; 3. Provide whole-child student supports; 4. Create high-performance school cultures, and 5. Develop data-driven, "high reliability" systems. McREL is a national, nonprofit education research, consulting, and professional services organization. In addition to administering major federal programs and contracts, it helps states, districts, and schools address five critical areas that matter most for ensuring student success. More details and the full report are at <www.changetheodds.org>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 12 August 2010 and reprinted with permission.)

AAAS's Project 2061 Begins Effort to Develop New Middle School Materials for Chemistry, Biochemistry

Project 2061, AAAS's long-term science literacy initiative, is embarking on a new three-year project to design and test classroom and teacher-support materials in the

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critical areas of middle school chemistry and biochemistry. Understanding chemical reactions is essential not only in advanced chemistry studies, but increasingly in biology, where frontier research is focused on the chemistry of life. Test scores and other evidence show, however, that U.S. students in grades six through twelve are struggling to understand chemical reactions in such basic areas as evaporation, photosynthesis, and biological decay. With a $2.44 million grant from the National Center for Education Research (NCER) at the U.S. Department of Education's Institute of Education Sciences, Project 2061 and the Biological Sciences Curriculum Study (BSCS) will work to develop new materials for teachers and students, test them in four diverse school districts, and then refine the units based on their evaluations. "Today's middle and high school students must be better prepared if they are going to succeed in college level biology courses, which demand a solid understanding of chemistry," said Project 2061 Director Jo Ellen Roseman. "Existing curriculum materials and instruction are not getting the job done. A new approach is needed."

Research done by Roseman and colleagues, published in 2008, found that fewer than 25% of middle school students understood that a chemical reaction produces something with different properties than the substances before their reaction. Fewer than 20% understand that molecules change in a chemical reaction, but that atoms within the molecules do not. Other Project 2061 research found that in a national sample of some 3000 middle school students, fewer than one in five correctly answered questions about the link between matter transformation and growth. That lack of understanding at the middle school level appears to carry over to higher grades. A Project 2061 study of students at an elite New England private high school found that, while most seniors would have had at least a basic chemistry course, only 37% of them correctly answered questions about the transformation of matter and energy in living systems. The new prototype units will be based on the latest research insights into how students learn, and the most effective methods of supporting students as they build understanding. The materials will help students connect their existing knowledge to new ideas and replace their alternative explanations of phenomena with ones that are more scientifically accurate. In addition, the project will develop materials to help teachers understand the science and new ways of teaching it to their students. Learn more about Project 2061 at <www.project2061.org>.

Diplomas Now Wins $30 Million Education Department Grant

The Department of Education's Investing in Innovation Fund (referred to as i3) gave its "highest ranking" to the Talent Development - Diplomas Now application from the Center for Social Organization of Schools at Johns Hopkins University in partnership with City Year, Communities In Schools, and 14 school districts. The application is among one of 15 highest-rated applications in the Validation category of the i3 competition, which had more than 1,700 applicants. The priority area for the Diplomas Now application was "persistently low-performing schools." Diplomas Now is a partnership of Johns Hopkins University's Center for Social Organization of Schools/Talent Development, City Year, and Communities In Schools. PepsiCo Foundation is the founding investor of Diplomas Now, granting $11 million since 2008. Through PepsiCo, the partnership has secured the 20% matching funds required by the Department of Education for the grant to be formally awarded. Diplomas Now is a school turnaround model that unites three experienced non-profit organizations to work with the nation's most-challenged middle and high schools to increase the number of students who graduate from high school. The funding will allow Diplomas Now to grow to an additional 60 middle and high schools in 14 school districts, to serve an anticipated 57,000 additional students.

Diplomas Now is rooted in research from Johns Hopkins University's Center for Social Organization of Schools and the Philadelphia Education Fund that identified three predictive dropout indicators: low attendance, poor behavior, and course failure in English or math. In partnership with school administrators and teachers, Diplomas Now works to eliminate these early warning indicators through whole school reform (Talent Development), integrated student supports (Communities In Schools), and deploying national service members as full-time tutors, mentors, and role models (City Year AmeriCorps members). More details are at <www.diplomasnow.org>.

(*Editor's Note*: The preceding two items were excerpted from the *Triangle Coalition Electronic Bulletin* for 19 August 2010 and reprinted with permission.)

Presidential Advisors Highlight Plan for Improvements in K-12 STEM Education

America is home to extraordinary assets in science, engineering, and mathematics that, if properly applied within

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the educational system, could revitalize student interest and increase proficiency in these subjects and support an American economic renewal, according to a new report from an independent council of Presidential advisors. The new report by the President's Council of Advisors on Science and Technology (PCAST) makes specific recommendations to better prepare America's K-12 students in STEM subjects and also to inspire those students -- including girls, minorities, and others underrepresented in STEM fields -- to challenge themselves with STEM classes, engage in STEM activities outside the school classroom, and consider pursuing careers in those fields. The Council includes twenty of the Nation's leading scientists and engineers, who were appointed by the President to provide advice on a range of topics. Among the recommendations in the report, "Prepare and Inspire: K-12 Education in Science, Technology, Engineering, and Math (STEM) for America's Future," are that the Federal government should:

- recruit and train 100,000 great STEM teachers over the next decade who are able to prepare and inspire students;
- recognize and reward the top 5 percent of the Nation's STEM teachers, by creating a STEM master teachers corps;
- create 1,000 new STEM-focused schools over the next decade;
- use technology to drive innovation, in part by creating an advanced research projects agency – modeled on the famously innovative Defense Advanced Research Projects Agency (DARPA) – for education;
- create opportunities for inspiration through individual and group experiences outside the classroom;
- support the current state-led movement for shared standards in math and science.

In preparing the report and its recommendations, PCAST assembled a Working Group of experts in curriculum development and implementation, school administration, teacher preparation and professional development, effective teaching, out-of-school activities, and educational technology. The report was strengthened by additional input from STEM education experts, STEM practitioners, publishers, private companies, educators, and Federal, state, and local education officials. Many of the recommendations in the report can be carried out with existing Federal funding of current programs, the report concludes, although new authorities may be required in certain cases. Fully funding all of the recommendations could require investments of approximately $1 billion per year, according to PCAST -- much of which, the report notes, could come from private foundations and corporations, as well as from states and districts. The 108-page "Prepare and Inspire" report can be accessed online at <http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-stemed-report.pdf>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 23 September 2010 and reprinted with permission. See separate story about this report on page 1, this issue.)

Preparing the Next Generation of STEM Innovators

The National Science Board has released a new report, "Preparing the Next Generation of STEM Innovators: Identifying and Developing our Nation's Human Capital." The National Science Board firmly believes that to secure our Nation's long-term prosperity we must identify and develop the talented young men and women who will become the next generation of STEM innovators. This endeavor begins with educational opportunities: the opportunity to achieve to the best of one's ability, the opportunity to think creatively, and the opportunity for the engagement and excitement that STEM provides. As a result of the research, the Science Board has identified three major areas where they believe focused attention is essential. First, while there are some examples of high-impact educational policies and practices that are effective in enabling tomorrow's potential STEM innovators to thrive, many more are needed. Second, a commitment to equity and diversity, and analyses of demographic trends, lead to the conclusion that new and ambitious efforts to cast a wide net in seeking and inspiring tomorrow's STEM leaders are critical. Finally, the Science Board says that when the learning environment is infused with high expectations and a commitment to excellence, the potential for future innovators to flourish is great. To identify and develop the next generation of STEM innovators, the Board makes three keystone recommendations

1. Provide opportunities for excellence. Students should learn at a pace, depth, and breadth commensurate with their talents and interests and in a fashion that elicits engagement, intellectual curiosity, and creative problem solving – essential skills for future innovation.
2. Cast a wide net to identify all types of talents and to nurture potential in all demographics of students.

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3. Foster a supportive ecosystem that nurtures and celebrates excellence and innovative thinking.

Contained within each keystone recommendation are multiple specific policy actions for NSF, the federal government, and/or the nation. Additionally, the Board proposes a research agenda for each keystone recommendation. These research findings will inform policy-making in critical areas, such as how to nurture early interest in STEM, best practices for developing STEM related abilities, and means for improving teaching effectiveness. The report is available online at <http://www.nsf.gov/nsb/publications/2010/nsb1033/pdf>.

(*Editor's Note*: The preceding item was excerpted from the *Triangle Coalition Electronic Bulletin* for 30 September 2010 and reprinted with permission. See separate story about this report on page 3, this issue.)

President Obama Announced Launch of Skills for America's Future

At a meeting this week of the President's Economic Recovery Advisory Board (PERAB), President Obama announced the launch of "Skills for America's Future," a new, industry-led initiative to dramatically improve industry partnerships with community colleges and build a nation-wide network to maximize workforce development strategies, job training programs, and job placement. President Obama said, "We want to make it easier to join students looking for jobs with businesses looking to hire. We want to put community colleges and employers together to create programs that match curricula in the classroom with the needs of the boardroom. Skills for America's Future would help connect more employers, schools, and other job training providers, and help them share knowledge about what practices work best. The goal is to ensure there are strong partnerships between growing industries and community college or training programs in every state in the country."

Building on the success and example of the "Educate to Innovate" campaign to increase science, technology, engineering, and math (STEM) learning, Skills for America's Future will facilitate industry partnerships with community colleges and other training providers in support of the President's goal of 5 million more community college graduates and certificates by 2020. Skills for America's Future will build high-impact partnerships with industry, labor unions, community colleges and other training providers in all 50 states. In addition, the President also announced the establishment of a federal "Skills for America's Future Task Force," to coordinate federal efforts and ensure the private sector is best poised to work with and leverage federal training and education efforts. Also this week, Dr. Jill Biden hosted the first-ever White House Summit on Community Colleges, which highlighted the critical role that community colleges play in developing America's workforce and reaching our educational goals. On that day, leaders of "Skills for America's Future" led a breakout session with industry leaders, community college representatives, organized labor, and workforce training experts to highlight best practices and key factors of such robust, successful partnerships.

NACME Convenes Experts to Discuss America's Critical Need for Engineers and Scientists

The National Action Council for Minorities in Engineering, Inc. (NACME), a leading supporter of minority higher education in science, technology, engineering, and math (STEM), has brought together a group of members of Congress, Administration officials, and academics to look at the overall status of STEM education in the United States, the legislative landscape, and workforce issues in meetings entitled, "The New American Dilemma: Our Nation's Critical Need for Engineers and Scientists." "The need for greater focus and investment in STEM education in America is well documented in terms of improving our economic competitiveness, national security, and standard of living," said Dr. Irving Pressley McPhail, President and Chief Executive Officer of NACME. "We were pleased to be able to bring together an exceptional group of leaders concerned about these issues and who understand the importance of community colleges in the process of expanding the ranks of minority graduates in STEM disciplines."

The guest speakers focused on the issues facing minorities in getting college degrees in the STEM disciplines. As part of the day's events, NACME released its Community College Transfer Study which examines the role of community colleges as a critical pathway to meeting the national crisis in STEM education and analyzes the current and future role of community colleges in developing and expanding the ranks of graduates in these areas. The organization's study showed that twenty-one percent of NACME scholars have transferred from a two-year community college to a NACME partner university and that NACME transfer students have a higher grade point average (GPA) than traditional four-year NACME scholars. NACME is the largest private provider of schol-

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arships in engineering for the underserved and underrepresented minority student population and the leading source of research information on the status of minorities in engineering education and employment. NACME has also helped launch a national network of urban-centered, open enrollment, high-school level engineering academies that will provide all students with a strong science and math education so that they will be college-ready for engineering study. The study is available online at <http://www.nacme.org/user/docs/CCTS-20% complete.pdf>.

U.S. Must Involve Underrepresented Minorities in Science and Engineering to Maintain Competitive Edge

National efforts to strengthen U.S. science and engineering must include all Americans, especially minorities, who are the fastest growing groups of the U.S. population but the most underrepresented in science and technology careers, says a new report from the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. According to "Expanding Minority Participation: America's Science and Technology Talent at the Crossroads," minority participation in science, technology, engineering, and mathematics (STEM) education at all levels should be an urgent national priority. The report offers a comprehensive road map for increasing involvement of underrepresented minorities and improving the quality of their education.

Underrepresented minorities – including African Americans, Hispanics, and Native Americans – comprised just over nine percent of minority college-educated Americans in science and engineering occupations in 2006, the report notes. This number would need to triple to match the share of minorities in the U.S. population. And to reach a national target that 10 percent of all 24-year-olds hold an undergraduate degree in science or engineering disciplines, the number of underrepresented minorities would need to quadruple or even quintuple. To be successful, the new report says, these efforts must include an ongoing, comprehensive approach to encourage underrepresented minorities to pursue science and engineering degrees. In the short term, the nation should work to double the number of those who receive undergraduate STEM degrees, a goal that is "a reasonable and attainable down payment on a longer-term effort to achieve greater parity overall." Studies show that minorities major in STEM at the same rate as do other groups but are more likely not to complete degrees or to change majors. To reach this goal, higher education institutions should create programs that provide underrepresented minority students in STEM with strong financial, academic, and social support. Financial support will allow them to complete their degrees and better prepare for the work force or graduate school. The committee estimated that such programs would cost approximately $150 million annually, eventually rising to about $600 million per year as more students are included. The report is available online at <http://www.nap.edu/catalog.php?record_id=12984>.

Houghton Mifflin Harcourt Takes Leadership Role in National Implementation of Common Core Standards

As states and school districts across the country struggle to manage the transition to the new Common Core Standards, Triangle Coalition member, Houghton Mifflin Harcourt (HMH), has assumed a leadership role in providing school districts with comprehensive implementation support. Many schools are turning to HMH for customized transition plans to be in full compliance with Common Core Standards as effectively and efficiently as possible. The company's Alliance Initiative includes a wide array of customized programs and services for every aspect of a school's implementation of Common Core – from content to professional services, from assessment to data and curriculum management. The Common Core Standards are changing the way educators plan and deliver instruction, as well as the way they assess students' knowledge. As educators adjust curriculum and instructional resources to align with the Common Core Standards, there will be a critical need for easy-to-use tools that pinpoint exact needs, identify successful practices, measure student progress, and align data with curriculum.

With this in mind, HMH has developed a comprehensive Common Core Transition Model which provides teachers and administrators with resources and guidance in three key areas -- Professional Services, Instructional Materials, and Assessment and Data Management. In addition to classroom-embedded training and teacher demonstrations, the Common Core Transition Model delivers an array of student and teacher materials to address each schools specific adoption needs as well as tools to map positive student outcomes to instructional strategies and teacher behaviors so that best practices can be shared amongst educators. For more information about Houghton Mifflin Harcourt and the Common Core Standards, please visit <www.hmheducation.com/commoncore>.

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Triangle Coalition

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(*Editor's Note*: The preceding four items were excerpted from the *Triangle Coalition Electronic Bulletin* for 7 October 2010 and reprinted with permission.)

NAEP Grade 12 Reading and Mathematics National and Pilot State Results

The performance of 12th graders nationwide in reading and mathematics has improved since 2005, according to new results from the National Assessment of Educational Progress (NAEP), or The Nation's Report Card. However, the average score for reading was lower compared to 1992, and significant achievement gaps among major racial/ethnic groups remain in both subjects. For the first time, the 2009 results also show the performance of 12th-grade public school students in the 11 states that volunteered to participate: Arkansas, Connecticut, Florida, Idaho, Illinois, Iowa, Massachusetts, New Hampshire, New Jersey, South Dakota, and West Virginia. States were not selected based on geography or size, and are also not representative of the nation. The 2009 NAEP, which is test is administered and analyzed by the National Center for Education Statistics, tested representative samples of 12th graders from 1,670 schools across the nation. About 52,000 students were assessed in reading and 49,000 in mathematics. Mathematics results were compared only to 2005, when a new framework was adopted, and were based on students' responses to questions designed to measure their knowledge and skills across four content areas: number properties and operations; measurement and geometry; data analysis, statistics, and probability; and algebra.

The average mathematics score for 12th graders overall was 3 points higher than in 2005. About one-quarter of students performed at or above Proficient, and two-thirds performed at or above Basic. Students who took more advanced mathematics courses scored higher on average than students who took lower-level courses, with those taking calculus scoring highest. In mathematics, all racial/ethnic groups made gains since 2005. The average score for Asian/ Pacific Islander students was up 13 points from 2005-14 points higher than the average score for White students-and the average score for American Indian/Alaska Native students was up 10 points over the same period. Students attending suburban schools scored higher on the mathematics assessment than those attending schools elsewhere. Higher average scores were also associated with students who expected to attend four-year colleges and with students whose parents had higher levels of education. Regarding the results, U.S. Secretary of Education Arne Duncan commented that the "report suggests that high school seniors' achievement in reading and math isn't rising fast enough to prepare them to succeed in college and careers. Math scores also show only incremental gains over four years ago."

(*Editor's Note*: The preceding was excerpted from the *Triangle Coalition Electronic Bulletin* for 1 December 2010 and reprinted with permission.)

STEM Experts to aid Governors in Building STEM Agendas in States

The National Governors Association Center for Best Practices (NGA Center) has formed a Science, Technology, Engineering, and Math (STEM) Advisory Committee to inform its work in this area and help the 29 new governors, as well as incumbents, develop comprehensive STEM agendas in their states. Advisory Committee members will serve two-year terms and represent expertise across education, policy, business, and STEM content areas. The committee will guide the expansion of the NGA Center STEM agenda to include both K-12 and higher education; provide a series of recommendations for building and advancing comprehensive STEM education agendas; and inform the development of a national STEM meeting the NGA Center will host in the fall of 2011.

"The increasingly globalized economy requires workers with strong science, technology, engineering, and math skills," said John Thomasian, director of the NGA Center. "This Committee is intended to provide the perspectives of a variety of stakeholders to governors and states as they work to establish and grow STEM education programs that can contribute to economic competitiveness." Founded in 1908, the National Governors Association (NGA) is the collective voice of the nation's governors. Its members are the governors of the 50 states, three territories, and two commonwealths. For more information about NGA Center STEM education efforts, visit <www.nga.org/center/edu>.

(*Editor's Note*: The preceding was excerpted from the *Triangle Coalition Electronic Bulletin* for 8 December 2010 and reprinted with permission.)

EASIER ACCESS TO THE *NEWSLETTER* ONLINE is at <http://www.holtonsworld.com/TCNL.php>. This link is provided courtesy of Brian Holton, New Jersey physics teacher. Tell your friends about it!

Science addresses "Education & Technology"

The special section on "Education & Technology" in the 2 January 2009 issue of *Science* describes new educational opportunities from commercial software that evaluates essays and tutors algebra to courses taken online or from open educational resources. It also presents new opportunities for testing as well as teaching, as described by Edys S. Quellmalz and James W. Pellegrino in their perspective on "Technology and Testing." They point out that digital transmission enables paperless administration and scoring of tests. It also enables electronic scoring of free response items, now that scoring software has been developed to give numerical scores that differ from human scorers by no more than the difference between two humans (15%), and administration of questions that involve simulations. Computerized adaptive testing, by selecting questions on the basis of previous responses, can arrive at a final score with a smaller number of questions. However, Quellmalz and Pellegrino note, the law requires that a high stakes test like NCLB be administered just like its paper-and-pencil version.

Patricia M. Greenfield's perspective on "Technology and Informal Education: What is Taught, What is Learned" describes what has been learned about "multitasking." "The understanding of pictures or icons develops at an earlier age than the ability to read words," Greenfield writes. This skill is important for interacting with visual media, among them video games and their enhancement of divided attention, which "is the precursor and prerequisite for multitasking." Although "playing 2 hours of a shooting game called *Counter-Strike* improved multitasking scores significantly over those of a no-play control group" [as measured with *Synwork*, which simulates elements of work-based activities and measures composite performance on four tasks carried out simultaneously], "we do not know . . . whether each of the four tasks could have been performed better or processed more deeply if done alone, rather than in a multitasking environment."

Another example of multitasking is following a talking head and a ribbon of information flowing across the bottom of a TV screen. "A controlled experiment showed that college students recalled significantly fewer facts from four main news stories in CNN's visually complex environment than from the same stories presented . . . with the news anchor alone on the screen." In addition, students in a college classroom with closed laptops "recalled significantly more material in a surprise quiz after class than did students in the open laptop condition."

Skills developed playing video games are not without their benefits, however; they facilitate learning to fly a plane or becoming a laparascopic surgeon. On the other hand, Greenfield notes that real-time media offer no time to reflect – only reading does. "Reading is also key to the development of critical thinking," she continues; ". . . an experimental reduction in television watching in a group of 6-year-olds decreased intellectual impulsivity, increased reflection, and increased reading." ". . . there is [also] evidence that visual technology inhibits imaginative response." Greenfield makes the point that ". . . society needs reflection, analysis, critical thinking, mindfulness, and imagination . . . . The developing human mind still needs a balanced media diet. . . ."

In their perspective on "Laptop Programs for Students," Andrew A. Zucker and Daniel Light describe a four-year longitudinal study in Texas of more than 20 experimental schools using laptops matched with a comparison group of schools using them. "After 3 years," they write, "the researchers found positive impacts of laptops on technology use and proficiency, increased interest among teachers in student-centered instruction, reduced student disciplinary action, and great teacher collaboration. However, there was generally no significant impact on students' test scores in reading and writing and only a weak impact in mathematics . . . the Texas study found that the availability of computer technology by itself had little or no impact on the intellectual challenge of teachers' lessons. . . ." Improving the quality of education, Zucker and Light conclude, rests with improving the ingredients which comprise it – "learning, goals, curricula, teaching strategies, and assessments." If computers are to be a part of this, teachers will need to experience professional development on how to use them to this effect.

In their review of "Online Education Today," A. Frank Mayadas, John Bourne, and Paul Bacsich report that 3.94 million students (22% of the total student population) are enrolled in at least one online course in the fall of 2007, mostly at public institutions, with about half at community colleges, including more than 20,000 at Penn State's World Campus and 35,000 at the University of Massachusetts. Four fifths of the online enrollees at the University of Central Florida were born since 1980. Grades and course completions for online courses seem to be about the same as for traditional courses, Mayadas, Bourne, and Bacsich observe. They also note that online learning has proved to be more popular in the U.S. than in Europe,

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RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

1. Bijal Trevedi, "The Right Bugs," *Miller-McCune*, **3** (3), 68-75 (May-Jun 10).

The "right bugs" are the bacteria that can accomplish a given chemical reaction, and this article describes environmental microbiologist Terry Hazen's efforts to identify appropriate bacteria and "feed" them to stimulate them to achieve a desired end. The basis for this is "the doctrine of infallibility," which "contends that there is no known compound, man-made or natural, that microorganisms cannot degrade." Among the reactions achieved from bacterial action have been conversion of chromium VI to chromium III, decomposition of trichloroethylene, and the transformation of viscous oil to less viscous (and hence more easily extracted) fuels.

2. Robert Hargraves and Ralph Moir, "Liquid Fluoride Thorium Reactors," *Am. Sci.*, **98**(4), 304-313 (Jul-Aug 10).

These authors criticize present American reactors using solid uranium fuel, for three reasons: 1) heat and radiation damage the fuel to the point that it must be withdrawn "after consuming only three to five percent of the energy in the uranium they contain"; 2) some fission products (Xe-135 in particular), which build up in the fuel rods, act as a poison to the reactor's chain reaction; and 3) among the waste products are long-lived transuranic isotopes that make nuclear waste disposal especially problematic.

They propose instead the molten salt breeder reactor (MSBR), research on which terminated in 1970. The fuel for this reactor is the lesser-known fissionable isotope, U-233, which is present in tetraflouride form dissolved in molten lithium and beryllium fluoride. The core is surrounded by a blanket of thorium tetrafluoride in molten lithium and beryllium fluoride, and liquid fluoride salts also serve as coolant. About half the neutrons from U-233 fission are absorbed by Th-232 in the blanket, and – after two beta decays – more U-233 is "bred," also in tetrafluoride form. Bubbling fluorine gas through the blanket converts U-233 tetrafluoride to gaseous U-233 hexafluoride while leaving thorium tetrafluoride untouched. The U-233 hexafluoride is then removed to the core, where it is reduced to tetrafluoride form. The result is a continuously-operating reactor, which – with a seeding of U-233 – has the effect of converting a ton of thorium into a ton of fission products (and an insignificant amount of transuranics), 83 percent of which are stable after 10 years, with the other 17 percent needing to be stored for 300 years. This is contrasted in a diagram in the article with the present uranium reactors, which require 250 tons of uranium to produce a ton of fission products and leave behind 215 tons of uranium depleted in U-235 and 34 tons of other spent fuel, consisting of uranium and transuranics. Moreover, the MSBR coolant would operate at a higher temperature than water in present reactors and not be under pressure, and the MSBR would be less susceptible to nuclear proliferation.

Although the pebble bed and prismatic core reactor designs under consideration for the Next Generation Nuclear Plant project will allow uranium fuel burnup to reach 19 percent before it is replaced, Hargraves and Moir lament that this is a small improvement compared to what they feel the MSBR would offer. Although "Thorium is not currently under consideration for the DOE's development attention," they note that "in India, which has no uranium but massive thorium reserves" it *is*.

(*Editor's Note*: See a nuclear engineer's comments on molten salt breeder reactor technology in separate box on pages 35-36.)

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A Nuclear Engineer comments on the Molten Salt Breeder Reactor

After over thirty years of observing the energy industry, I am a little skeptical of the Next Great Concept. These ideas always look great on paper, but problems crop up when the concept is actually built and put into commercial production. Because of the cost of these projects, it is essential that the plant be on line, producing energy, as much as possible, since no revenues are generated when the plant is down.

When I was a young man, the anti-nukes had one argument that I thought was particularly good. In the late 70s, the average capacity factor for the nuclear fleet was about 62%, and the anti's had some sort of statistical analysis which purported to show that the older the reactor, the lower its capacity factor (a dubious correlation, since a 10-

year old reactor in 1979 would be an old-man of the fleet). The argument was that the design capacity factor was 80%, so these reactors just couldn't be economic at 62%. The nuclear industry mumbled a response, but I didn't think it very convincing to the disinterested observer.

Today, the average capacity factor (calculated on the same basis) is about 90%. A plant with a capacity factor less than 80% is lagging very much in the rear of the pack [six reactors (out of 104) have capacity factors less than 80% (only one reactor has a capacity factor less than 70%)].

One of the reasons for the increase in capacity factors is that we have finally figured out how high-temperature water and steam behave and how to operate and maintain plants using them.

A problem which I have with non-light water reactor concepts is that we don't really understand what we don't know about their operating characteristics. If you would have asked an engineer back in 1965 if we understood high temperature water and steam, he would have pointed to experience with utility and maritime boilers and said "sure."

I figure that we have some sort of learning curve in the deployment of non-light water concepts. Some of the capacity factor improvement (human factors, procedures) can be translated to non-LWR concepts, but we will encounter material problems presently unforeseen which will at least initially make the technology look like it will not live up to its potential. In the case of molten salts, we really don't have anywhere near the operating / technology base now compared to the experience with water and steam in 1965.

The MSBR concept seems to have a lot of complicated plumbing and chemical processing. I like to keep things simple. Also, one must be very careful of neutron economy when breeding U-233; the breeding increase is small, and one cannot afford to waste any neutrons.

From a reactor physics point of view, I wonder about the controllability of the reactor. We depend on delayed neutrons when controlling a reactor. Roughly about 0.6% of the neutron population in a thermal reactor (fueled with U-235) is delayed, with half-lives up to 1 minute. For U-233 fission, the delayed neutron fraction is even lower, about 0.3%. These delayed neutrons are generated by the neutron decay of certain fission products and are essential for the controllability of the reactor. If the uranium is circulated out of the core, some number of the delayed neutrons will be born and absorbed outside of the core, so they will not be part of the neutron balance and will not contribute to the controllability of the reactor. Very negative reactivity coefficients will be needed to compensate for the lower effective delayed neutron fraction. Fortunately, molten salt reactors do have such reactivity coefficients.

I don't find proliferation arguments to be particularly germane. If a country wants to develop nuclear weapons, nuclear power plants are not a particularly effective path to do so. I don't want to make it technologically simple to develop nuclear weapons, but the capabilities needed to develop nuclear weapons are not that simple nor are they cheap. Proliferation solutions are ultimately political – if you want to develop nuclear weapons, you will be able to do so, regardless of what powers your electric grid. The challenge is to remove the political benefits of developing nuclear weapons and to raise the political costs of doing so. That North Korea has developed nuclear weapons shows that it can be done if one is willing to pay the price. On the other hand, nations such as Germany, Spain, and Japan have not developed nuclear weapons, despite having significant nuclear power programs.

Certainly, molten salt breeder reactors have some attractive features. The high coolant temperatures will allow for high thermal efficiencies in the power-conversion portion of the plant, and the low coolant pressure is certainly advantageous. The benefits of the MSBR are promising, and one does not want to argue "but we've never done it that way." Nonetheless, the costs of developing this concept will be extremely high, particularly when compared to a relatively mature light water reactor technology.

- B. Alan Guthrie III

(*Editor's* Note: Mr. Guthrie has over thirty years experience in the nuclear power industry, with a focus on reactor physics, and is a former student of the editor.)

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3. Olla Arjamaa and Timo Vuorisalo, "Gene-Culture Coevolution and Human Diet," *Am. Sci.*, **98**(2), 140-147 (Mar-Apr 10).

The thrust of this article is that you are what you are not only because of what you eat but also because of what your ancestors ate. Genetic and cultural evolution marched hand in hand, as starch was introduced into diet and fire became available for cooking. More recently, lactose tolerance has evolved in cultures dependent on milk in their diet, while the risk for Type II diabetes is currently an increased target for natural selection.

4. Martin Enserick, "'Biased' Viruses Suggest New Vaccine Strategy for Polio and Other Diseases," *Science*, **320**, 1709 (27 Jun 08).

A "biased" virus is one bioengineered to create the same amino acids with alternative codons that don't work as effectively. A polio virus so "biased," by not being as virulent in an organism, could therefore enable the organism to build up immunity against it.

5. Erik Stokstad, "A Second Chance for Rainforest Biodiversity," *Science*, **320**, 1436-1438 (13 Jun 08).

Secondary forests, growing up from the "ruins" of clear-cut primary forests, are not of the same quality of the original but remarkably close in their fostering of biodiversity.

6. Robert F. Service, "Solar Cells Gear Up to Go Somewhere Under the Rainbow," *Science*, **320**, 1709 (27 Jun 08).

Researchers at Idaho National Laboratory have reported converting infrared radiation to electricity.

7. James A. Evans, "Electronic Publication and the Narrowing of Science and Scholarship," *Science*, **321**, 395-399 (18 Jul 08).

A survey showing a narrowing of research citations for online journals suggests that this may result from reduction in browsing, which is enabled by only hard-copy journals.

8. Dennis Normile, "Reinventing Rice to Feed the World," *Science*, **321**, 331-333 (18 Jul 08).

Three strategies are presented to increase the world rice crop: 1) Increase the number of submergence-resistant varieties (this can be done by inserting Gene Submergence 1A (Sub 1A) in chromosome 9); 2) Developing new hybrids by breeding modern varieties with wild and exotic varieties; 3) Converting rice from a C3 plant (like wheat, barley, and potatoes) to a C4 plant (like maize and sugar cane).

9. Robert F. Service, "New Purdue Panel Faults Bubble Fusion Pioneer," *Science*, **321**, 473 (25 Jul 08).

Rusi Taleyarkhan has been found guilty of scientific misconduct for alleging that fusion results from firing neutrons and ultrasound into deuterium-enriched acetone.

10. Elizabeth Finkel, "Australia's New Era for GM Crops," *Science*, **321**, 1629 (19 Sep 08).

Australian states without bans against genetically modified crops are seeing agricultural improvements – increased yields from salt-tolerant wheat in Western Australia, and grasses in Victoria which will reduce methane emission from cows (which accounts for nearly one eighth of Australia's greenhouse gas emissions).

11. G. Philip Robinson, *et al.*, "Sustainable Biofuels Redux," *Science*, **322**, 49-50 (3 Oct 08).

The 23 authors of this report, including José Goldemberg, expect that "grain-based ethanol will likely remain in the nation's energy portfolio" even with fulfillment of the legislative mandate for cellulosic ethanol. They thus advocate agricultural measures that would make growing this grain more sustainable (25% of US corn production went to produce ethanol in 2007, more than 30% in 2008). They also expect that the land for growing cellulosic crops globally will match that for today's row crop agriculture. Though this would be on marginal land and thus not compete with agriculture, it would deprive that land of what would otherwise be greater biodiversity. They also caution against environmentally unsound agricultural practices on this land.

12. Christopher M. Holman, "Trends in Human Gene Patent Litigation," *Science*, **322**, 198-199 (10 Oct 08).

Jensen and Murray identified 4270 US patents claiming at least one human gene, with the total covering over

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a fifth of the known human genes. Holman could locate only 31 human gene litigations going back to 1967, with only seven involving genes in patents cited by Jensen and Murray. He also found that none of the 4270 patents claiming human genes had ever resulted in a decision favoring the patent holder (which he says is the test of a patent's legal effect).

13. Dennis Normile, "Clinical Trials Guidelines at Odds With U.S. Policy," *Science*, **322**, 516 (24 Oct 08).

The World Medical Association wants to amend the Helsinki Declaration governing clinical trials of new medications to safeguard the health of those not receiving the new medication. Rather than a placebo, the "control group" should receive "the best, proven existing intervention."

14. Richard G. H. Cotton, *et al*., "The Human Variome Project," *Science*, **322**, 861-862 (7 Nov 08).

The goal of the Human Variome Project (www.humanvariomeproject.org) is to establish a database of all variations of genes affecting human health, in order to facilitate diagnosis of genetically-caused diseases.

15. Salman Hameed, "Bracing for Islamic Creationism," *Science*, **322**, 1637-1638 (12 Dec 08).

Given that more than half the people polled in Turkey, Indonesia, Pakistan, Malaysia, and Egypt believe that Darwin's theory of evolution "could not possible be true" and that Pakistani biology teachers typically present the Islamic perspective of the origin of life along with evolution (frequently eschewing human evolution), "the message about evolution in the Islamic world needs to be framed in a way that emphasizes practical applications and show that it is the bedrock of modern biology – thereby capitalizing on the existing prescience attitude. The national academies of Muslim countries will need to tailor the specifics of the message according to the political and cultural realities of their respective countries. Religion in the Muslim world plays a much larger role in the social and cultural landscape, and thus, our discussions with the general public need to take that into account . . . . efforts that link evolution with atheism will cut short the dialogue, and a vast majority of Muslims will reject evolution."

16. John Whitfield, "Does 'Junk Food' Threaten Marine Predators in Northern Seas?" *Science*, **322**, 1786-1787 (19 Dec 08).

Changes in fish population following the *Valdez* oil spill led to changes in diet for species feeding on the fish. A decline in fish nutrition led to a decline in the predators' health.

17. Noel Sharkey, "The Ethical Frontiers of Robots," *Science*, **322**, 1800-1801 (19 Dec 08).

Concern is expressed that trends in robots providing care to children or the elderly and to robot-operated weapons systems could lead to problems if the role of humans is completely removed.

18. John D. Sterman, "Risk Communication on Climate: Mental Models and Mass Balance," *Science*, **322**, 532-533 (24 Oct 08).

"A 'Manhattan Project' cannot solve the climate problem," because the solution requires the participation of all in terms of lifestyle changes. A civil rights movement would be more appropriate, but "the damage caused by segregation was apparent to anyone who looked, but the damage caused by GHG [greenhouse gas] emissions manifests only after long delays."

19. Eugene A. Rosa, "Nuclear Waste: Knowledge Waste?" *Science*, **329**, 762-763 (13 Aug 10).

Since he no longer supports disposing of the 60,000 tons of high-level nuclear waste in the U.S. at the only Congressionally-designated nuclear waste repository at Yucca Mountain, NV, President Obama has directed Energy Secretary Chu to form a Blue Ribbon Commission America's Nuclear Future to "review . . . policies for managing the back end of the nuclear fuel cycle" and recognize that "a solution must be based on sound science and capable of securing broad support of those who live in areas that might be affected by the solution."

These authors point out that "people do not like projects that pose highly uncertain risks, unless they see great compensating benefits and have deep trust in institutions managing them." This has been the case in which "institutional cultures typically frame challenges as technical problems rather than societal challenges" and that "to the extent that the social side is recognized, it has often been viewed as an obstacle to overcome, not an element of the democratic process." They therefore main-

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tain that "the Blue Ribbon Commission . . . should make the rebuilding of social trust and credibility central to their operations and their proposed strategies for waste management, then draw on the social sciences needed to fulfill these commitments."

20. Paul Webster, "The AIDS Funding Dilemma," *Miller-McCune*, **3**(4), 58-65 (Jul-Aug 10).

The success of George W. Bush's President's Emergency Plan For AIDS Relief (PEPFAR) in Africa has prompted drives toward similar treatment programs targeting malnutrition and diseases preventable by vaccines. In contrast to a peak of $18 billion per year for PEPFAR, $10 billion per year could treat malnutrition, and an additional $1 billion per year could provide necessary immunization to the 72 poorest countries. The concern is whether addressing these additional medical problems would be at the expense of efforts to combat AIDS.

21. Vince Beiser, "Resurrecting the Dead Sea," *Miller-McCune*, **32**(5), 50-61 (Sep-Oct 10).

The Jordan River drains into the Dead Sea, 420 meters below sea level. But withdrawal of water from the Jordan, mostly for agricultural purposes, is causing the Dead Sea to shrink. Additional water is pumped from the southern end of the sea for minerals extraction, and water subsidence has pocked the area with dangerous sinkholes.

The Israelis, Palestinians, and Jordanians are considering a project that would reverse this trend – and also given them their first cause to work together: replenish the Dead Sea with water flowing through a channel from the Red Sea, and, at the same time, generate hydroelectric power to run desalination plants.

There are, however, environmental concerns: 1) the effect of the rate of water withdrawal from the Red Sea on conditions in the Gulf of Aqaba, which could adversely affect its ecology, 2) the fact that the Arava Valley, through whch the channel would run, straddles two tectonic plates, and 3) the creation of gypsum when sulfate-rich Red Sea water meets calcium-rich Dead Sea water.

AN EASIER WAY TO ACCESS THE *NEWSLETTER* ONLINE

is to go to http://www.holtonsworld.com/TCNL.php. This link is provided courtesy of Brian Holton, New Jersey physics teacher.

Ed & Tech

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where "there have been a number of high-profile failures of online universities."

In his review of "Opening Education," Marshall S. Smith reports that the efficacy of open educational resources (OER) was validated by tracking two groups of Carnegie Mellon students taking the beginning statistics course – one with traditional lectures, the other with tutoring software. Both groups, Smith writes, scored similarly on in-class exams, but the latter group posted greater gains between a pre-and post-standardized assessment. Smith imagines creating a library of 50 such open courses for high school students and a like number of beginning college courses, for $300 million, which he says is less than 2% of California's budget deficit for 2009-10, with another $100 million for end-of-course assessments. The annual maintenance for this, he adds, would be $50 million. This would allow the best teachers to reach many more students, but he cautions that "widespread use would require a significant change in the role of some teachers from presenter to mentor."

Unfortunately, academic technological developments do not often become well-known, unless they are commercially developed, because they are not marketed, nor do the grants that fund their development provide for marketing them. Examples of this in *Science*'s "Education & Technology" section are the National Science Digital Library (which has become the National Science Distributed Learning program) and video games developed by academicians.

Debates apply course content in Portland

Shannon Mayer wants her students to be able to apply the content they're learning to their lives and to communicate about it. She sought to incorporate activities to do this that also related to the content of her courses at the University of Portland. One, as she reported at the meeting of the American Association of Physics Teachers in Portland (OR) on 19 June, was a debate about a proposal to install windmills off the coast of Cape Cod – she felt that the technology was not controversial but that its implementation would stimulate controversy. Other debates focused on SUV fuel economy standards (raising Corporate Average Fuel Economy standards as a way to reduce dependence on foreign oil) and requirements for commercial lighting.

REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Alan Hirshfeld, *Eureka Man: The Life and Legacy of Archimedes* (Walker, New York, 2009), viii + 242 pp. $26.00. ISBN 978-0-8027-1618-7.

Although the title of this book may reflect the best-known story of arguably the greatest mathematician of the ancient world, this story pales in comparison with totality of Archimedes' achievements. Hirshfeld wastes no time to tell us this in his first chapter, "The Essential Archimedes": in addition to Archimedes' work on buoyancy are listed his achievements in mathematics (his "greatest joy") and his development of the concept of center-of-gravity and a cranked screw irrigation device; Hirshfeld also reports of work in optics, a model of the solar system, a steam-powered cannon, and a compressed -air organ, for which no evidence survives.

This first chapter also begins the first part of the book, "Master of Thought," which covers the first half of the book's subtitle – the *life* of Archimedes. Here we learn of Archimedes' determination of pi from the convergence of perimeters of inscribed and circumscribed regular polygons, with the number of sides increasing to 96, and the surface area and volume of cones and spheres (an achievement all the more remarkable without decimal numbers, algebra, and trigonometry). We read about his number games and calculations about the universe in *The Sand-Reckoner* (which is also the principal source for knowing about Aristarchus' model). We learn about Archimedes' ability to detect adulterated gold from his work on buoyant forces and his development of the principle of the lever as the basis of the equilibrium of a system of masses. And we read of the military defenses Archimedes developed for his native city of Syracuse, caught between more powerful powers to its north (Rome) and south (Carthage) and beset by a history of instability from a course of shifting alliances with these two warring neighbors.

Archimedes' achievements alone would be reason enough to enjoy this book, but the most exciting part is yet to come: the second part, about the *legacy* of Archimedes, how Archimedes' writings have been passed down to us. We read that three compilations of Archimedes' work were generated in Byzantium, the final capital of the Roman Empire, and Hirshfeld's account of what happened to them reads like a good mystery story. Because many of Archimedes' works are known to us today, we know that the ending of the story is not tragic, although there were many "close calls." The copy which enabled Thomas Heath to translate the works of Archimedes into English turned out to have been washed and overwritten perpendicular to Archimedes' original, apparently due to a parchment shortage, in 1229, and thus became a *palimpsest*. Photographs in the book show what it looked like when Heath made his translation, the state of disrepair into which the palimpsest later fell, and the results of present preservation efforts, which can be viewed digitally at <http://www.archimedespalimpsest.org>.

Fortunately for us, this is the only one of the three known compilations to be passed down that contained the *Method of Mechanical Theorems*, and from this Hirshfeld pulls out one final example of Archimedes' genius to delight and impress us: his calculation of the volume of a paraboloid of revolution. Hirshfeld likens Archimedes' method of determining the volume of a solid to imagining the solid as a loaf of bread and slicing it (just as we do today with integral calculus). Considering a cylinder circumscribed around the paraboloid, if it is suspended from a lever at a distance half the cylinder's height from the fulcrum, Archimedes shows that a slice of the cylinder is balanced by the corresponding slice of the paraboloid on the other side of the fulcrum a distance of the cylinder's full height. Since the paraboloid thus balances the cylinder at twice the distance from the fulcrum, its weight (and therefore volume, assuming the paraboloid and cylinder to be made of the same material) must be half that of the cylinder. Not until Newton and Leibniz developed the calculus were such mathematical achievements to be seen again.

\- John L. Roeder

(*Editor's Note*: This review was reprinted with permission of the American Institute of Physics from John Roeder, *The Physics Teacher*, **48**(4), 272 (April 2010), copyright 2010, American Association of Physics Teachers.)

Henry Petroski, *The Essential Engineer: Why Science Alone Will Not Solve Our Global Problems* (Knopf, New York, 2010), x + 274 pp. $26.95. ISBN 978-0-307-27245-4.

At the Eleventh Technological Literacy Conference of the National Association for Science, Technology, and

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Society, I enjoyed a presentation that Henry Petroski made about the structure and evolution of bridges, and when I saw this latest book he had written, its title suggested itself as one that I should read to review for this *Newsletter*. The subtitle, it occurred to me, was written and placed on the jacket cover to grab people's attention – after all, according to those clamoring for greater science literacy, if science can't solve problems like climate change and depletion of fossil fuels, what will?

Mindful that the author is an engineer and given the main title of the book, I suspected that the answer had something to do with engineering. After all, the subtitle says that "science *alone* [emphasis mine] will not solve our global problems." It's not that science has *no* role to play, but rather that science's role is *not* the *only* one. Some engineering needs to be thrown into the mix.

My hunch was right, but I didn't realize at the outset the extent to which Petroski would go to make his case. I realize after reading his book that he chose his main title because he wanted to make the point that the engineer is *essential* to solving those global problems, and he's tired of seeing engineering standing in the shadows of science for so long, acting as the "fall guy," as exemplified by the following cliché from the 1967 publication, *The Engineer and His Profession*: "Every rocket firing that is successful is hailed as a *scientific achievement*; every one that isn't is regarded as an *engineering failure*." (p. 28) And a 2008 poll by the National Academy of Engineering concluded that "the public believes engineers are not as engaged with societal and community concerns as scientists or as likely to pay a role in saving lives." (p. 29) Petroski suspects that this different image of scientists and engineers results because science and art are done for their own sake and are thus supported by grants, while this is not true for engineering, which, because of its supporting role, is sometimes viewed as "unglamorous."

To remedy what he regards as confusion from unwarranted lumping together of science and engineering, Petroski seeks in this book not only to emphasize the important role of engineering but also to distinguish it from science. "Science is about knowing; engineering about doing," he writes. "Scientists warn, engineers fix." (p. 17) While scientists may have identified the cause of diseases from bad water, he points out that it was engineers who devised ways to make the water healthy to drink.

Petroski indicates that the primacy with which science is viewed is actually due to an engineer himself – Vannevar Bush, whose 1945 report, *Science – the Endless Frontier*, argued for what eventually became the National Science Foundation and the concept of R&D (Research and Development). But by 1965 Bush is quoted by Petroski as saying that ". . . engineering is more a partner than a child of science." Indeed, in their Project Hindsight of 1969, the Department of Defense found that "events" contributing to the development of twenty core weapons systems were 91% technological and only 9% scientific. Moreover, Petroski points out, because engineering is needed to develop instruments that scientists use, it doesn't have to be preceded by science. After all, the steam engine preceded and led to the development of thermodynamics, and the airplane preceded and led to the development of aerodynamics. Petroski also advocates weighting the R&D budget in favor of D, because "if the budget is front-loaded with dollars for undirected basic research, all that may be produced is knowledge that is irrelevant and inefficacious as far as solving the problem at hand. There is certainly nothing wrong with scientists pursuing basic research in terms of basic knowledge, but it is not necessarily the way to spend money for attacking a particular problem." (pp. 122-123)

With the distinction between science and engineering established, Petroski concedes that engineering alone will not solve our global problems, nor can even science and engineering acting together. Writing about planning for protection against natural disasters, he states that "No matter who works on them, the highly challenging and often unprecedented problems presented by such potential earthshaking phenomena make it highly unlikely that solutions, no matter how technically elegant, will be easy or straightforward to implement." (p. 70) And in addressing complex problems like climate change and alternative energy, he observes that ". . . the solution to problems involving complex systems can be expected to require the involvement of complex systems of people and approaches," predominantly scientists and engineers but including people with other backgrounds, "international experience, interdisciplinary knowledge, and intercultural sensitivities." (p. 172) "The goal, after all, is not science and engineering for their own sake, but for the sake of the planet and its inhabitants. We should all strive to be of one culture – and not talk past, down to, or over the heads of each other . . . . it may be the very fact that potentially devastating planetwide problems . . . can by definition affect everyone everywhere that will lead an all-inclusiveness in the world's efforts to solve them." (p. 183)

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Letter to the editor:

Abrahamson responds to Meadows

In the last issue of your newsletter you devoted the better part of a page (p. 6) to a description of Lee Meadows's methods of teaching evolution. According to the article, he has been published in the *Journal of College Science Teaching* and *The Biology Teacher* in addition to having written a book, *The Missing Link*, and presenting at the 2010 NSTA national conference in Philadelphia. Since he apparently is very influential, I secured a copy of his book. Here is my considered judgment of what he wrote.

According to the book, *The Missing Link: An Inquiry Approach for Teaching All Students About Evolution* (Heinemann, Portsmouth, NH, 2009), Meadows is an excellent, inquiry-approach teacher. He writes from his own classroom experiences, and his multiple suggestions are inventive and practical. He emphasizes the need to tailor instruction to students in specific classes, and his students will acquire an understanding of evolutionary procedures and concepts. I recommend that science teachers obtain the book. Trying out some of Meadows's excellent pedagogical procedures almost certainly will enhance their teaching and students' learning.

Yet, I am troubled.

Meadows teaches in the South and assumes that many students come from creationist-believing homes. Given this situation, he suggests that a teacher begin the unit on evolution with this statement: "I care about you and your worries about studying evolution." (p. 34) He then suggests that, if most students are religious oriented, they could be shown a clip from Ben Stein's movie *Expelled* as an example of "the concerns that many people have about evolution." When the clip is over, there is to be class discussion: "I'd like to know from you how well you think that clip represents the concerns that people you know have."

Meadows does not recommend starting the unit in this negative fashion if a number of students are non-fundamentalist. But, is giving Ben Stein the first crack at students in any class a good way to begin? I cannot imagine organizing a world history unit on First Civilizations (that appeared about 6,000 years ago) by showing a clip on Adam, Eve and the Garden of Eden and then asking students if it represents the beliefs "that people you know have"? Such negative introductions may implant the notion that the subject matter is controversial even among students who'd not previously thought much about it.

As the unit progresses, Meadows suggests telling students almost on a daily basis that they don't have to accept evolution, just know what it involves. That is, he teaches evolution mostly from a utilitarian perspective. It's presented as a series of procedures they need to know to get ahead in the world. "Without an understanding of evolution, students will have a hard time making sense of many practical issues they will face in life." (p. 4) Doesn't this approach tend to foster an "It's all about me" attitude? Isn't it a bit like telling students in drivers' training classes to obey traffic laws so they don't get caught and fined? Is this self-centeredness what we want to promote? I don't see how students are inspired when they are told again and again "I expect you to understand _______, but I don't expect you necessarily to accept it." (p. 4)

Meadows does not delve into creationist beliefs during the course of the unit. "If you give too much credence to objections, then you risk allowing student concerns to derail the teaching of essential science concepts." (p. 41) Instead, he has students write out their objections that he posts on a bulletin board called a "parking lot" and tells students their objections will be considered later in the unit at an appropriate time (pp. 42 and 52). In this way he keeps the class on-message, but the parking lot idea seems problematic. As the unit progresses, more and more anti-evolution material likely will be posted, and by the end of the unit it's possible it becomes a creationist-like, student produced "shortcomings of evolution" display.

Meadows ends the unit with student projects, and he describes a plethora of possibilities. Most are good-to-excellent, but a few are questionable. To "meet the needs of theistic students [so that they stay] "true to the faith of their families" (pp.100-01), Meadows includes the following projects:

1) Students can "craft their own personal answer to the unit in a form that they feel comfortable with . . . documenting well the research that they have done and the new understandings that they come to." (p. 103) As I read this suggestion, they could meticulously quote from Genesis and

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Young Earth Creationists and come to the "new understandings" that evolution is more nonsensical or evil than they had imagined.

2) An individual or group "could create a survival guide for…future students." (p. 103) Is it appropriate for students to be constructing religious survival guides for use in future science classes?

3) "Some highly interactive students may interview leaders in their faith communities. . . ." In my experience, few projects are more hazardous than having students interview community people on a contentious topic. What if a student wants to interview a Muslim Imam or other minority religious leader? How might community leaders in a fundamentalist community react?

Now consider Meadows's understanding of science. He says that the "need to understand the difference between natural and supernatural explanations . . . is key to this approach to teaching evolution." (p. xii) He apparently sees some worldly happenings having natural causes while others have supernatural causes. Since science is limited to explaining natural happenings, he tells students that their miraculous beliefs (apparently of whatever kind) are beyond the scope of scientific study. Meadows is clear on this point. "Science can't be used either to explain or explain away supernatural events." (p. 18) ". . . it [science] can say nothing about the validity or deficiencies of supernatural explanations." Lesson 6, pages 76-93, is a lesson on the interface of religion and science that includes a teacher-led discussion "on the inability of science to disparage religion." (p. 79)

It's a long-used creationist claim that scientists can say nothing about the miracles that are associated with most religions. For example, in 1998 Warren Nord and Charles Haynes maintained that ". . . the modern scientific conceptual net — or scientific method — allows scientists to catch only replicable events . . . This means that miracles, which are by definition singular events cannot be caught." (p. 40, *Taking Religion Seriously Across the Curriculum*.)

I feel that Nord and Haynes are wrong, as is Meadows. Scientists have plenty to say about miraculous claims concerning the natural world. They don't let the belief that YHWH miraculously created the universe less than 10,000 years ago (a non-replicated event) go unchallenged. They don't remain silent when a religious leader claims that a single worldwide flood created the Grand Canyon. The displays in the Petersburg, KY, Creation Museum are critiqued.

Concerning Intelligent Design (ID), Meadows states clearly that it includes miracles, and therefore is not science. But, that doesn't mean that he rejects ID or miracles. ID is simply moved sideways into the supernatural category about which, he claims, science can say nothing. "Students need to understand that science limits explanations to those resulting from natural causes, but students can continue to believe that the supernatural exists." (pp. xii-xiii) Of course they can, and they will. However, should a science teacher claim that scientists can only remain silent when somebody proclaims that some miracle has occurred? Such a view opens the door to a new superstitious era that reminds me of the Middle Ages. (Meadows points out that a number of evolutionary scientists are religious people, and their view of science – that presumably makes allowance for miracles – is the concept that he teaches to his students.)

In his Introduction, Meadows makes this plea: "From the start, please don't think that this is a creationist book." (p. xiii) It is true that he does not teach creationism as it is taught in *Explore Evolution*. But *The Missing Link* does misrepresent the scope of scientific inquiry, and students are encouraged in a variety of ways to maintain the creationist beliefs that they bring to class. (As a note, creationist organizations such as the Discovery Institute have tried to broaden the definition of science to include miraculous happenings. (See *Explore Evolution*, p. 143.) Meadows narrows the definition to repeatable phenomena, another creationist tactic. Both should be resisted in my view.)

Meadows is very critical of science teachers who will not discuss religion and its relationship to science. He equates teachers who "stick to the science" with insensitivity, a way of signaling to students that their faith is not important. He does not even approve of a teacher suggesting that a student consult his religious leader. "This approach . . . ignores students' humanity and how they are trying to make sense of science in the broad worldview context of their beliefs about God, life, and how the world works." (p. 3) I object to these criticisms that I take quite personally. There are multiple ways to show respect for students that are less problematic than developing science lesson plans that focus on affirming "the value and beauty of students' [religious] beliefs." (p. 4)

Religious institutions are strong in this country, and a primary reason is the separation between religion and

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government. To maintain this constitutional ideal, public schools need to focus on naturalistic explanations. Youngsters from religious homes may learn different worldviews, one that includes multiple supernatural events. And there will be a disconnect. The unity of childhood beliefs will be broken, but this is not to be regretted. What is the purpose of education if it doesn't modify childhood beliefs? Furthermore, children are much more resilient than Meadows seems to think that they are. As they mature they will make decisions about how to integrate, juggle or decide among conflicting secular and religious sources of truth — as have generations before them. In my view science teachers do students and the country no favor by twisting science in an attempt to make their classes creationist-friendly.

- Brant Abrahamson, September, 2010

(*Editor's Note*: Brant Abrahamson described the creationist backgrounds of the authors of *Explore Evolution* in our Spring 2008 issue and reviewed *Explore Evolution* in our Fall 2009 issue. Retired after teaching 32 years at Riverside Brookfield High School, Brookfield, IL, he is committed to "help maintain a separation between church and state as this constitutional directive relates to textbooks used in American public schools.")

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In his penultimate chapter, Petroski lists the National Academy of Engineering's list of the twenty most important engineering developments of the twentieth century and the fourteen "grand challenges" for twenty-first century engineering. But he cautions that "Just as science is a never-ending quest to uncover the mysteries of the universe, so engineering is the never-ending pursuit of a better system. . . ." (p. 201) "The basic characteristic flaw of the [engineering] profession's practitioners is what drives change and makes achievement a process rather than simply a goal." (p. 202) This is because engineering solutions can have unintended consequences, and eliminating them is the incentive for developing a better solution: "Design is effectively proactive failure analysis." (p. 203)

All engineering problems must be solved within constraints, however, and the severest constraint is undoubtedly financial. Because "Money always seems to be scarcer than ideas," Petroski writes, "those with the money have to make tough decisions." (p. 122) This, in turn, means that money and politics ultimately dictate our priorities for dealing with global problems, be they protecting against natural disasters, safeguarding our environment, or providing sources of energy.

- John L. Roeder