TEACHERS CLEARINGHOUSE
FOR SCIENCE AND SOCIETY EDUCATION
NEWSLETTER

Sponsored by the
Association of Teachers
In Independent Schools

Affiliated with the Triangle
Coalition for STEM Education

Vol. XXXII, No. 2
Fall 2013

Modeling Instruction –
a reform movement in science education that continues to gain strength

by John L. Roeder

Why would five dozen physics and chemistry teachers pay to participate in a three-week workshop at Teachers College, Columbia University, in the middle of the summer? These teachers wanted to learn more about how the Modeling approach to teaching would improve their success in the classroom – at three workshops, two in physics (mechanics, and electricity and magnetism) and one in chemistry, all under the auspices of Physics Teachers NYC, led by Fernand Brunschwig and assisted by a board of teachers who use Modeling Instruction in their classrooms. I participated in the workshop in electricity and magnetism.

I first learned about the Modeling method of teaching physics at the 1997 summer meeting of the American Association of Physics Teachers (AAPT) and reported on it as one of several innovations in physics teaching in a special section of the Fall 1997 issue of this *Newsletter*. There I wrote of how it had been developed by a high school teacher, Malcolm Wells, in partnership with Professor David Hestenes at Arizona State University, and tested in Wells's doctoral dissertation (1987). Phase I had just trained 50 teachers from 23 states, and there were plans to train 150 more, all of whom would participate in two successive four-week summer workshops. At the first workshop, much like the mechanics workshops of today, participants worked through the units in the mechanics curriculum and were asked to implement them in their classrooms the following academic year. At the workshop the following summer the teachers were asked to work on developing curriculum using Modeling Instruction in one of four post-mechanics content areas (mechanical waves and sound, models of light, current electricity (based on revised CASTLE curriculum), electricity and magnetism) or underpinnings for ninth grade physical science and to implement this additional work in their classrooms.

Those early Modeling Workshops were funded by the National Science Foundation (NSF). Though the funding from NSF has long since ended, Modeling Workshops are going stronger than ever (their number has doubled in the past five years) and have been held in 32 states and American Samoa, organized by science faculty at 58 universities and colleges and 30 schools and school districts, including the U.S. Department of Defense Education Agency. These workshops are now typically only three weeks long, largely because the teaching materials have been developed, though Mark Schober, Larry Dukerich, and Michael Crofton, leaders of the workshops this summer at Teachers College, continue to revise and improve them.

Although Modeling Instruction has outlived its initial period of NSF funding, as an approach to teaching it has taken on a life of all its own. Teachers willingly pay to attend Modeling Workshops, and alumni of these workshops, known as "modelers," have formed their own organization, the American Modeling Teachers Association (AMTA), which coordinates presentations at meetings of the National Science Teachers Association (NSTA) as well as AAPT. No longer just for physics, Modeling Instruction has been adapted to teaching physical science (since 2000) and chemistry (since 2005) as well, and the first two-week biology Modeling workshop was held in 2010. Almost 6000 teachers have taken a Modeling Workshop, including 10% of the nation's physics teachers. In addition to Arizona State University, where Modeling began, Modeling Instruction is taught to pre-service high school science teachers at Florida International University, Brigham Young University, Illinois State University, Buffalo State College, and the University of Wisconsin at Oshkosh.

Why has Modeling Instruction experienced so much success? It seems to me that this is because reform-

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Wynne discusses Excimer Laser Surgery

James J. Wynne of the IBM T. J. Watson Research Center spoke to the three Modeling workshops at Teachers College, Columbia University, about "Excimer Laser Surgery – The Foundation for Laser Refractive Surgery and Future Applications" on 6 August 2013. This is a field in which Wynne, Rangaswamy ("Sri") Srinivasan, and Samuel E. Blum made pioneering strides and were honored by the National Academy of Engineering with the Fritz J. and Dolores H. Russ Prize. Unfortunately, Blum died before the award was presented at the White House by President Obama.

As Wynne explained, the first laser surgery was one on the retina with a ruby laser in 1961, with the laser used to weld the retina, but it also produced therapeutic damage (retinal tears, bleeding ulcers). Wynne himself started working with lasers in 1963 and in 1979 purchased a commercial excimer laser. A year later Srinivsan and Veronica Mayra Banton discovered that the 193 nm far ultraviolet line from an ArF excimer laser etched photopolymers useful to IBM in making chips. They realized that sharp cuts made with this laser healed without scar tissue and tested the laser on leftover Thanksgiving turkey to demonstrate its effectiveness. The next test would need to be on live tissue to test the healing process, and in 1981 excimer laser surgery was developed. It later became the foundation for LASIK surgery.

Wynne explained that excimer lasers operate by ablating a selected amount of material from a sample of tissue – this is the basis of LASIK (LAser in SItu Keratomileusis) surgery. Twenty-five million people, including Michelle Obama, as he learned at the White House presentation, have benefited from it.

Wynne's next medical application of excimer lasers has been to skin, especially burns. He and his colleagues found that lasers stop ablating skin once the epidermis has been penetrated, because the laser light is blocked by physiologic saline solution in the blood. But he observed that the 193 nm line from an ArF laser may be too slow for skin surgery, so they are investigating a two-laser system including the 308 nm line from a XeCl laser along with the 193 nm line from a ArF laser (the former is likened to "rough sandpaper" and the latter to "fine sandpaper").

IN THIS ISSUE

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 STEM Education.

“The Bomb in the Basement”

by John L. Roeder

In its listing of the world’s nuclear powers, Wikipedia, uses four categories: 1) “NPT-designated nuclear weapon states” (those acknowledged to possess nuclear weapons when the Nuclear Nonproliferation Treaty was originally developed and signed): China, France, Russia (then the U.S.S.R.), United Kingdom, and United States; 2) “Other nuclear weapons states”: India, North Korea, Pakistan (none of which have signed the Nonproliferation Treaty); 3) “States formerly possessing nuclear weapons”: Belarus, Kazakhstan, Ukraine, South Africa (the first three fell heir to former Soviet nuclear weapons when the U.S.S.R. was dismantled; South Africa had constructed six “gun” devices with enriched uranium before it terminated its program in 1990 and signed the Nonproliferation Treaty in 1991); 4) “States believed to have nuclear weapons.”

Only one country falls under category 4: Israel. The story behind the belief that Israel has nuclear weapons is told by Israeli journalist Michael Karpin in his book, *The Bomb in the Basement: How Israel Went Nuclear and What That Means for the World* (Simon and Schuster, New York, 2006). Karpin avoids betraying state secrets by basing his story on public sources of information, “foreign” assessments of Israeli capabilities, and information leaked by Israeli whistle blower, Mordechai Vanunu.

Karpin’s book is in many ways a history of the early years of Israel, since he traces Israel’s development of a nuclear weapon to the post-World War II belief of Israel’s first prime minister, David Ben-Gurion, that two things were essential to saving the Jewish people from extermination: a homeland and a weapon of deterrence. The U.S. was unwilling to allow him to produce weapons fuel in the “Atoms for Peace” reactor it provided, but France was more willing to help, largely because Israel could provide intelligence about the actions of Egyptian President Nasser related to the rebellion the French were facing in Algeria. And by acting militarily to provide a pretext for France and Britain to retake the Suez Canal after Nasser had nationalized it, Israel received a larger reactor from France, erected at Dimona.

Since Israel had its own uranium resources in the Negev desert, it could use its Dimona reactor to produce as much plutonium as it needed to develop nuclear weapons. But it needed to do so discreetly. And when knowledge of the reactor’s existence leaked out in 1960, Israel maintained that it was to be used only for peaceful purposes, an assertion that the Eisenhower administration accepted at face value. (At this point in his book, Karpin observes that the only area of the world for which spy satellite photos have not been published is Israel, and he speculates that this is to preclude evidence of U.S. awareness of the Dimona reactor.)

Continuing to the next presidential administration, Karpin writes that “[John F.] Kennedy’s posture toward Israel was more positive than Eisenhower’s had been” (p. 180), though Kennedy’s determination to limit nuclear arms development and proliferation ran counter to Israel’s interest. Karpin also notes that this warming between the U.S. and Israel also came at a time of cooling between Israel and France, as French disengagement from Algeria eliminated the need for Israeli intelligence. He wonders how this might have played out differently had Egypt’s President Nasser not wandered into the Soviet sphere. And he notes that Kennedy’s attitude toward Israel was balanced between considerations between the Jewish vote and nonproliferation. After a meeting with Ben-Gurion, Karpin quotes Kennedy as saying, “It is to our common interest that no country believes that Israel is contributing to the proliferation of atomic weapons.” (p. 193)

Israel found an even more sympathetic ear from Lyndon Johnson, who was now dealing with a new Israeli prime minister, Levi Eshkol. While Ben-Gurion had no qualms about deceiving the U.S. about Dimona, Eshkol did. Eshkol was able to assure Johnson about Dimona without deceiving him by saying that Israel would not be the first nation to introduce nuclear weapons into the Middle East.

It was during Johnson’s presidency that Israel amassed sufficient fissionable plutonium for a nuclear weapon, whose systems were tested by computer simulation in a “cold test.” Karpin attributes this to assertions of “foreign experts,” who based their conclusion from the following passage in the diary of Munya Mardor, the head of the Israeli Authority for Weapons Development, RAFAEL:

> On November 2, 1966, a test of special import was carried out. It represented the culmination of a period in the development of one of the principal weapons systems and the step which brought it to the final stages of its development and manufacture at RAFAEL. The success of the test was complete, for we achieved through it unambiguous experimental proof of the efficacy of the system . . . We had waited many years for this result. (p. 268)

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Bomb in the Basement

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But it was not until 1968 that, as a result of information from Edward Teller, the CIA assessed "for the first time that Israel had begun to produce nuclear weapons." (p. 287) Karpin also writes that Teller told fellow physicist (as well as Israeli statesman) Yuval Neeman that he was going to relate this information to the CIA in order to end the "cat and mouse game" (p. 292), a move subsequently supported by Eshkol, who would die in 1969.

Eshkol was succeeded by Golda Meir, and Johnson was succeeded by Richard Nixon, and Nixon and Meir got on even more famously than their predecessors – "after the Eisenhower administration's 1958 decision to relate to Israel as an asset, Kennedy's definition of relations with Israel as 'special,' and Johnson's silent consent to Israel's nuclear capability." (p. 319)

Karpin writes that Israel's nuclear capability has been able to co-exist peacefully in the Middle East because of the concept of nuclear ambiguity developed by Shalhevet Freier, "to achieve three goals: against the enemy, deterrence; to friendly nations, maintenance of a responsible image that makes normal relations possible; and for the Israeli people, a boost of self-confidence in the face of their security challenges." (p. 343) But he acknowledges that this equilibrium would be upset if another Middle East country gains nuclear capability, and the major candidate for this is Iran. He notes that eliminating the Iranian nuclear threat is not as easy as the 1981 Israeli bombing of Iraq's reactor, because Iran's facilities are very spread out, and U.S. technology would be needed to bomb Iran's facilities that are underground. He adds that Israel would support nuclear disarmament in the Middle East, but only through a process of building up trust in a lasting peace in a local framework, not in the larger context of a worldwide forum that is insensitive to Israel's interests or though signing the Nuclear Nonproliferation Treaty.

Modeling Instruction

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minded science teachers can see that it improves student understanding. It is based on facilitating student development of models to understand different facets of how things work. Each model is the subject of a different unit, which is introduced by what I described in my Fall 1997 coverage as the modeling cycle, the five steps of which are listed in the box.

The Modeling Cycle

1. The teacher presents a system to be investigated or a problem to be solved.

2. With guidance from the teacher, students develop a plan to investigate or represent the problem.

3. Student groups work together to perform the investigation or solve the problem.

4. Student groups present their results – on white boards (one for each group).

5. The teacher leads the class to develop a consensus among the group results and to evaluate the models they used to get their results.

If you are interested in learning more about Modeling Instruction, you should attend one of the three-week Modeling Workshops. To find out the one nearest where you live, contact Dr. Jane Jackson of Arizona State University at <jane.jackson@asu.edu>. Also, visit the AMTA website and see the list of the 50 Modeling Workshops held nationwide this summer: <http://modelinginstruction.org/workshops>

FORTHCOMING SCIENCE & SOCIETY EDUCATION MEETINGS

24-26 February 2014, Climate Leadership Conference, Hyatt Regency Mission Bay, San Diego, CA. To register, visit <http://www.climateleadershipconference.org/restration.html.>

4-6 March 2014, Building Energy 14: Conference and Trade Show for Renewable Energy and Green Building Professionals, Seaport World Trade Center, Boston, MA. Contact Northeast Sustainable Energy Association, 50 Miles St., Greenfield, MA 01301, (413)-774-6051, <nesea@nesea.org>.

8-10 April 2014, World Nuclear Fuel Cycle, San Francisco, CA, sponsored by Nuclear Energy Institute and World Nuclear Association. For information, contact Arika Johnson of the Nuclear Energy Institute, <amj@nei.org>, or Julia Deere of the World Nuclear Association, <events@world-nuclear.org>.

20-21 May 2014, 2014 Energy Efficiency Global Forum, Washington Convention Center, Washington, DC, sponsored by the Alliance to Save Energy.

Photovoltaics — then and now

(*Editor's Note*: Omer Yaffe's 22 November 2013 talk to the Physics Club of New York on photovoltaics recalled Julie Nucci's talk to the same group on the same topic five years previously. We decided to reprint our coverage of Nucci's talk from our Spring 2008 issue so that you could read coverage of the two similar talks side by side.)

(then)

"Getting a Charge out of Light"

"Getting a Charge out of Light" was the topic presented to the Physics and Chemistry Teachers Clubs at New York University on 14 March 2008 by Julie Nucci, the new Director of Physics Education at Cornell's Center for Nanoscale Systems. The way we get a charge out of light is to use photovoltaic cells, and Nucci introduced the importance of her topic by pointing out that, in spite of recent technological advances in such diverse areas as medicine and telecommunications, when it comes to energy, *we still burn stuff*. This has become both a political and environmental problem, Nucci noted.

In 2002 solar photovoltaic cells provided only 0.006% of US energy and wind only 0.15%, with geothermal 0.31%, hydro 2.71%, biomass 2.78%, nuclear 8.13%, coal 22.87%, natural gas 22.66% (3.6% imported), and petroleum 40.13% (24.0% imported). Nucci also reported that more than half the energy provided to Americans is lost during electricity generation, transmission, and distribution. The annual global energy demand is currently 13 terawatts (TW), and this is projected to rise to 20 TW by 2030 and 30 TW by 2050. If renewable sources could be fully utilized, wind could provide only 2-4 TW, ocean currents and tides less than 2 TW, hydro 4.6 TW (0.9 economically feasible, 0.5 unexploited), geothermal 12 TW, and biomass 5-7 TW (using all cultivatable land). In sharp contrast, solar could possibly generate 600 TW (practical amount based on the 120,000 TW total energy striking the earth's surface). Nucci provided the figures for worldwide use of two forms of solar energy in addition to those for photovoltaic electricity: 0.00003 TW, or 0.015% of world use from solar electricity; 0.006 TW, or 0.3% of world use from solar heating; and 1.4 TW, or 11% of world use from biomass (which, she added, was unsustainable).

Though solar energy is free, Nucci pointed out that its infrastructure isn't. Though photovoltaic systems are designed to work for 25 years, their economic competitiveness suffers from a high startup cost. Although the US Department of Energy's Solar America Initiative has a goal to reduce the cost of solar electricity to less than 10¢ per kilowatt hour, analysis of trend curves suggests

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(now)

Yaffe speaks on Photovoltaics

by Jack DePalma

With special thanks to his thesis advisor, Professor David Cahen, of the Weizmann Institute, Omer Yaffe, of the Energy Frontier Research Center, an interdisciplinary initiative affiliated with Columbia University's Department of Physics, began his 22 November presentation to the Physics Club of New York on "Solar cells – Principles, Possibilities and Limitations." With a mention of the 2013 IPCC Report and the need for renewable and sustainable energy sources for the long term future, Yaffe began with a brief refresher on the Greenhouse Effect. He explained how by increased burning of carbon based fuels, mankind has released excess CO_2, which more effectively traps reflected infrared radiation heating the atmosphere and causes global climate changes. He spoke of the strong motivation and interest in the engineering and development of non-carbon based, fully sustainable, long-term energy sources. Cost effective and improved performance photovoltaic solar cells will be part of the solution. Distinguishing at first between renewable and sustainable energy sources, Yaffe suggested that not all renewable energy forms are completely sustainable.

Yaffe also pointed out that the energy density of an energy source is also a very important consideration. There are many forms of available, accessible energy resources with low energy density. Energy density is a relative measure of the concentration of energy available in a fuel. Gasoline has a high energy density, which makes it a most useful fuel, whereas wind farms can tap the low energy density of moving air but since the energy density of wind is low, many turbines are needed to make sufficient electrical energy for practical use. Hot water from passive solar thermal accumulators, hydroelectric power and biofuels like ethanol were each mentioned and briefly compared for renewability and sustainability. Fully sustainable and high density energy sources are desired for the future; and a variety of energy sources will be needed to meet the many differing situations and actual energy use needs in the future. Yaffe mentioned that battery performance and energy storage issues are serious limitations to providing sustainable and renew-

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Sustainability – a new face of STS

by John L. Roeder

The New York Energy Education Project (NYEEP) of the 1980s was New York State's response to the energy crises of the 1970s and the withdrawal of funds for energy education at the national level by the Reagan administration, and I was happy to have been chosen one of its 40 resource agents. In 1988 NYEEP became NYS$_2$TEP (the New York Science, Technology, and Society Education Project), and I well remember the time spent at a summer institute learning how to transform a traditional science lesson into a lesson on the same topic but with a focus on science, technology, and society (STS). After all, STS was not an additional subject but a new way to teach presently existing ones.

Fast forward twenty-five years and you have SISL, Sustainability Improves Student Learning, on the web at <http://serc.carleton.edu/sisl/index.html>, "a select group of associations and disciplinary societies working together to 1) increase students' learning in undergraduate courses, and 2) better prepare students for the 21st-century 'Big Questions that relate to real-world challenges such as energy, air and water quality, and climate change." This, plus a message on the urgency of teaching sustainability and an overview of the remainder of the website, are found on the home page, which also forms the first of a series of pages which can be read in linear fashion as well as sampled from a menu.

The second page of the website presents a "Beginner's Toolkit," which consists of two parts: "Why Teach Sustainability?" (among other things, there is more student engagement, and better citizens will result) and "Tips on Integrating Sustainability" (sustainability is not a topic to be added but rather infused into existing courses by choosing real world examples).

The third page presents the three "Key Components of Sustainability Assignments":

1) "Promote understanding without doom and gloom."
2) "Focus on solutions."
3) "Empower students to make positive changes, moving from analysis to systematic action."

The fourth page is devoted to empowering students, followed by a fifth offering "Disciplinary Perspectives," with a menu of eight different STEM disciplines: Biology, Chemistry, Computer Science, Engineering, Geoscience, Mathematics, Physics, Technology, each developed by one or more of the SISL organizations: the American Association of Physics Teachers (AAPT), the American Chemical Society (ACS), American Institute of Biological Sciences (AIBS), American Psychological Association (APA), American Society for Engineering Education (ASEE), Association for Career and Technology Education (ACTE), Mathematical Association of America (MAA), National Association of Biology Teachers (NABT), National Association of Geoscience Teachers (NAGT), National Numeracy Network (NNN), and Special Interest Group in Computer Science Education (SIGCSE).

Each Disciplinary Perspective provides links to activities, textbooks and other resources, journal articles, K-12 resources, and opportunities for continuing education and networking. For example, the physics perspective has links to PhET simulators, Rick Tarara's Energy Management Simulators, David MacKay's *Sustainable Energy – without the hot air* (profiled in the Fall 2009 issue of this *Newsletter*), Al Bartlett's "The Essential Exponential," two NYS$_2$TEP modules (*Using Earth's Resources* and *Energy: How Does It Impact Our Lives?*), and the AAPT Physics and Society Education Group (which contains links to this *Newsletter*).

The remaining pages of the SISL website are devoted to contributing an activity, teaching an activity (from their database currently of 279), resources and discussions, and workshops. Everything on the SISL website about teaching sustainability could be said about infusing the Science, Technology, and Society approach to teaching in the days of NYS$_2$TEP, which terminated for lack of funding in 1996. All the materials developed by NYEEP and NYS$_2$TEP have been provided for posting on ComPADRE so that they can continue to be used, now to teach sustainability.

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:

After a series of tremors shook the city of L'Aquila, Italy, "members of the National Commission for Forecasting and Preventing Great Risks discussed the possibility of a large earthquake, but did not issue a safety warning" at a meeting the last day of March 2009, ac-

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Alexandratos addresses water treatment

Water covers 70% of the Earth's surface, but 97% of the water is in the oceans. Life depends on the remaining 3% that is fresh water, yet it continues to be polluted by runoff, landfills and dumps, mining, and manufacturing. Polluted water causes two to three childhood deaths per month in Malawi. And while water scarcity is greatest in the Southern Hemisphere, it is emerging as a problem in some industrialized countries. This was the backdrop presented by Spiro Alexandratos of the Hunter College Department of Chemistry in his 13 December 2013 talk to the Physics and Chemistry Teachers Clubs of New York on "Environmental Remediation: Purification of Water with Designed Polymers." Hydraulic fracturing ("fracking") further increases strain on water resources, he went on. And by 2025, he ventured, quoting an article in *Chemical and Engineering* News, 3.5 billion people will live in a water-stressed area.

The water we drink from taps in our homes must be treated by coagulation, ozonation, and filtration, Alexandratos noted. But if the drinking water source has been polluted, further pretreatment is needed. The two current approaches are treatment with 1) activated carbon and 2) polymer-supported reagents. All sorts of contaminants adhere to carbon, and "activating" it means cleaning it so that its surface will attract still more contaminants. But there are two problems: the non-selectivity of what adheres to activated carbon, and the need to dispose of the activated carbon after it has attracted its "fill" of contaminants. Polymer-supported reagents begin with styrene droplets to form polystyrene beads, which are treated with ligands to produce cation and anion exchange resins. When contaminated water is passed through a column packed with these beads, the beads absorb the contaminant and pure water flows out of the column. The contaminated beads can be cleaned and the waste buried. This is an improvement over activated carbon, Alexandratos said, but it is still not selective enough.

What is needed, he said, was selective binding of contaminants at a rapid rate, with a high capacity. He and his colleagues have now developed polymers which specifically select arsenic, perchlorate, actinides, silica, and uranium. The perchlorate and actinide-selective polymers have been produced commercially as Purolite 530E and Diphonix, respectively. Both have earned R&D 100 Awards.

Alexandratos told how the arsenic and actinide-selective polymers were developed. The development of the arsenic selective polymer began with N-methyl D-glucamine (NMDG), which had been available from Rohm and Haas since the 1950s as IRA 743. Because it was known to bind borate, H_2BO_3, it was expected to bond to H_2AsO_4 but was found to show a low affinity for it. Then things were found to change when Alexandratos's group made their *own* NMDG and exposed it to 100 ppm arsenic and 560 ppm sulfate: 99% of the arsenic was removed, maximally for pH between 3.5 and 6.5 but not at all above ph = 9. The reason was found to be that the nitrogen atom in NMDG was protonated in Alexandratos's NMDG but not in the NMDG from Rohm and Haas. The arsenic so collected could be removed by treating the protonated NMDG which had bound to arsenic with a 0.0001 molar solution of sodium hydroxide. This swept away the arsenic and deprotonated the NMDG, which could then be reprotonated to collect more arsenic.

The starting point for developing the actinide-selective polymer Diphonix was the realization that water-soluble diphosphonic acids have a high affinity for actinides. When diphosphonic acids were attached to polymer beads, though, they showed a high affinity for actinides but a slow rate of attracting them. This problem was overcome by adding sulfonic acid, which attracts almost everything, but only the actinides were "kept" because of the selectivity for them by the diphosphonic acids. Diphonix, thus developed, removes 99.9999% of the uranium from water, and a cheaper compound made with monophosphonic acid removes 95%.

A final question asked why Diphonix is not used to treat the actinide waste from the reactors in Hanford, WA, which made the plutonium used in the first nuclear weapons. Alexandratos recalled the euphoria he felt when he first thought of this, only to have his spirits dampened by a colleague who correctly predicted that nothing of that nature would be done due to the complex nature of the problem and the need for further study.

Infusion Tips

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cording to "Live Science" for 26 September 2013. After a 6.3 quake on 6 April 2009 killed 309 people, "six of the country's top geoscientists and one government official were convicted in October 2012 of manslaughter and sentenced to six years in prison for statements they allegedly made."

One of the convicted scientists, Enzo Boschi, argues in a letter in the 26 September 2013 issue of *Science* that his conviction is "illogical" in view of the impossibility of predicting earthquakes, which was the thrust of his remarks at the 31 March 2009 meeting. All seven who were convicted have filed appeals. If you were an appellate judge, how would you decide?

Levine discusses engineering failures

Sheldon Levine, Vice President for Marketing and Business Development, AeroNav Laboratories, made the opening presentation to the 115th season of the Physics Club of New York on 20 September 2013. Titled "Engineering Failures and Design Principles," it began with quotations on the importance of learning from failure by Henry Petroski ("The best way of achieving lasting success is by more fully understanding failure.") and Bill Gates ("It's fine to celebrate success but it is more important to heed the lessons of failure.").

Levine then proceeded to recount a series of engineering failures and the design lessons learned from each one, beginning with perhaps the most famous of all: the Tacoma Narrows Bridge in the state of Washington, a long narrow suspension bridge which opened on 1 July 1940 and was quickly nicknamed "Galloping Gertie" because of its excessive motions in the wind. On 7 November of that same year, wind speeds of up to 42 miles per hour were measured, with a resultant rise and fall of three feet at the center of the span. Traffic was stopped, and the bridge collapsed a short time later.

"All bridges have some movement," Levine observed, but "movements usually dampen out, whereas the Tacoma bridge movement seemed to last forever." He then listed seven things that caused the bridge to collapse and noted that it took decades to realize some of them:

Shallowness of its stiffening side plate girders
Narrowness of its roadway width in relation to the span length (the bridge was only two lanes wide)
Only one third the stiffness of typical bridges (due to the preceding two factors)
Weakness in torsion and consequent subjection to the effects of aerodynamic wind conditions (flutter)
Sixty times less damping than typical suspension bridges
Lack of full appreciation of wind conditions prevalent in the Narrows area
Side girders that did not allow air to pass readily to reduce vortex shedding.

"Bridges that were built prior to this period, such as the East River bridges, were built conservatively with large amounts of steel," Levine noted, adding that "the result was stiff structures able to withstand severe winds. However," he continued, "with the advent of improved materials and advances in structural design, bridges were built using lighter and hence less massive structures. Hence aerodynamic effects that were not of prior concern now became important issues. However, the aerodynamic effects were not well understood at the time. The bridge's torsional natural frequency was calculated to be 0.2 Hz, a low number."

Levine then went on to list two theories leading to the Tacoma Narrows Bridge's collapse:

1) Von Karman vortex shedding from the edges of the side girders exciting the natural frequency. The vortex shedding frequency was calculated to be 1 Hz.
2) Dynamic aeroelasticity or flutter, which is a complex interaction between inertial, elastic, and aerodynamic forces usually associated with aircraft. This effect caused structural oscillation at a frequency of 0.2 Hz, which resulted in torsional resonance ultimately leading to failure.

"Vortex shedding is a phenomenon in which vortices are generated by the edges of structures in a windstream," Levine explained. "Alternating in time, the generated vortices cause wind and pressure fluctuations. When this happens at the edges of the side girders, the result is a fluctuating torsional moment." Regarding the second theory, Levine went on to say, "Aeroelastic flutter results in vibration at the natural frequency of the structure. This is caused by the motion induced by the alternating pattern of vortices, coupling with, and increasing the aerodynamic loading causing the structure to move even further. In the absence of sufficient damping (energy dissipation) failure will occur." He concluded his presentation on the Tacoma Narrows Bridge by observing that it was subsequently rebuilt with improved damping, increased torsional stiffness with such measures as deep trusses, and side members opened to allow air to flow through, thus minimizing the effects of vortex shedding.

Levine then went on to observe that the Bronx Whitestone Bridge was built using similar techniques as the Tacoma Narrows Bridge but that the Whitestone Bridge is wider and hence exhibits greater stiffness and damping. "Nevertheless," he added, "modifications were made incorporating features such as additional damping, and modifications to the side girders for improved airflow to minimize vortex generation and flutter." But later, he continued, they took the weight off again to streamline the bridge and lengthen its life.

But if lack of stiffness was a problem with the Tacoma Narrows Bridge, too much was a problem with Liberty Ships in World War II. Twenty-seven hundred ten such ships were built with the help of prefabricated all-welded construction to a standard design instead of using the

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engineering failures

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prior design with riveted construction (which could stop the progression of cracks). Of these a thousand thirty-one suffered hull and deck cracks due to brittle fracture, with twelve breaking in half. Levine pointed out that the field of fracture mechanics, concerned with the study of the formation of cracks in materials, was generally not well understood at that time. Unlike plastic fracture, where extensive deformation takes place prior to failure, no plastic deformation takes place prior to brittle fracture. "Hence," Levine said, "brittle failures occur at stress levels lower than ductile failures." Levine attributed the problem with the Liberty Ships to flaws and residual stresses in the all-welded construction, due in part to inexperienced welders, low fracture or notch toughness materials, and loss of fracture toughness of the steel due to the transition from ductile to brittle fracture characteristics under low temperature ambient conditions like those in the North Atlantic. The problem was corrected with the use of steels with improved weldability and fracture toughness characteristics, improved designs to lower structural and weld stress levels, and reduction of stress concentrations.

Back on land, Levine next considered the John Hancock Tower, a sixty-story building in Boston consisisting of a steel frame covered originally with 4.5 foot by 11.5 foot double-glazed glass panels, each weighing 500 pounds. These panels had been used before but not on such a tall flexible building. On 20 January 1973 a severe windstorm caused 65 of them to fall to the ground. Tests showed that the deflection of the steel frame under the action of the wind was not the primary cause of failure. However, to reduce the building deflections, tuned dynamic dampers, each weighing 300 tons, were added at the top of the building. They float on a film of oil atop the building and are attached via springs to the building's sides. Fifteen hundred tons of steel bracing were also added to increase the building's lateral stiffness. The failure of the glass panels, which were correctly installed, was ultimately found to be caused by the design of the double-pane joints. Because the joint between the inner and outer glazing was so strong that it could not yield and transmit any motions caused by movements of the building frame, all 10,344 panels in the tower were replaced with more flexible single-glazed panels.

The next engineering failure considered by Levine, also on land, was the system of levees protecting New Orleans and breached by Hurricane Katrina on 29 August 2005. Levine observed that the only areas of the city experiencing severe flooding were those developed since 1900 (representing an outward expansion of the city into lower -lying areas) and that most of the levees were constructed by the U.S. Army Corps of Engineers using "standard" handbook designs. He explained that the majority of the flooding was caused by the failures of the levees at three locations including the 17th Street Canal. This canal breached an opening at least 50 yards in length. It breached with the water level four feet below the design specifications. Soil borings that were subsequently taken showed a layer of peat between five and 20 feet thick below the levees. The breaching allowed water from Lake Pontchartrain to flood large areas of the city, especially the Ninth Ward. Although New Orleans has numerous emergency pumping stations, Levine pointed out that the mass evacuations that were ordered and the subsequent power failure left the pumping system inoperable and with no one to operate it. Pumping did not resume until two to four days after the storm. Levine attributed the massive failure of the New Orleans flood protection system to insufficient height of the levee walls, poor design of the levee walls with insufficient footings, insufficient depth of the wall foundations, poor subsoil conditions consisting of high proportions of low shear strength materials such as peat, using "standard" handbook designs where "non-standard" conditions prevailed, and insufficient means to prevent scouring of the soil beneath the levee foundations. He added that the following steps have since been taken: increased pumping capacity for the canals; permanent repairs to storm-damaged levees; soil mechanics studies; purchase of land adjacent to levees for future use; building additional levees.

Poor subsoil conditions, which plagued the John Hancock Tower as well as New Orleans, played a major role in the next engineering failure considered by Levine: the Leaning Tower of Pisa, which was constructed between 1174 and 1272. Levine stated that the 200 foot high tower started to lean almost immediately, with the highest rate of inclination around the end of the thirteenth century. The rate of leaning has been continuously reduced since that time by various stabilizing features such as concrete pumped into the ground and the use of support cables.

The penultimate engineering failure cited by Levine was the 1952 de Havilland Comet, one of the first commercial pressurized aircraft driven by jet propulsion. By 1954 seven of them had crashed. Levine explained that the reduction of atmospheric pressure at altitude and the subsequent return to normal atmospheric pressure upon landing causes the cabin to expand at altitude and shrink upon landing, thereby imposing landing and consequent

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Nucci

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that more time (between 30 and 40 years) will be needed unless new breakthroughs occur.

In explaining the physics of the operation of a photovoltaic cell, Nucci presented a mechanical model with two wheels adjacent to level surfaces – but one level surface was higher than the other, and the two level surfaces were joined by an incline. Energy from an absorbed photon of light creates a ball and a bubble (a ball-bubble pair). The bubbles rise to cause the upper wheel to turn, and the balls roll down the incline to cause the lower wheel to turn. In each case, the energy of the photon is converted to work done by the turning wheels. The balls represent electrons that are free to move in a material, and the bubbles represent "holes," or the absence of electrons.

Nucci next invoked the band theory of solids, noting an overlap between valence and conduction bands in a metal like copper, a 1.1 electron volt energy gap between these bands in elemental silicon, and a 3 electron volt energy gap between the valence and conduction bands in silicon dioxide. She noted that copper, like all metals, is a good conductor of electricity, with a resistivity of 1.68 microohms-cm. Electrons in the conduction band are free to move. On the other hand, silicon is a semiconductor, with a resistivity of about 10 thousand ohm-cm. Electrons in its conduction band are more limited in their motion, with electrons and holes hopping among local lattice points. On the other hand, silicon dioxide is an insulator, with resistivity ranging from 9.1 to 10 quadrillion ohm-cm. Nothing moves in it to conduct electric current.

Nucci then went on to say that the conductivity of silicon is enhanced by doping it with atoms containing three or five valence electrons. In an undoped semiconductor, the Fermi energy level (the level for which the probability of finding an electron is exactly one half) is halfway in the gap between the conduction and valence energy bands. Doping silicon to add holes to the lattice (*p*-doping) lowers the Fermi energy; doping silicon to add electrons (*n*-doping) raises the Fermi energy.

When a piece of *p*-doped silicon is placed next to a piece of *n*-doped silicon, a diode is formed, and the Fermi energy levels equilibrate, causing the energy levels of the bands to be higher on the *p*-doped side than on the *n*-side. This results in a voltage gradient set up by the migration

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Yaffe

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able energy supplies today without the release of additional CO_2.

The three basic photovoltaic cells types are a) the elemental or basic silicon based cell, b) the compound semiconductor cell, and c) the organic, excitonic or nanostructured type cell. Photovoltaic cells basically use the photoelectric effect to convert sunlight into electric power. Single crystal, polycrystalline, thin film, amorphous, rigid, flexible, quantum dot, tandem and layered all can be descriptions of the various ways photovoltaic cells have been engineered. With actual considerations of balancing production costs, output efficiency and energy cost payback time, Yaffe showed the development of the three types of photovoltaic cells that have been engineered and over time improved, with costs reductions and energy output increases. Yaffe showed a graph that illustrated production price over time for differing photovoltaic types, showing power improvements over time. The interpretation of the data was too complicated to explain easily, as Yaffe said. And he said that most research is directed today towards determining which material(s) are best suited for the next (third) generation solar cells. Differing types of solar cells already are used in a variety of applications. He discussed the graph of the current-voltage characteristics for a typical p-n diode, the simplest solid state photocell device; and in detailed discussion he reviewed the current, and voltage, and power performance as the core of the issue of photocell basics.

Yaffe then presented the Shockley-Queisser limit (of about 34% efficiency) as the fundamental limit in efficiency of a traditional photovoltaic cell. Wasted energy in the form of heat (as thermal vibrations), wasted energy when electrons "over jump" the band gap, and wasted energy needed to overcome internal resistance extracting the photocurrent all limit the throughput of cells. Real solar cells have crystalline defects and it is known that their performance deteriorates with time. As Yaffe talked of the three generations (of photocell development) he explained how each has use for its cost, performance and application. Describing the basics of the photon-photocell interaction, Yaffe singled out the important properties of an ideal photovoltaic cell material. Silicon is a material that a) absorbs light, b) has accessible, separate and distinct electron energy states of the correct band width difference that matches light and be such a material from, c) which we can readily separate opposite charges and extract the photocurrent. He talked of attempts to

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engineering failures

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stress concentrations on the structure. He said that "the cause of the failures was ultimately found to be metal fatigue occurring at relatively sharp corners of the window frames, and the window reinforcing plate rivet holes" and that "the designers had not taken into account the issue of window frame/cabin interactions." He added that "the rivets holding the window reinforcing plate had the holes punched, not drilled" and explained that "this resulted in a significant increase of the stress concentrations, leading to a catastrophic reduction in the metals' ability to carry repetitive loading due to the variation in cabin pressurization occurring during takeoff and cruising at altitude."

"Hence," Levine went on, "each time the plane was pressurized while flying at altitude, the window frame elongated plastically and eventually failed due to cracking. During testing the complete window assemblies were not fitted into the cabin test section. Finally in the test machine, the ductility of the material allowed redistribution of the stresses. But in flight the presence of 'sudden' bumps caused catastrophic dynamic peak stresses initiating failure."

Levine ended his presentation much as he had begun it, citing problems with another suspension bridge that were similar to those besetting the Tacoma Narrows. The example here was the Millennium Bridge for pedestrians to cross the Thames River in London. It was opened on 10 June 2000 and closed two days later due to excessive vertical and lateral motions. The motion was found to be caused by pedestrians exciting the bridge's lateral natural frequency of approximately 1 Hz. Levine explained that "this phenomenon is known as synchronous lateral excitation, which is caused by the slight sideways sway of pedestrians when walking." He added that "the problem was fixed by adding 37 fluid viscous dampers to control horizontal movement and 52 tuned mass dampers to control vertical movement," a $7 million repair project for a $30 million bridge.

(*Editor's Note*: The greater than usual amount of detail in this coverage was enabled by on-line access to the PowerPoint slides that accompanied Levine's presentation. To access this file, visit <www.aeronavlabs.com>, click on "resources" on the home page, then go to "articles," then to "seminars" and select "(3) Engineering Failures & Videos of Actual Testing.")

Nucci

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of mobile electrons toward the *p*-side and the migrations of holes toward the *n*-side. This gradient causes electrons excited from the valence band into the conduction band by incident photons of sunlight to flow through a circuit, from the *n*-side of the diode to the *p*-side. The process of incoming light causing an electric current is opposite that of a light emitting diode (LED), which emits light after electric current flows through it.

Efficiency is a key factor in converting the sun's energy into electricity. Schockley and Queisser determined that a photovoltaic cell's maximum efficiency was only 31% for a single p-n junction, with one electron-hole pair (exiton) formed from each photon, thermal relaxation of electrons and holes to the band edges, and unconcentrated sunlight. Generation I and II photovoltaic cells, consisting of single *p-n* junctions, all lie below this limit, although Generation II cells are less costly (and less efficient) than Generation I cells. The goal of Generation III photovoltaic cells is to increase efficiency by multiple junctions, multiple exiton generation, and suppressing thermal relaxation. Global research efforts are underway in an effort to realize the potential of these solar devices.

Yaffe

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improve performance and efficiency. Tandem cells that tap more of the light's energy, and spectral splitting to channel high energy light to different materials than the low energy light. Designer photovoltaic cell materials more effectively utilize sunlight.

There were several questions from the audience regarding solar cell use in today's economy, also a discussion about how government funding that helped develop photovoltaic energy generation in Germany has dried up in the recent economic climate. The question was raised as to the best way to store solar energy (Yaffe said by pumping water upward against gravity), and other problems of solar energy sources were discussed as the evening came to a close.

(*Editor's Note*: Jack DePalma is President of the Physics Club of New York.)

Curtain opens for CHORUS dress rehearsal

by H. Frederick Dylla

The 4 October issue of *Science* magazine dedicated its cover story and a special section to "Communication in Science," with a particular emphasis on how the important business of peer-reviewed scholarly publications is evolving under the pressure for wider access to both publications and data, particularly when researchers are supported by public funding. The issue appeared just as publishers from around the world gathered for the annual Frankfurt Book Fair, a major industry event and the chosen venue for the official launch of the publishing community's broad-based solution for providing such access: CHORUS.

The Clearinghouse for the Open Research of the United States (CHORUS) is a collaboration initiated by a group of scholarly publishers from the Professional and Scholarly Publishing Division of the American Association of Publishers. As announced at Frankfurt, CHORUS has formally incorporated as a nonprofit organization to provide public access to articles that report on federally funded research.

At the Frankfurt Book Fair, CHORUS organizers formally introduced and demonstrated the CHORUS pilot project, developed with the help of seven participating publishers (including AIP, APS, IEEE, ACS, OUP, Wiley, and Elsevier) and the CrossRef organization. CrossRef provides essential services to the international publishing and library communities. Briefly, CHORUS provides public access to publications that are identified as reporting on federally funded research through CrossRef's new FundRef service, which went live this past May. Anyone interested in a particular article (that can be identified through a sort by funding agency, subject matter, or any other standard search term) is directed to a free, public, full-text version of the article residing on the publisher's platform, which hosts and permanently stewards the chosen article.

The CHORUS collaboration invites all interested parties to learn more about the project at <www.chorusaccess.org> and to view and investigate the pilot demonstrations at <http://search.chorusaccess.org> and <http://dashboard.chorusaccess.org/usdoe/#>.

The pilot will run through the end of the year; essential feedback will be evaluated and folded into the development of a full production system in 2014. The publishing community is developing CHORUS as a public service to all stakeholders: funding agencies, the academic community, and the interested public. It is being offered to the government agencies at no cost, allowing them to maintain their focus on funding research and research management. Publishers are willing to shoulder the cost of CHORUS because it relies largely on existing infrastructure built up by the publishing industry through years of collaboration. The largest and most well known of these collaborations is CrossRef, an initiative designed precisely for promoting standards for identifying and interlinking scholarly publications. The CrossRef database comprises more than 63 million online publications and related objects, contributed by more than 4600 publishers and directly linked to more than 2000 libraries.

Why are publishers willing to underwrite the additional costs required to develop CHORUS? Because it is the most pragmatic and least costly public access solution that can be widely adopted. CHORUS provides free access to content that is produced and supported via two basic publishing models: author-paid and (usually library-paid) traditional subscriptions. With the former, a publication's costs are paid up front by the author or the author's sponsor, and full access is granted upon publication to all; CHORUS will provide links to this content. With the latter, CHORUS will grant full access after an embargo period imposed by the funding agencies. With proper design, the embargoes are long enough for publishers to recover publication costs and for libraries to refrain from cancelling their subscriptions. Controversy persists about the length of such embargo periods. Since 2008, the NIH has imposed a 12-month embargo for NIH-funded research works, largely biomedical in nature. However, the publishing community has argued that biomedicine is a well-funded, fast-moving field of scholarship; other fields cannot conform easily to a single embargo period.

This mixed economic model, author-paid instant open access and library-paid embargoed access, is the grand economic bargain that must be in place for CHORUS or any other public access solution to be sustainable.

CHORUS organizers are giving a full array of briefings to US funding agencies, publishers, library associations, and research administrators to promote the initiative. We aim to demonstrate that CHORUS and other proposed access solutions (such as the university-led SHARE proposal) have common elements such as universal identifiers and demonstrated methods of long-term preservation of electronic documents. We invite all interested parties to explore the CHORUS pilot demonstration and send us your feedback.

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STM innovations for tackling big data

by H. Frederick Dylla

Ever since the first mass web browser was introduced in the mid 1990s, online publications have flourished and multiplied. Early on, publishing communities identified the need to devise structure around these publications, lest they get lost in the recesses of the vast World Wide Web. We are having moderate success in interlinking communications across the web, but a formidable challenge still presents itself in terms of dealing with a relatively new development introduced online — an abundance of data — much of which is associated with scholarly publications.

How to structure this data and link it to relevant publications was the central issue discussed at this year's International STM Publishing Association seminar on innovations in the scientific and technical publishing industry. Publishers gathered early this month in London to learn from those at the forefront of this issue. Frank Stein of IBM's Watson Project put the matter into perspective: 90% of the world's data was created in the last two years, and 80% of this data is unstructured.

Plenary speaker Sayeed Choudhary, associate dean for data management at Johns Hopkins University (JHU), noted that the entities that best handle massive quantities of digital data are the internet giants: Facebook, Amazon, Google, and Apple. No business or government sector (except perhaps the NSA) competes with their scale in terms of speed and throughput of data management. He sees data management as a unique opportunity for libraries and STM publishers to work together, particularly in the areas of defining standards, identifiers and structures for data, and the linking to respective data repositories.

Choudhary defined two classes of scientific data: (1) "big data," which is defined as having the three V's—high volume, high velocity, and variety—and (2) "spreadsheet science," which encompasses single investigator or small group science. JHU hosts the repository for a very large astronomical database, the Sloan Digital Sky Survey, that currently holds more than 150 terabytes of data from observations of galactic and extragalactic objects. The project is a superb example of a library team taking the lead in a large data management project. Even with its well-structured data system, he noted that the database would have benefited from a data structure identification (metadata) system much earlier in the project timeline.

Many agree that the first and most important data management problem to solve is the preservation and linking of data that is associated with peer-reviewed publications. It is ironic that data associated with publications is often born digital but often disappears on a departing researcher's thumb drive. Of note, EMBO, the publishing arm belonging to the European Molecular Biology Laboratory, routinely enables authors to connect data sets behind any of the figures and tables associated with their publications. AIP Publishing and AAS are participating in a current NSF-funded project to examine author attitudes and publishing protocols for linking data sets to publications in several astronomy and plasma physics journals.

There is much to be done in dealing with data on three fronts: the hardware that performs calculations, stores, and displays the data; the software that manipulates the data; and the human interface for interacting with and interpreting the tremendous volume of information.

On the hardware front, Frank Stein described how IBM is developing entire new business divisions around the power of its Watson supercomputer. Near-term applications include delivery of medical information to caregivers on hand-held devices with access to large fractions of the world's clinical and pharmaceutical information. Behind the hand-held delivery device is Watson—a 10-ft cube of computer hardware that consumes 100 kW of power, whose judgment can still be dwarfed by a more qualified medical professional.

Matthew Day of Wolfram (known for its powerful "Mathematica" software) described a new venture, Wolfram Alpha, an information-processing tool that allows anyone to pose questions of varying degrees of complexity to Wolfram's system of interlinked databases. The answers can be delivered in simple graphical outputs, which subjugate the voluminous underlying data. A modest version of Wolfram Alpha powers Apple's Siri service on the iPhone.

Chris Lintott of Oxford University and the principal investigator behind the crowd-sourced science project Zooniverse gave a striking example of what can be accomplished with the linking of multiple observers. The first Zooniverse project involved the classification of millions of galaxies that are now visible in images from deep space taken by both land-based and space-based telescopes. The Zooniverse website asks for volunteers to

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The Project 2061 Assessment Site: A Resource for both Test Questions and Misconceptions

The assessment website of Project 2061, <http://assessment.aaas.org>, presents over 600 multiple choice questions for middle and early high school students and the distribution of answers from at least 2000 students for each one. The website shows not only how many students knew the correct answer but also, by the distribution of incorrect answers, what the students' major misconceptions were. According to an article about the website in *Science* (Earl Lane, "AAAS Testing Web Site Probes Students' Misconceptions About Science," *Science*, **332**, 552 (29 April 2011)), only 0.2% separated the percentage of correct answers between girls and boys; students speaking English as a second language scored an average of 7% lower.

If you are using the website, click on "topics" from the menu, then select a topic to get a listing of key ideas from which you can select "sub-ideas," "items and student performance," and "misconceptions." The following topics are available:

1. from life science: cells, evolution and natural selection, human body systems, interdependence in ecosystems, matter and energy in living systems, reproduction, genes, and heredity.

2. from physical science: atoms, molecules, and states of matter; energy: forms, transformation, transfer, and conservation; force and motion; substances, chemical reactions, and conservation of matter.

3. from earth science: plate tectonics; weather and climate I: basic elements; weather and climate II: seasonal differences; weathering, erosion, and deposition.

4. from nature of science: control of variables, models.

The misconceptions are catalogued by ID number.

Those who register can create their own tests from the questions in the database.

STM innovations

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help classify galaxy images. In the first day of the website's existence, classification rates exceeded 70,000 per hour, and in its first year more than 3.5 million galaxies were classified. Despite the sophistication of modern image processing software, the human brain is still better with certain pattern recognition tasks. Zooniverse as a citizen science enterprise has since moved beyond astronomy to tackle the myriad of identification tasks in zoology and archaeology.

Seminar participants also learned of several new tools being offered for data management in a smorgasbord of 5-minute "flash" presentations that included techniques for data highlighting (LENS), more accurate materials characterization (SCAZZL), enabling peer review of author citations (Social Cite), and a method of "geocaching" location information in articles so that research locations can be mapped (JournalMap).

Building structure for data management is still in its infancy, but I believe that these powerful tools that are being developed will help the community converge on solutions that will help tackle the big problem of big data.

(*Editor's Note*: H. Frederick Dylla is Executive Director and CEO of the American Institute of Physics. This article is excerpted with permission from his newsletter, *AIP Matters*, for 16 December 2013.)

CHORUS

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In the interest of full disclosure, I note that I have devoted a significant fraction of my time to the CHORUS project since the groundwork was laid in February. I perform this commitment because I sincerely believe that the project will solve the public access issue, and allow each segment of the scholarly research triangle—funders, researchers, and publishers—to concentrate on the crux of their business.

(*Editor's Note*: H. Frederick Dylla is Executive Director and CEO of the American Institute of Physics. This article is excerpted with permission from his newsletter, *AIP Matters*, for 4 November 2013.)

ACT assesses college and career readiness

The Condition of College and Career Readiness 2013 is "ACT's annual report on the college readiness of the most recent high school graduating class," which provides "insights to guide and catalyze efforts to improve college and career readiness for the next generation of young people." According to this report, "ACT research illustrates the criticality of academic readiness for student success" but also "underscores the importance of additional complimentary factors for college readiness and success, including student academic behaviors. . . ."

The criteria for academic readiness are the College Readiness Benchmarks, which are the "minimum scores needed in the ACT subject area tests to indicate a 50% chance of obtaining a B or higher or about a 75% chance of obtaining a C or higher in credit-bearing first-year college courses" -- an 18 in English, a 21 in Reading, a 22 in Mathematics, and a 23 in Science. The criteria for academic behaviors are ascertained from ACT Engage Grades 6-9, which is a self-report instrument that determines student scores for motivation (which correlate with grade point average), social engagement (which correlates with extracurriculars), and self-regulation (which correlates inversely with disciplinary events). According to the report, "This information, available in middle school, allows for early identification of and intervention with students who may be less likely to complete high school and go to college." (p. 22)

The report states that 54% of the 2013 high school graduates took the ACT® college readiness assessment, but that more than 40% did so in only 31 states, which excluded the northeastern states from Virginia to Maine and the West Coast. The average scores on the ACT subject area tests and the percentage of students meeting the ACT College Readiness Benchmarks on them for the past five years are reported as follows:

Subject	% meeting ACT College Readiness Benchmarks					Average Score				
	2013	2012	2011	2010	2009	2013	2012	2011	2010	2009
English	64	67	66	66	67	20.6	20.5	20.6	20.5	20.6
Reading	44	53	52	52	52	21.1	21.3	21.3	21.3	21.4
Math	44	42	43	45	46	20.9	21.1	21.1	21.0	21.0
Science	36	28	29	30	31	20.7	20.9	20.9	20.9	20.9
All four	26	23	24	25	25	20.9	21.1	21.1	21.0	21.1

The average ACT composite test scores for the past five years and the percentage of students meeting the ACT College Readiness Benchmarks on each of the 2013 tests are reported by race/ethnicity as follows:

Race/ Ethnicity	Average ACT Composite Test Scores by year					% meeting College Readiness Benchmarks (2013)				
	2009	2010	2011	2012	2013	English	Reading	Math	Science	All four
Asian	23.2	23.4	23.6	23.6	23.5	74	55	71	53	43
White	22.2	22.3	22.4	22.4	22.2	75	54	53	45	33
All	21.1	21.0	21.1	21.1	20.9	64	44	44	36	26
Pac. Isl.			19.5	19.8	19.5	55	33	37	27	19
NatAmer	18.9	19.0	18.6	18.4	18.0	41	26	22	18	10
Hispanic	18.7	18.6	18.7	18.9	18.8	48	29	30	21	14
AfroAm	16.9	16.9	17.0	17.0	16.9	34	16	14	10	5

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college and career readiness

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The report also includes information about the five fastest -growing career fields requiring a higher – education degree, which account for 55% of projected 2010-2020 job openings, and the interest in them expressed by students taking the ACT® college readiness assessment: While education accounts for 17% of these openings, only 6% of ACT test takers expressed an interest in the field. While computer and information specialties account for 11% of the openings, only 2% of the ACT test takers expressed an interest. The other three fields are community services, management, and marketing/sales, each accounting for 9% of the projected openings, while only 7%, 6%, and 2% of ACT test takers, respectively, expressed an interest. The percentage of students expressing an interest in each of the fastest - growing career fields, also those expressing and not expressing an interest in STEM (science, technology, engineering, and mathematics) careers, who met the ACT College Readiness Benchmarks on each of the 2013 tests is reported as follows:

Subject	% of students meeting ACT College Readiness Benchmarks expressing an interest in						
	Education	Comp./Info.	Comm.Svc.	Management	Mktng/Sales	STEM	Not STEM
English	65	68	63	54	63	70	59
Reading	43	50	44	34	39	57	44
Math	38	54	36	35	39	57	33
Science	31	48	30	27	29	41	21

The report concludes with recommendations for increasing readiness for college (especially for the 31% whose ACT scores met none of the ACT College Readiness Benchmarks):

1) Implement the Common Core State Standards (presently adopted for English and math by 45 states and the District of Columbia, but for science by only RI, KY, KS, VT, MD, DE, CA and WA as of November 2013).
2) Provide a core curriculum imbued with challenge and “aligned with college and career readiness standards.” (The report cites evidence that the percentages meeting ACT College Readiness Benchmarks are much higher for students who have experienced a high school core curriculum, defined to be four years of English and three years of math, science, and social studies.)
3) Monitor student progress and intervene early when necessary. (“ACT Engage Grades 6-9” is a way to do this.)
4) Set clear performance standards.
5) Develop data systems to enable monitoring student progress and train teachers to use them.

The report is available online at <www.act.org/readiness/2013>.

NSB releases STEM Ed Data and Trends

by John L. Roeder

The National Science Board has released the STEM Education Data and Trends, available online at <http://www.nsf.gov/nsb/sei/edTool/index.html>, which draws on the most recent *Science and Engineering Indicators* report (presented in interactive format) to provide an interactive website answering questions related to all levels of education: pre-K, primary, middle, high, college, and workforce. Having just read *The Hidden STEM Economy* (see page 17, this issue), I thought it would be interesting to see how its information compared with that on this website. I went to the workforce category of questions and inquired about the distribution of degrees held by those in the science and engineering workforce, their salaries, and states with the highest percentage of science and engineering jobs.

The percentage of workers in science and engineering with what *The Hidden STEM Economy* calls “sub-bachelor’s” education is 26.5%, according to *Science and Engineering Indicators*, little more than half the percentage of STEM jobs *The Hidden STEM Economy* says are available at the sub-bachelor’s level. But I also realized that *The Hidden STEM Economy* counts members of

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STEM jobs without a bachelor's degree

You don't have to have a doctorate, or even a bachelor's degree, in order to have a STEM job. At least, not in the way the Jonathan Rothwell considers it in the report, *The Hidden STEM Economy*, that he wrote for the Brookings Institution.

Rothwell notes that the importance of high quality in STEM (science, technology, engineering, and mathematics) education and a STEM work force has received strong bipartisan support since Vannevar Bush advocated it in the early 1940s and that 20% of U.S. jobs require high level of knowledge in a STEM field, double that in 1850. But he laments that previous studies and reports, including *Rising Above the Gathering Storm* (covered in the Fall 2005 issue of this *Newsletter*), have focused on training PhD scientists to the exclusion of vocational training and contributions made by blue-collar workers and the STEM knowledge they require. Rothwell considers that "there are two STEM economies": 1) the professional STEM economy, focused on research, and 2) workers from high and vocational schools and community colleges, who "produce, install, and repair the products and production machines patented by professional researchers."

He "presents a new and more rigorous way to define STEM occupations," based on the Department of Labor's Occupational Network Data Collection Program (O*NET), which classifies workers not by what they do but rather what they "need to know to perform their jobs." Rothwell determined a STEM knowledge score for each of 736 occupations by polling about 24 workers in each about the degree to which they need to use each of six STEM components (physics, chemistry, biology, engineering and technology, computers and electronics, and mathematics) to do their jobs on a scale of one to seven, according to a rubric of what would qualify as a two, four, or six. From this he defines two categories of STEM jobs:

"*high-STEM*": jobs for which the STEM knowledge score is higher than 1.5 standard deviations above the mean in at least one STEM field.

"*super-STEM*": jobs for which the combined STEM knowledge scores for all STEM fields is at least 1.5 standard deviations above the mean combined score.

Rothwell labeled each job with the experience and training characterized by the largest number of workers; wages were gauged by those earned by a worker with the same level of education.

Within this context Rothwell reports four major findings:

A. "As of 2011, 26 million U.S. jobs – 20 percent of all jobs – require a high level of knowledge in any one STEM field." Although only 4-5% of this is in "professional industries," including all "super-STEM" jobs brings this up to 9%, and adding the "high-STEM" jobs brings the total up to 20%. Twelve million of these jobs require a high level of science knowledge, 7.5 million mathematics, and 5.4 million computer-related knowledge.

B. "Half of all STEM jobs are available to workers without a four-year college degree, and these jobs pay $53,000 on average – a wage 10% higher than jobs with similar educational requirements." Rothwell goes on to write that "30% of today's high-STEM jobs are actually blue-collar positions," which "include installation, maintenance, and repair, construction, protective services, transportation, farming, forestry, and fishing, building and grounds cleaning and maintenance, healthcare support, personal care, and food preparation." In contrast with the 10% salary advantage for high-STEM jobs that require less than a bachelor's degree, Rothwell also writes that blue-collar STEM jobs have a 22% salary advantage.

These STEM jobs available to workers without a four-year college degree are what Rothwell calls "The Hidden STEM Economy," and he devotes the bulk of his report to contrasting it with what would conventionally be the STEM economy in a series of tables: 1) by education requirements and professional classification; 2) characteristics of categories of US workers; 3) major occupational categories; and 4) major industries. The data in these tables reveal a great deal about the role of STEM in the structure of US employment. These tables are reproduced at the end of this article (pages 18-20).

C. "STEM jobs that require at least a bachelor's degree are high clustered in certain metropolitan areas, while sub-bachelor's STEM jobs are prevalent in every large metropolitan area." The hundred largest metropolitan areas are home to 65% of U.S. population, 66% of super-STEM jobs, and 68% of STEM jobs, including 77% of jobs requiring a high degree of computer knowledge. The percentage of jobs requiring super-STEM knowledge ranges from 19% in San Jose (CA) to 5% in Las Vegas, but the percentage of STEM jobs "available to workers

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STEM jobs

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without a bachelor's degree" spans a narrower range – from 7% in Las Vegas to 13% in Baton Rouge, because "every city and large town needs mechanics and nurses."

D. "More STEM-oriented metropolitan academies perform strongly on a wide variety of economic indicators, from innovation to employment." "Economic performance is superior on a wide range of indictors in metropolitan areas with high STEM versus low STEM concentrations." "Median household incomes and average wages are also higher in STEM-oriented economies." "The average worker living in the most STEM-oriented metropolitan areas realizes an eleven percent boost in real wages compared with those living in the least STEM-oriented metropolitan areas. The effect is much higher (19 and 26 percent) for high-STEM and super-STEM workers, and considerably lower (8 percent) and statistically insignificant for non-STEM workers."

Rothwell "identifies the previously unheralded role of blue-collar and other STEM occupations demanding less than a bachelor's degree," which make commercialization of inventions from "STEM-knowledgeable professional workers . . . feasible and possible." While "many researchers have studied why there is a shortage of highly educated STEM workers, . . . less attention has been paid to why sub-bachelor's level STEM jobs are hard to fill."

"The U.S. federal government is actively investing more than $4.3 billion in 255 programs with the primary goal for primary effect of increasing the supply of STEM workers," Rothwell writes, but he notes that only 22% of this is slated for sub-bachelors education *vs.* 45% for bachelor's degrees or higher, "despite the fact that half of STEM jobs . . . do not require a bachelor's degree." The remaining third of the $4.3 billion focuses on STEM education at the K-12 level.

Rothwell also notes that at the state and local level, "community colleges receive 42% less funding per student . . . compared with research universities." Yet "community colleges award more than one-half of all postsecondary STEM degrees."

Rothwell concludes that "the excessively professional definition of STEM jobs has led to missed opportunities to identify and support valuable training and career development at the federal level and weakened coordination between workforce development and education at the state and local levels." "The overemphasis on four-year and higher degrees as the only route to a STEM career has neglected cheaper and more widely available pathways through community colleges and even technical high schools," which provide all the education requirements for half of all STEM jobs. "In this sense, jobs that require less than a bachelor's degree represent a hidden and unheralded STEM economy."

The Hidden STEM Economy is available online at <http://www.brookings.edu/~/media/files/reports/2013/06/10%20stem%20economy%rothwell/thehiddenstemeconomy610.pdf>.

STEM Jobs by Educational Requirements and Professional Classification (% of total), 2011

	Brookings high-STEM	Brookings super-STEM	NSF	Department of Commerce	all US jobs
less than HS dipl	2	0	0	0	11
HS dipl or equiv	13	11	4	4	50
Postsecondary certificate	17	18	1	1	9
A.A.	19	10	13	14	6
B.A.	37	43	65	74	20
M.A.	6	4	8	4	3
Doctoral or professional degree	7	14	8	3	2
Nonprofessional occupation	31	29	0	0	42
all US jobs	20	9	5	5	100

Major Industries, 2011

Industry (ranked in order of % of super-STEM jobs)	% of jobs that are high-STEM	% of jobs that are super-STEM	% of US high-STEM jobs	% of US super-STEM jobs	% of all US jobs
Utilities	44	27	2	3	1
Professional, scientific and technical services	39	19	13	15	6
Construction	38	17	13	14	7
Mining, quarrying, oil and gas extraction	25	15	1	1	0
Manufacturing	30	13	16	17	10
Public administration	27	12	7	8	5
Health care and social assistance	29	10	20	17	13
Other services (excl. pub. admin.)	17	9	5	6	5
Information	22	7	2	2	2
Management (of companies/enterprises)	30	7	0	0	0
Transportation and warehousing	10	6	2	3	4
Wholesale trade	9	3	1	1	3
Retail trade	6	3	4	5	12
Educational services	7	3	3	3	9
Administration, support, waste management, remediation	9	3	2	2	5
Agriculture, forestry, fishing, hunting	4	3	0	1	2
Real estate, rental, and leasing	10	3	1	1	2
Finance and insurance	28	2	6	1	4
Arts, entertainment, recreation	4	1	1	0	2
Accommodation and food service	1	0	0	0	8

Characteristics of Categories of US Workers, 2011

	high-STEM	super-STEM	not high-STEM	all US workers
Age	42.9%	43.%	41.1%	41.4%
Female	33%	22%	51%	47%
Foreign-born	17%	18%	16%	16%
Asian (non-Hisp.)	8%	10%	4%	5%
Black (non-Hisp.)	8%	6%	12%	11%
Hispanic (all)	10%	9%	16%	14%
White	72%	73%	65%	67%
avg. yrs. on job training	1	1.3	0.4	0.4
avg. yrs. experience	3.9	3.9	1.5	1.5
STEM B.A.	26%	27%	5%	9%
mean income	$59,767	$68,061	$33,454	$38,677
unemployment rate	6.10%	5.40%	9.30%	8.70%

Major Occupational Categories, 2011

Category (ranked by mean STEM score)	mean STEM score	% of jobs that are high-STEM	% of jobs that are super-STEM	% of US high-STEM jobs	% of US super-STEM jobs	% of all US jobs
architecture and engineering	10.6	100	95	9	19	2
life, physical, social science	8.6	87	76	4	7	1
healthcare practitioner and practical	3.1	76	29	22	19	6
computer and mathematical science	2.9	100	30	13	9	3
installation, maintenance and repair	2.6	53	39	10	17	4
management	1.1	27	13	6	7	5
construction and extraction	0.9	40	13	8	5	4
education, training, and library	-0.6	9	7	3	5	7
business and financial operations	-0.7	42	8	10	4	5
farming, fishing, forestry	-2.6	8	2	0	0	0
production	-2.6	23	4	7	3	7
arts, design, media, sports, entertainment	-3.2	16	2	1	0	1
sales	-4.2	0	0	0	1	11
law	-4.2	0	0	0	0	1
protective service	-4.6	12	2	1	1	2
personal care and service	-5.0	1	0	0	0	3
transportation and material moving	-5.1	6	2	2	2	7
community and social services	-5.3	0	0	0	0	1
office and administrative support	-5.8	1	0	1	0	17
food preparation and service	-5.9	0	0	0	0	9
healthcare support	-5.9	5	1	1	0	3
building and grounds cleaning and maintenance	-6.5	5	1	1	1	3

STEM Ed Data and Trends

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the STEM community more broadly the *Science and Engineering Indicators* does and that this might account for the difference.

The median salaries for 2010 (just a year earlier than the 2011 data in *The Hidden STEM Economy*) are $75,820 for science and engineering, $33,840 for all US workers. This is consistent with the table comparing characteristics of US workers in *The Hidden STEM Economy*, which shows $59,767 and $68,061 mean salaries for high- and super-STEM US workers, respectively, *vs.* $38,677 for all US workers.

BOOK REVIEWERS NEEDED!

Have you read a good book on the role of science in society lately? Why not review it for the *Newsletter* and share your experience with fellow *Newsletter* readers? Just send your review to Editor John L. Roeder at <JLRoeder@aol.com>.

The states with the highest percentage of science and engineering jobs (with no data for OR, PA, and NY) are WA, SA, MN, MI, VA, MD, DE, NJ, MA, CT, and AK.

Infusing Science into Studying the Middle Ages

by Bernice Hauser with Cassandra Parets,
Horace Mann School

When we were asked to help shore up and revitalize the scientific component allied with the study of the Middle Ages at an alternative school, we were mystified by the sparse information regarding doctors, medicine, patients, and especially the feared Black Plague. So, we wondered, could the students compare the Black Plague to a recent virus that occurred in China? Could they gather statistics on how long men and women lived then (about 30 years) to compare with current life expectancy across the globe? Could they contrast and analyze what factors impacted the changes to life expectancy? Could they explore the issues of Obamacare with the way patients were then treated? Would they appreciate the rich heritage and culture of Islam? Would they be able to discuss the impact of the Crusades in a meaningful way — and how the effects of the Crusades still influence Middle Eastern values, interests and decisions made today?

We understand that these students are only in fifth and sixth grade, but we firmly feel that they need not only a bedrock foundation across disciplines to appreciate the complexities of living in the Middle Ages, but also cognizance and competence in using available technological tools to show what they have learned in a meaningful way.

We spoke with these students and asked them what questions they had about medicine and health as practiced in the Middle Ages. Their responses included the following:

- What kinds of medicine were available then?
- How were doctors trained?
- How long did people live?
- What diseases killed most of the people?
- Did they have antibiotics then?
- Were doctors paid?
- Did doctors belong to a guild like the individuals who made gold goblets?
- Were there female doctors?
- Were there hospitals?
- What were some common treatments during this time?
- What kind of medical and surgical instruments did they use?
- Were doctors licensed?

Why not, we thought, have these queries form the basis of their research on the science of medicine and healing in Medieval Times?

Readers and subscribers of this *Newsletter* know that my approach to any new sphere of study is to tell educators to immerse themselves in learning everything you can about the specific study. The following is a sample of background information that illuminates what we hope the students will be able to discover on their own. For instance, it is important to know that in those times, herbs were the main source of treatment for diseases. In 65 A. D. Dioscorides, a Greek, wrote his *Materia Medica,* that covered the medicinal use of more than 600 plants. His book provided one of the first definitive books about the power of healing plants. Samples: wormwood was used to rid the digestive system of worms and was also placed in clothes to repel fleas; marjoram was used to make healing poultices to place on bruises and swellings; fennel (which is also a diuretic) was used to relieve bloating. English lavender was used to treat insomnia, migraine headaches and depression; foxglove was used to treat and regulate heartbeat and strengthen the heart muscle (precursor to digitalis); garlic (which lowered blood pressure and was a natural pesticide against mosquito larvae) was used to kill intestinal parasites and was eaten daily as a protection against the Bubonic Plague. Chives were used to control excessive bleeding and to counter ingested poisons; and ginger was used for motion sickness.

The most common diseases during the Middle Ages were dysentery, epilepsy, influenza, diphtheria, scurvy, typhoid, smallpox, scabies, impetigo, leprosy, pneumonia, stroke, heart attack, St. Vitus' dance, swollen lymph nodes, and St. Anthony's Fire induced by a fungus with symptoms of burning pain in extremities leading to severe convulsions and severe psychosis.

In the Middle Ages, your health, personality, even your future, were determined by the stars. Every court in Europe had a resident astrologer. They predicted the weather and one's fortune as well as possible nosebleeds, carbuncles, and scabs. They even calculated from astrological tables the best time to treat a patient. People believed that a person's character and health were determined by a mixture of elements known as "humors" — blood (hot), phlegm (wet), yellow bile (choler/dry), and black bile (melancholy/cold). It was believed that these affected people's moods — too much blood made you cheerful, whereas too much yellow bile/choler made you

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Middle Ages

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angry. If one humor dominated, the result was disease and abnormal behavior. The humors were made of a combination of four elements: fire, water, air, and earth. Thus doctors would advise their patients to eat foods that were suited to people with a specific type of humor.

An important development at this time was the study of the human body. In the late Middle Ages, dissections were carried out at universities in such cities as Bologna in Italy. The number of dissections grew considerably after the fourteenth century.

But, for the most part, medical treatment was based on guesswork, on folklore, and also in believing that Christian faith plus prayer could restore good health or bring about a miraculous cure. Their belief in the "influence" of the atmosphere around them to cause sickness gave us the name *Influenza.* Folklore beliefs, passed from generation to generation, played a major part in medicine and healing. Another interesting fact is the medieval treatment of bleeding with a leech (a blood-sucking water worm) that probably stopped many people from getting better. Medieval people also believed in God's direct power over their bodies — the Black Plague was thought to be punishment from God. (Carried by black rats bitten by infected fleas, the plague, highly contagious, was thought to be brought from Asia by European sailors.)

Medicine was limited and very basic. The study of medicine was considered inferior to the pursuit or study of theology. Every cure was considered a miracle from God. Learned medicine was still firmly associated with the Church and the monastery with its library, infirmary, hospital and herb garden. (St. Benedict's Rule laid down that every monastery must have a hospital.) Later on the practice of medicine became codified and physicians had to be licensed in order to practice. There were no antibiotics. The Black Death was treated by cutting open the swelling areas and applying mixtures of butter, onion and garlic. Wounds were cleaned with old wine or vinegar. Stomach pains were treated with wormwood, mint, and balms. To qualify as a doctor of medicine took about ten years, so the number of fully qualified physicians remained quite small – there were not enough qualified doctors to treat the ill patients. Only the very wealthy would receive treatment by a physician who would have gone to one of the three noted medical schools – Bologna, Montpellier, Salerno – that flourished in the late Middle Ages. Hospitals were considered one of the major innovations of the Middle Ages — universities specializing in medicine flourished in the 12th and 13th centuries. One of the most famous teachers at Salerno was Conatantinus Africanus, who was born in Carthage in the 11th century. He knew Arabic, but not Greek, and took Arabian books and a thorough knowledge of Arabian medicine to Salerno.

Surgeons were one level above barbers and one level below physicians; they belonged to the Company of Barber Surgeons. Barbers were allowed only to pull teeth. (But the nobility had more sophisticated treatment and often had missing teeth constructed of wood, shell, or sheep horn affixed or implanted with flax twine or uncomfortable wire riggings.) Learned physicians and learned Monks referred to texts written by Hippocrates, Galen, Celsus, Avicenna, Roland of Parma, Roger Frugard and Guy de Chauliac.

Were there women physicians? Officially, no. Realistically, yes. As nurses, midwives, herbalists, there is little doubt that that much of the routine unpaid care of the sick took place in the home and was carried out by women. Studies of the life and work of Hildegard of Bingen (1098-1179) provide a lens into the remarkable work compiled by this individual. Hildegard's *Physica, The Book of Simple Medicine,* or *Nine Books on the Subtleties of Different Kinds of Creatures,* is probably the first book by a female author to discuss the elements and the healing abilities of plants, animals and metals.

The local *wise woman* was often the first person contacted by the poor people. She used various herbs to produce homemade medicines and potions. In the late Middle Ages many people, especially the church administrators, would accuse this *wise woman* of being a witch. Because there were so few hospitals established for healing purposes, many ill individuals often went into the monasteries where monks cared for them and administered the herbal healing potion then thought to effect a cure. Herbal medicine was in wide use during these times and patients usually were treated in their homes. Surgery such as amputations, removal of cataracts, and dental extractions were practiced widely. Apothecaries carried healing potions that they then sold to the local population. Midwives usually helped with deliveries of babies.

Educators have to have sustained discussions about Medieval society and life as it was then practiced — it is the crucial underpinning to students' comprehending why diseases flourished, why the early Medieval Era discarded the great medical strides made by the Greeks and Romans and why by becoming more superstitious, they resorted to witchcraft, astrology and flourishing herbs to treat most ailments. Why they did not utilize the ad-

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vanced medical knowledge that had been codified by the Islamic Society at that time is an important concept to explore. (The Physicians to the Nobility did make use of this advanced knowledge — a great disparity between treatments accorded to rich nobles and kings and the treatment practiced on serfs, peasants, vassals, and the common townspeople.)

Students need to learn and gather information of how the nobility and the common peasant lived – there were no flushing toilets, and chamber pots were widely used. Unsanitary practices flourished at that time. Trash thrown into "gutters" in the streets spread diseases easily, people were not in the habit of bathing daily, and epidemics were a frequent occurrence. There were famous universities such as in Bologna, Italy, where doctors first began to dissect corpses to find out how the human body worked. Grave diggers stealing corpses for money was a fact acknowledged by many townspeople. It was common practice for lepers to be isolated in special hospitals outside the town walls. This isolation reduced the spread of the disease that was almost eradicated in Europe by the end of the Middle Ages. One also cannot study medicine at this time without learning about the *Black Death* or the *Black Plague* that in one year from 1348-1349 depleted one-third of the population of Europe. In the 14th century, Italian doctors discovered that this disease spread rapidly when healthy people came in contact with the sick. From then on, they isolated sick patients. This was the first step in controlling infectious diseases.

We also think it crucial for the students to research the notable scientists in the Islamic Society of that time. The rebellions and crises that exist today in that part of the world could be contrasted with the rich, vibrant, and educated Islamic society that existed during the Middle Ages. Few students have any knowledge of the myriad contributions that have been passed down to Western Society from the Islamic Culture. Renowned Islamic scholar/physicians were Rhazes, Avicenna, Albucasis and Averroes. Avicenna (980-10370) was Islam's "Prince of Physicians." His great medical treatise, *The Cannon*, was written for physicians, but the shortened version called the *Poem on Medicine* served as a layman's introduction to medical theory.

The crucial piece is how to have the students ready for the challenges of living in a technological inter-connected world by doing their research not only with hard texts from their school's library but by also utilizing approved web sites to gather their data. Research involves not only physical books, but also online libraries, encyclopedias, and the World Wide Web, which can be accessed from a personal computer, a school computer, a tablet, or even a smart phone.

It's easy to lose track of where you read a certain article, making it difficult to go back to when that time comes. This is where cloud based storage can be incredibly useful. Google Drive, Dropbox, Evernote, and iCloud give the ability to keep all of your files accessible from anywhere, and on any device. Students can access their research from just about any device with an Internet connection. Google Drive is great for storage, because when you use Google Docs for word processing, it incorporates collaboration by giving students and teachers the ability to comment on the Google Doc that was shared with them. The fact that it's free and web-based levels the playing field for all students. It doesn't matter if they use a Mac, PC, iPad or Chromebook, they can all work on the same document and it looks the same on every device.

Another great free service is Evernote, and it's one of my favorite ways to keep everything in sync. It works on Mac, PC, iPad, iPhone, iPod Touch, Android, Blackberry & Windows Phone. You can even access it from the web. It gives you the ability to create and sync notes of any kind, text, images or even audio or document files. One of the most useful features is the ability to clip full webpages, including images, links and text, tag these clippings to keep them organized, and then share with other users. The original source URL is recorded in order make it easy to revisit or cite these sources later. The sharing aspect makes it great for collaborating with fellow students on a project.

Students should be able to discern legitimate sources from non-legitimate sources. Twenty-first century students may be tempted to type their search into Google and click on the first link that pops up. Very often, this will take them to Wikipedia. It is important to note that Wikipedia is not a legitimate source because anyone can edit it and articles are subject to change. It can, however, be a good jumping off point. Many Wikipedia articles cite sources that are reputable. When looking for articles on health, instead of WebMD, which is a commercial website, try PubMed.gov, a website by the U.S. National Library of Medicine. Other Suggested Databases include World Book Online <www.worldbookonline.com> and Grolier Online <http://auth.grolier.com/login/go login page.html>.

Technology brings with it the ability to become more creative with the ways of delivering information.

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Instead of a research paper on herbs used in the Middle Ages, students can perform a scavenger hunt at their local produce market, snapping pictures using a tablet, smartphone or iPod Touch of the different herbs that they can find that were also used in the Middle Ages. An example would be "this plant was used to ward off the Black Plague." Using iMovie, they can make a video public service announcement of the dangers of using leeches. They can make presentations using PowerPoint, Keynote or iPad apps like Haiku Deck that incorporate images along with the information. A research project can include music from the time period as well as pictures of traditional clothing, since much of this information can be found online. Even crafty projects that live outside the digital world can be documented with digital photography or video and added into a student's digital portfolio.

One important skill when it comes to educational technology is troubleshooting. Sometimes the device just isn't working, and we must either figure out the problem or figure out how to work around the problem. This is an invaluable skill to have in the 21st century, and one that all students should learn, but not just so that they can be good at using technology. This is a skill that can be applied to many aspects of their life. Many times in life, things do not happen as we planned for and we must quickly adapt. This happens in every profession out there: doctors, lawyers, farmers, and designers all need to know how to handle the unexpected bumps on their road calmly and with focus. Trying to figure out why you can't connect to the Internet or why you can't access a document is a great place to start developing these skills.

It is not our intention to mandate that teachers use any of the above suggestions. They best know their students. They may wish them to work in pairs or alone. They may permit their students to choose a topic, or they may assign the topic. They may also supply guidelines for the presentation that best fits in with what they have already been taught about technology and research reports. They may have collectively compiled a rubric to assess the work of each student. (We have included in this article a rubric that has worked well for us. See page 25.) What we are advocating is that educators need to move on from utilizing past practices such as poster board presentations to make use of the new technology possibilities out there. We are not devaluing the importance of public speaking and having a presence before a group of individuals. With everything in its place the center should still hold.

We wish to thank Pat VanderWerff, Horace Mann Lower Division Librarian; Caroline Bartels, Head of the Horace Mann Katz Library; Mindy Lisman, Katz Library Assistant; and Gregory Donadio, Horace Mann Upper Division History Department, for their invaluable assistance with this article.

Recommended Student Resources :

Timothy Levi Biel, *The Black Death* (Lucent Books, Inc., California) 64pp. 89-112269 CIP AC

Mike Corbishley, *The Middle Ages* (Facts on File, New York) 96pp. ISBN 0-8160-1973-8

Neil Grant, *Medieval Europe* (Smart Apple Media, Minnesota) 46pp. ISBN 1-58340-254-3

Sarah Howarth, *The Middle Ages* (Viking/Penguin, New York) 48pp. ISBN 0-670-85098-5

Andrew Langley, *Eyewitness Medieval Life* (DK Publishing, Inc., New York) 72pp. ISBN 0-7566-0705-1

Catherine Oakes, *The Middle Ages* (Harcourt Brace Jovanovich, New York) 64pp. ISBN-0-15-2004-51-3

Recommended Adult Resources:

Sigrid Goldiner, "Medicine in the Middle Ages," in *Heilbrunn Timeline of Art History*, The Metropolitan Museum of Art/medm/hd_htm (January 2012)

Lois N. Magner, *A History of Medicine* (Informa Health Care, New York) 611pp. ISBN 0-8247-4074-2

Marjorie Rowling, *Life in the Medieval Times* (Putnam, New York) 223pp. ISBN399-502580-0

Nancy Siraisi, *Medieval & Early Renaissance Medicine* (University of Chicago Press)

Recommended Sites:

The New York Academy of Medicine
1216 Fifth Ave.
New York, NY 10029
212-822-7200

The New York Botanical Garden
2900 Southern Blvd.
Bronx, New York 10458
718-817-8703
<nybg.org>

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The Cloisters
Fort Tryon Park
New York, New York 10040
212-923-3700
www.metmuseum.org

The Cathedral Church of St. John the Divine
1047 Amsterdam Ave. (112th St.)
New York, New York 10025
212-316-7540
info@stjondivine.org
www.stjohndevine.org

Our Suggested Rubric:

	Excellent	Good	Satisfactory	Unsatisfactory
Comprehension				
Understands Topics				
Applies Concepts				
Makes Thoughtful Analysis				
Uses Technology in Meaningful Ways				
Effort				
Completes Homework				
Comes to Class with Materials				
Comes to Class on Time				
Budgets Time Wisely				
Class Participation				
Collaborates with Peers				
Participates in Class				
Behaves Appropriately				
Responsibility				
Seeks Clarification				
Is Attentive to Class Discussion				
Is Engaged in the Work				
Shows Consistent Effort				
Motivation/Attitude				
Demonstrates Enthusiasm with Material				
Takes Intellectual Risks				
Shares Experiences as it Relates to Class Discussions				

The Metropolitan Museum of Art
1000 Fifth Ave.
New York New York 10028
212-535-7710
www.metmuseum.org

Wave Hill
675 Independence Ave.
(West 249St. & Independence Ave)
Bronx, New York 10471
718-549-3200
www.wavehill.org

(*Editor's Note*: Joining forces with Primary Education Correspondent Bernice Hauser of Horace Mann School for this article is Cassandra Parets, Technology Integrator at Horace Mann, and her Tech mentor.)

News from Triangle Coalition

NAGB Highights Long-Term Trends in NAEP Reading and Math Scores

The National Assessment Governing Board (NAGB) recently released a long-term trend assessment of the National Assessment of Educational Progress (NAEP) reading and math scores for ages 9, 13 and 17 year olds. The report titled, *The Nation's Report Card: Trends in Academic Progress 2012*, includes scores from the first assessment administered in 1971 to the most recent in 2012. The report's comparison of scores over time provides a look at how America's students are doing in comparison to previous generations.

According to the trend report, gender gaps and achievement gaps between white students and other races, such as black and Hispanic, have narrowed over the four decades. Results also found that while the percent of 17-year-olds whose parents finished college have increased, scores for students with parents of higher education have stayed flat, leading education experts to second guess whether increased parental engagement translates to better scores and academic improvement. Statistics also show a lack of improvement in age 17 reading and math subjects, with the most recent scores collected in the 2012 assessment remaining parallel to1971 levels. Despite the few notable concerns, the long-term trend assessment results display improvement in varying aspects and degrees across all ages and demographics measured since 1971. For more information, go to <http://nces.ed.gov/nationsreportcard/ltt/>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 11 July 2013, reprinted with permission.)

Mathematics Community Responds to PCAST Call to Action

In 2012, the President's Council of Advisors on Science and Technology (PCAST) released a report, *Engage to Excel* [covered in our Winter 2012 issue], that made sweeping recommendations for producing one million additional science, technology, engineering and mathematics (STEM) graduates by 2020. The third recommendation, related specifically to the unique role of mathematics in the STEM education pipeline, called for "a national experiment in postsecondary mathematics education to address the math preparation gap."

At the recent PCAST meeting on 18 July, leaders from the mathematics community responded to the recommendation and illustrated some of the current endeavors and challenges facing mathematics education.

The following individuals served as panelists for a discussion on Mathematics Education: Toward 2025:

- Eric Friedlander, Dean's Professor of Mathematics, University of Southern California; Noyes Professor of Mathematics (Emeritus), Northwestern University; President Emeritus, American Mathematical Society
- Mark Green, Professor Emeritus of Mathematics, University of California, Los Angeles
- David Bressoud, Professor of Mathematics, Macalester College; President Emeritus, Mathematical Association of America
- Frank Kelly, Professor of Mathematics, University of Cambridge

Mark Green kicked off the discussion by examining a recent National Research Council (NRC) study, *The Mathematical Sciences in 2025* (http://www.nap.edu/catalog.php?record_id=15269). He emphasized that in the 15 years since the last related study, the role of mathematical sciences has changed and expanded significantly. As a growing number of students enter STEM majors and thus require a solid basis of mathematical foundations, the potential for mathematics to become a barrier also increases. Green says the mathematical sciences community must transform mathematics to become a gateway rather than a barrier. Green says the key to motivating students in mathematics, especially at the K-12 level, is to help them gain a clear understanding for how it is used.

With more students entering mathematics through new pathways and non-traditional entry points, the NRC recommends system-wide reforms such as curricula redesign, course modification, and cultural change. The proposed changes include diversifying teaching methods, including engagement with online education, increasing the use of modeling and simulation to expose students to a variety of modes of thinking and foster the development of problem-solving skills, and tailoring mathematics pathways for students from various disciplines.

Green mentioned that a National Academies committee has committed to support efforts to mobilize stakeholders and provide tools for a community wide effort to help bring reform to scale. Committee-funded initiatives

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include nationwide distribution of the full report to mathematics and state education departments and four regional follow-up meetings.

Eric Friedlander, speaking from his perspective as both a practitioner and leader in the mathematics community, summarized his points with three "R's," stating that mathematics is in need of relevance, renewal, and retention. He conveyed that reform should involve curricular reform, inter-departmental cooperation, emphasis on teaching methodologies with measured outcomes, and adoption of online technologies which complement, not replace, traditional education. He warned, however, that online technologies have the potential to negatively impact disadvantaged groups of students.

Friedlander identified the need for an over-arching framework and guidelines for mathematics education that can be individualized and adopted at local levels. He pointed out that the American Mathematical Society is developing an archive of mathematics best practices, methodologies, course materials, assessment tools and virtual meetings in order to support the mathematics community. He emphasized the critical role of all stakeholders including PCAST, academic leaders, government agencies and business leaders in helping to improve mathematics education, support reform efforts and address the challenges at hand.

David Bressoud spoke of the changing landscape in mathematics education and cited the National Science Foundation-sponsored study, *Characteristics of Successful Programs in College Calculus* (http://www.maa.org/programs/faculty-and-departments/curriculum-development-resources/characteristics-of-successful-programs-in-college-calculus). Traditionally, Calculus I served as an "initiation" course for all students going into STEM disciplines, but currently 70% of students taking Calculus I have previously taken a course in high school. According to the study, more students are now taking Calculus II in the fall term rather than spring term, increasing by 50% from 2005-2010. While engineering remains the top career field intended by Calculus I students (34%), a growing number of students intend to pursue careers in bio sciences (31%), a shift to which the mathematical community must respond, says Bressoud.

Frank Kelly discussed the findings of a 2012 Deloitte report on *Measuring the Economic Benefits of Mathematical Science Research in the UK* (http://www.epsrc.ac.uk/newsevents/news/2012/Pages/mathsciresearch.aspx). The study estimated that mathematical sciences contributed to approximately 10% of all jobs in the UK and about 16% of the total UK gross value added (GVA). While the demand for mathematical sciences graduates continues to increase, the UK struggles with maintaining enough qualified math teachers.

The message to students, says Kelly, is that mathematical science has both beauty and utility. "The flow of trained mathematical scientists into other disciplines and into industries in the future is critical to the UK's economic growth prospects…," said Kelly. "Young people with an aptitude and interest in the subject will find university mathematics and statistics to be beautiful, challenging and extraordinarily stimulating. They should be reassured that, in addition, it is a subject which underpins our 21st century technology, economy and society, and that the demand for trained mathematical scientists is exceptionally high."

Following the presentations, PCAST member Jim Gates stated he was encouraged by the informed, impassioned response around what the mathematics community is already doing and the challenges that have yet to be addressed. He invited the mathematics community to continue an ongoing dialogue with PCAST to "reignite the American dream."

Further details on the PCAST meeting including the full video recording and the presenters' slides are available on the PCAST website <http://www.whitehouse.gov/administration/eop/ostp/pcast/meetings/past>.

New Library of Congress Guide Identifies Science Education Resources

A new guide from The Library of Congress, *Science Education in the 2st Century*, provides references and resources that highlight methods, curricula, standards, and strategies that promote learning in K-12. This latest addition to the The Library of Congress SCIENCE TRACER BULLET SERIES lists information on books, resources, activities and projects designed to engage K-12 students. Some provide incentives and novel ideas for science teachers, methods of integrating standards into the classroom, or new ways of making cross-curriculum connections. Other materials seek to inspire both teacher and student, to encourage further study and/or careers in the sciences, or to advance science literacy through the school into the community.

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Special attention has been given to digital literacy, inquiry, and the importance of STEM education to the nation's future. View the guide at the Library of Congress's Science Reference Services site.

(*Editor's Note*: The preceding two items were excerpted from the Triangle Coalition STEM Education Bulletin for 16 August 2013, reprinted with permission.)

National Science Board Releases STEM Education Data and Trends Tool

The National Science Board (NSB) recently released the STEM Education Data and Trends tool, a rich resource for anyone searching for answers to those and many other questions. The online statistical tool provides key information on the current state of science, technology, engineering, and mathematics (STEM) in the United States through an easy-to-use interface. Organized as a "timeline" spanning prekindergarten through employment, the tool provides useful insights for all with a stake in STEM education: parents, students, guidance counselors, teachers, policymakers, and others.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 17 October 2013, reprinted with permission. Also see additional story on page 16 of this issue.)

NAEP-TIMSS Study: U.S. Eighth-Graders Perform Above International Average on Mathematics and Science Assessment

According to a new report released last week by the U.S. Department of Education's National Center for Education Statistics (NCES), American eighth-graders performed higher than the international mathematics and science averages on the Trends in International Mathematics and Science Study (TIMSS), a study that compares scores from 38 countries and 9 subnational education systems. The special 2011 NAEP-TIMSS Linking Study uses eighth-graders' scores on the 2011 National Assessment of Educational Progress (NAEP) to draw comparisons and predict student performance on the 2011 TIMSS.

The study was initiated so that the 43 states that did not participate in TIMSS would be able to compare student performance in mathematics and science to that of students in other countries, while the other 9 U.S. states served as "validation states" in the Linking Study.

"We found that most eighth-graders in the U.S. are competitive in math and science when their predicted performances were compared to their peers from around the globe," said NCES Commissioner Jack Buckley. "Still, our leading states are behind the highest-performing countries. Even Massachusetts, a top U.S. performer in math and science, struggles to compete with top performing countries."

Massachusetts scored the highest in Mathematics, while Alabama scored the lowest. Forty-seven states scored higher than average in science, with Massachusetts again scoring the highest and Washington, DC scoring the lowest. While Massachusetts led the U.S., only 19 percent of the state's eighth graders scored "advanced" in math compared to about 50 percent of students in Taiwan, South Korea and Singapore.

"It's a good news, bad news scenario:" said Buckley, "all of our high performing states are being outperformed significantly by these other countries." To read the full report, visit <https://nces.ed.gov/nationsreportcard/studies/naep_timss/>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 30 October 2013, reprinted with permission.)

PISA RESULTS: U.S. Slips in International Reading, Science, and Mathematics Rankings According to Latest Results from Programme for International Student Assessment

Released 3 December, the results of the 2012 Programme for International Student Assessment (PISA) show that American fifteen-year-olds ranked seventeenth in reading, twentieth in science, and twenty-seventh in mathematics among the thirty-four countries of the Organisation for Economic Co-Operation and Development (OECD). Those rankings are lower than in the previous PISA given in 2009 when the United States ranked fourteenth in reading, seventeenth in science, and twenty-fifth in mathematics.

Like traditional tests, PISA, which consists of multiple-choice and open-ended questions, tests students on what they have learned, but it goes one step further by also asking students to extrapolate what they have learned and apply that knowledge in unfamiliar settings, both in and

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outside of school. The thirty-four OECD member countries and thirty-one partner countries and economies that participated in PISA in 2012 represent more than 80 percent of the world economy.

"More and more countries are looking beyond their own borders for evidence of the most successful and efficient policies and practices," said OECD Secretary-General Angel Gurría. "Indeed, in a global economy, success is no longer measured against national standards alone, but against the best-performing and most rapidly improving education systems. . . . By identifying the characteristics of high-performing education systems, PISA allows governments and educators to identify effective policies that they can then adapt to their local contexts."

As shown in the table below, the United States, with a mean score of 481, ranks twenty-seventh out of thirty-four OECD countries in math performance—below the OECD average (494) and far behind top-performers Korea (554), Japan (536), and Switzerland (531), as well as Canada (518). Not included in the table are the thirty-one partner countries and economies that also took PISA, many of which performed better than the United States, including Shanghai-China (613), Singapore (573), and

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PISA 2012: Mean Math Scores Among OECD Member Nations

Country	**Mean Score**		**Country**	**Mean Score**
Korea	554		**OECD Average**	494
Japan	536		United Kingdom	494
Switzerland	531		Iceland	493
Netherlands	523		Luxembourg	490
Estonia	521		Norway	489
Finland	519		Portugal	487
Canada	518		Italy	485
Poland	518		Spain	484
Belgium	515		Slovak Republic	482
Germany	514		**United States**	481
Austria	506		Sweden	478
Australia	504		Hungary	477
Ireland	501		Israel	466
Slovenia	501		Greece	453
Denmark	500		Turkey	448
New Zealand	500		Chile	423
Czech Republic	499		Mexico	413
France	495			

RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

1. Bjorn Stevens and Sandrine Bony, "Water in the Atmosphere," *Phys.Today*, **66**(6), 29-34 (Jun 2013).

Although water comprises only 0.25% of Earth's atmospheric mass, its effects on the atmosphere's behavior have disproportionate significance. Water's role in atmospheric circulation requires considering the troposphere to be in a state of radiative convective (not just radiative) equilibrium. As a greenhouse gas, water vapor in the troposphere exerts a continuous warming effect. But in the form of clouds, it produces a cooling effect during the day by increasing Earth's albedo. Perhaps most significantly, it is expected to amplify the effects of other atmospheric constituents, such as the temperature increase from doubling the amount of carbon dioxide in the atmosphere. In the absence of water this temperature increase would be only about 1 K, but the presence of water would increase the temperature by another 1.5 K.

2. "The Power of Green": Energy Conservation Activities from Scholastic and Con Ed for grades K-8, available online at <http://www.scholastic.com/powerofgreen/>, with links to Con Ed activities.

These activities are available for language arts, math, science, and family resources. There is also a contest and a quiz. The "family resources" link gives activities and tips for energy conservation. The math activities are "Who Left the Lights On?" (a verbal puzzle, for grades 3-5), "Energy by the Numbers" (bar graphs, for grades 3-7), "Saving Energy Cents" (pie chart, for grades 3-7), "Powering a Home" (reading an electric bill, for grades 6-8), and "Green Power" (calculating energy savings, for grades 6-8). The science activities are "The Art of Being Green" (art from unneeded objects), "Spot the Safety Dangers" (in pictures), "Make an Energy-Saving Poster," "What's Your Energy Source?" (inventorying energy-conserving behavior), "Spot the 10 Hazards" (in pictures), and "Be a Power Saver" (inventorying passive solar, hot water use, electric appliance use, and disconnecting chargers), all for grades 3-7.

3. Dawn C. Meredith and Edward F. Redish, "Reinventing physics for life-sciences majors," *Physics Today*, **66**(7), 38-43 (Jul 2013).

Concerned that life-science majors and their advisors have "the sense that physics is hard and useless to biologists," these authors argue that physics courses for life-science majors "need to do more than draw their examples from a life-sciences context; they also need to help their students recognize that understanding the underlying physics leads to a deeper understanding of biology." Noting that "biologists . . . focus on real examples and emphasize structure-function relationships" while "physicists stress reasoning from a few fundamental principles," they assert that a first step in rethinking introductory physics for life sciences is "to better understand the ways physicists and biologists think about their own sciences and the ways they teach those sciences to undergraduates."

4. *Discover Your Changing World with NOAA*, An Activity Book, available online at <http://oceanservice.noaa.gov/education/discoverclimate>.

This 52-page booklet contains ten climate-change related activities for middle and high school students, six things to make for laboratory experiments (a solar heat engine; a solar cooker; an electronic temperature sensor; a weather vane, barometer, and rain gauge; red cabbage indicator; and atmospheres with and without carbon dioxide), and four pencil-and-paper things to do or experience (an "extinction polyhedron," a Jeopardy-type game on climate literacy, developing and communicating a message, and the "Carbon Journey Game").

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Hong Kong–China (561). When including these countries, the U.S. ranking slides down to thirty-six out of sixty-five.

In reading, the United States's mean score (498), beat the OECD average (496), but fell far behind top-performers such as Shanghai-China (570), Hong Kong–China (545), Singapore (542), Japan (538), and Korea (536). Canada (523) was the highest-performing country in North America.

In science, the United States's mean score (497) trailed the OECD average (501), as well as those of top performers Shanghai-China (580), Hong Kong–China (555), Singapore (551), Japan (547), and Finland (545). Again, Canada (525) was the highest-performing country in North America.

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REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Vicki Oransky Wittenstein, *For the Good of Mankind? The Shameful History of Human Medical Experimentation* (21st Century, Minneapolis, 2014). 96 pp. ISBN 978 -1-4677-0659-9.

Although the earliest tests of new medications are done with animals, they cannot be approved for use by the Food and Drug Administration without tests that demonstrate their side effects and efficacy in humans. Humans participating in these tests must be informed about their purpose and possible outcomes and give their consent in writing, but it was not always this way. In the past people have been conscripted to participate in medical experimentation without their informed consent, and they were typically people who were not in a position to assert themselves against wrongdoing – *e.g.*, prisoners, orphans, the disabled, and the enslaved. Their story is the subject of Wittenstein's book.

In her opening chapter, titled "Creating Human Guinea Pigs," Wittenstein equates early medicine and experimenting, her earliest example being Edward Jenner's exposing his gardener's son to cowpox in order to inoculate him against smallpox. But her first example of humans participating in medical tests giving written consent and receiving compensation and medical care was Walter Reed's diagnosis of the mosquito as the carrier of yellow fever in the early 1900s.

Even then, Reed's work was the exception rather than the rule, especially when it came to Nazi Germany's inhumane treatment of Jews as medical specimens, chronicled in the second chapter, "Nazi Crimes Against Humanity." An outcome of this after World War II was the Nuremberg Code, which called for 1) informed consent of humans participating in medical experiments, 2) prior experimentation on animals, 3) avoiding physical and mental harm to participants, and 4) freedom of participants to withdraw from the experiment.

Yet in the third chapter, on "Exploitation in the Name of War," we learn that the U.S. medical establishment was also guilty of violating the terms of the Nuremberg Code in exposing humans to radiation in order to ascertain its effect on them. Not until Eileen Welsome's 1993 articles in *The Albuquerque Tribune* about plutonium injections did this become widely known. Reading Welsome's articles prompted then Secretary of Energy Hazel O'Leary to declassify documents about exposing Americans to harmful radiation in the name of research without their knowledge or consent. But prisoners, whose participation in medical experiments was ideal because they were continually available and their diet and environment could be controlled, still wanted to participate in medical experiments – for the remuneration they received. The Belmont Report in 1979 called for "three ethical principles – respect for persons, beneficence, and justice." (p. 57)

In her final chapter, "Can We Safeguard Human Risks?" Wittenstein notes that current laws protect participants only in research receiving federal funding, though they are expected to extend to all *recipients* of federal funding. Meanwhile, she adds, the scale of research on new drugs has escalated considerably, and along with it the number of participants needed – up from 7.8 to 19.87 million between 1999 and 2005. She expresses concern that the increased demand for participants might cause research to be carried out in other countries, where adherence to respect, beneficence, and justice might not be followed as conscientiously.

Wittenstein performs a very valuable service in providing a very readable account – for teens as well as adults –

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For the first time, three U.S. states—Massachusetts, Connecticut, and Florida—independently participated in PISA. In math, Massachusetts (514) and Connecticut (506) posted mean scores higher than the OECD average and that of the United States as whole while Florida (467) trailed both.

The complete PISA results are available at <http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf>.

Highlights for the United States are available at <http://www.oecd.org/pisa/keyfindings/PISA-2012-results-US.pdf>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 5 December 2013, reprinted with permission.)

TEACHERS CLEARINGHOUSE FOR SCIENCE AND SOCIETY EDUCATION, INC.
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Albert Alan Bartlett (1923-2013)

A long-time friend and contributor to this Newsletter, Physics Professor Emeritus Albert Alan Bartlett of the University of Colorado at Boulder, better known to his friends as "Al," passed away at age 90 on 7 September 2013.

Al was best known for teaching us that no matter how small the rate at which something grows, continual growth at that rate will still be exponential. Concerned about living on a finite planet with finite resources, he felt that growth of world population was unsustainable. One of his expressions of this concern was an article, "Why Have Scientists Succumbed to Political Correctness?" originally published in the Spring 2008 issue of this *Newsletter* and reprinted in our Winter/Spring 2009 issue after it was announced that this article had won Bartlett the 29th Annual Global Media Award for Excellence in Population Reporting in the category of Best Magazine Article.

Bartlett's last presentation of his views on sustainability to the American Association of Physics Teachers came at the summer 2011 meeting in Omaha. Not content with coverage of that talk in our Fall 2011 issue, he sent us a manuscript fleshing out his ideas more fully, which was published as the lead story of our Winter 2012 issue. It would do us well to celebrate his life by heeding what he had to tell us.

Clearinghouse Update

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

Update on the Earliest Americans

In our Fall 2004 issue Technology Correspondent John White argued that the Clovis settlements of 11,000 years ago were not the oldest in what is now the United States. A story by Heather Pringle, "Texas Site Confirms Pre-Clovis Settlement of the Americas," in the 25 March 2011 issue of *Science*, bears him out, describing a 15,500-year-old site near Buttermilk Creek, TX, and also near a Clovis site dated at 13,200 years ago. Pringle cites nearly two dozen other North American pre-Clovis sites but observes that the "evidence [for them] was incomplete or flawed."

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of a topic that should be of great concern to the entire public. She is also to be praised for documenting most, but not all, of her examples, although her citations are more likely to be trade books and newspapers rather than the scientific literature. And rare are incorrect statements like "The radiation frequently caused changes to their genes, as their children and grandchildren developed diseases from the inherited genetic mutations" (p. 45), which suggest the inheritability of acquired characteristics.

\- John L. Roeder