TEACHERS CLEARINGHOUSE
FOR SCIENCE AND SOCIETY EDUCATION
NEWSLETTER

Affiliated with the Triangle Coalition for STEM Education

Vol. XXXIII, No. 1
Winter/Spring 2014

Methane Paradoxes and Dilemmas

by John D. White

This year North America surpassed Russia as the world's greatest energy producer. Recent increases in shale-derived methane or "natural gas" comprise a major component of that growth. At the same time, methane has grown as a concern by climate scientists. For now carbon dioxide is far more prevalent, but a similar weight of methane may be as much as 20 times as harmful over a century, according to an estimate by the Environmental Protection Agency (http://www.epa.gov/climatechange/ghgemissions/gases/ch4.html) and (http://earthobservatory.nasa.gov/IOTD/view.php?id=5270). A more optimistic figure by industry sources puts atmospheric methane's half-life at just seven years.

Energy choices for North America have included "enough," "less," and even "none." Since 2000, several hydroelectric dams have been demolished and aged-out nuclear power plants have not been replaced. Coal-fired plants have switched to gas as a hedge against a carbon-tax. In the 1980s the US looked at four *trillion* barrels of shale oil locked in rocks in Colorado, Wyoming, and Utah, but decided the combined prices — technology and ecology — were too high and left the "kerogen" oil in place. In the current euphoria over plentiful, cheaper energy, several considerations deserve attention and may inform current policies in half of the United States lying above oil and gas reserves. Seventeen of these will be listed below.

(continued on page 16)

Irma S. Jarcho

I Will Remember Irma

I will remember Irma Jarcho as a probing bold visionary. Her personal charm, her boundless energy, her creativity and wisdom and her extraordinary calm in the face of adversity were admirable.

I will remember her too, for her hearty laugh, her optimism, and for bringing passion, knowledge, and caring into her classes and into the lives of those with whom she worked.

I will remember Irma for discharging her obligations with a profound meticulousness and decisiveness. Endowed with emotional strength and confidence, and imbued with a firm belief in reaching out, she gave generously of her time and resources to a multitude of educational boards, organizations and foundations.

(continued on page 2)

Remembering Irma

The guiding spirit behind the Teachers Clearinghouse and this *Newsletter* is now just a memory, but one which will continue to lighten my heart and provide inspiration.

Little did I expect what would happen when I agreed to be part of a panel on ethical issues in the teaching of science at the 18 November 1981 meeting of the Association of Teachers in Independent Schools. That was the day I met Irma Jarcho (who was also on the panel), and my life has never been the same ever since. Irma persuaded Nancy Van Vranken, who was in the audience, and me that we should join forces to promote the infusion of societal issues in science courses. Being on sabbatical from the New Lincoln School that year, she was in a position to provide the needed leadership,

(continued on page 2)

Remembering Irma

(continued from page 1)

which led to a meeting of like-minded teachers at the New Lincoln School on 11 March 1982, and the Teachers Clearinghouse was born.

Until she became Editor Emerita twenty years later, Irma was my comrade in arms. Although I had agreed to edit this *Newsletter*, she provided a good percentage of its content, which reflected the many lectures she attended, materials she read, and conferences she participated in. In many cases, we would attend these events together, and she became one of my very best friends. This last statement should not be taken lightly, because we are given very few *best* friends in life, people with whom we feel free to discuss anything and we know will be there to listen to us in time of need. Irma was that kind of person. I will always be grateful that I had the opportunity to know her and work with her, and the memory of our friendship will be my guiding spirit in the continued efforts of the Clearinghouse.

- John L. Roeder

I Will Remember Irma

(continued from page 1)

I will remember Irma for her unique jewelry, her quirky hairdo and her wonderful sense of humor. Her witty and illuminating talks and ripostes always exquisite *tours de force*, can still be recalled.

But above all, I will remember Irma for her kindness, generosity of spirit and for her unflagging support, abiding faith and continuous encouragement of me to venture into other realms – presenting at National Science Conventions, writing for professional science publications, developing early childhood/ primary science curricula for educators. I am not a traditionally trained science teacher in the formal sense of the word. But doing "science" with young children appeared to be something I was passionate about – Irma sensed and teased out what was preventing me to go forward, and with her usual feistiness, aplomb and skillful mentoring, cajoled and emboldened me to take risks and thus to succeed beyond my wildest imagination.

How honored I am to have known her all these years — a Renaissance individual — her compassion, her scholarship, her boundless energy, her insights, her limitless contributions to society, her witty and pithy comments have always enthralled and inspired me. Well done!

Thank you, Irma. Your indomitable spirit lives on!

- Bernice (Bunny) Hauser

IN THIS ISSUE

The TEACHERS CLEARINGHOUSE FOR SCIENCE AND SOCIETY EDUCATION, INC., was founded at The New Lincoln School on 11 March 1982 by the late 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 17 Honeyflower Lane, West Windsor, NJ 08550-2418 or via e-mail at <JLRoeder@aol.com>. The Clearinghouse is affiliated with the Triangle Coalition for STEM Education.

A Renewable Energy Future?

(*Editor's Note*: When I began teaching about energy issues upon my arrival at The Calhoun School in 1973, I would conclude by envisioning an energy future ultimately based on renewable sources. After all, I reasoned, that's all we ultimately would have. The question, I would then go on, is how we were going to get to that future based on renewable resources, which then seemed very elusive, largely because of their significantly greater cost. The three articles on this page suggest that a renewable energy future might not be as elusive as previously thought.)

Gore's "Turning Point"

Eight years after Al Gore wrote a book and made a movie to impress upon us the "planetary emergency of global warming" (his subtitle for *An Inconvenient Truth*), he wrote an article with a more optimistic feeling in the 18 June 2014 issue of *Rolling Stone*. He begins "The Turning Point: New Hope for Climate" as follows:

> In the struggle to solve the climate crisis, a powerful, largely unnoticed shift is taking place. The forward journey for human civilization will be difficult and dangerous, but it is now clear that we will ultimately prevail. The only question is how quickly we can accelerate and complete the transition to a low-carbon civilization.

The "surprising – even shocking – good news" is "our ability to convert sunshine into usable energy . . . much cheaper far more rapidly than anyone had predicted," Gore writes: the cost of photovoltaic electricity is competitive with that from other sources in at least 79 countries, and the 43% decrease in cost of wind-generated electricity since 2009 has made it cheaper than coal-generated electricity. By 2020 more than 80% of world population will live where photovoltaic electricity is competitive with other sources.

As evidence of this "largely unnoticed shift," he notes that Germany now generates 37% of its electricity

(continued on page 19)

A Changing Energy Future for the World

by Art Hobson

The tide is turning. Energy use is entering a time of fundamental change and great hope. Some changes have surprised me and changed my views about energy use and the climate problem.

Many nations are switching from coal and nuclear electricity to renewables and efficiency. Germany gets 27 percent of its electricity from renewables, mostly from wind and photovoltaic solar, and plans to reach 80 percent by 2050. For comparison, 13 percent of U.S. electricity comes from renewables. Germany will scrap most fossil-generated electricity, while phasing out nuclear, by 2050. Their unprecedented solar energy growth has been fueled by a "feed-in tariff" that pays rooftop solar homes for electricity fed into the grid. These enlightened policies, plus energy efficiency, are putting Germany on the road to a carbon-free and nuclear -free future.

Ever since 1990, I had been mildly supportive of nuclear power as a welcome alternative to fossil electricity because of the threat of climate change. But the surprising success of the renewable and efficiency revolution, and the surprising severity of the Fukushima nuclear

(continued on page 21)

Considering future energy options:

Extrapolations from a real experiment

by H. Frederick Dylla

I had the opportunity last week to spend some time with a good friend, a fellow physicist with whom I shared nearly 40 years of collaboration and conversations largely around the subject of energy. My friend is Fritz Wagner, the former director of the Institute of Plasma Physics (IPP) in Greifswald, Germany, and a recognized international expert in plasma physics, experimental fusion devices, and analysis of the world's current energy situation.

Since Wagner retired as the IPP director five years ago, he has spent much of his post-retirement years studying the global energy situation and potential solutions. Given that the economic health of a developed nation is proportional to the availability and use of energy resources, this subject is clearly connected to our well-being. Many factors influence this issue, including the often competing demands of economically efficient energy production, control of CO_2 release, and the global interconnectivity of energy production and use. A singular goal would be to minimize the all-too-frequent con-

(continued on page 20)

Letter to the Editor

In Defense of Modeling Instruction

Having used the Modeling pedagogy to facilitate student learning of physics and chemistry for the final seven years of my teaching career, I am an enthusiastic promoter of the method. When I have the opportunity, I tell people that I had great fun teaching chemistry and physics during the first twenty eight years of my career, and even more fun teaching using the Modeling method in my last seven years.

Modeling provides wonderful opportunities for a teacher to uncover student misconceptions, and work on correcting them. During my first year using modeling strategies, there were numerous times when I thought to myself, "That student really thinks that is true." That made me realize that numerous students had completed my classes with those same misconceptions. I wished I had discovered the Modeling pedagogy years earlier.

I had participated in a three hour introduction to modeling at a Physics Teaching Resource Agent institute in 2001. The experience piqued my interest, but also confused me. It was not until 2003, at a three week workshop, that I fully understood what Modeling was all about. The Modeling unit on kinetic energy was the clincher for me. I remember saying out loud, as we analyzed the data from the lab we performed, "It really is that way!"

Two years ago, I presented an introduction to Modeling at the Georgia Science Teachers Association meeting. I included information about kinetic energy in that presentation. Afterward, a teacher talked to me about an experience she had while teaching kinetic energy. A student had asked a question about the relationship between the kinetic energy and the mass, and she told the student "That's what a scientist found after many years of investigation." (I am being vague on purpose, so that those who read this article will think about what they "know" about kinetic energy.) Having participated in the one hour intro to Modeling presentation, she told me she now had an evidence-based answer to that question. It was particularly rewarding for me.

I must take one minor exception to the presentation of the article in the Fall 2013 issue of the *Newsletter*. The second step listed, "With guidance from the teacher, students develop a plan to investigate or represent the problem." That is true early on in a course taught using Modeling. However, I found that as the year progressed, my students got better and better at developing experimental procedures, and needed my assistance less and less. This brings me to my take on Modeling and NGSS (Next Generation Science Standards). A very important goal included in NGSS is that students become scientifically literate. The Modeling method helps students develop a deep understanding of the scientific process, so meets that goal very well. Engineering concepts and strategies are also a significant portion of NGSS. As my students got better and better at developing experimental strategies, without realizing it, they were developing and using good engineering techniques. It also gave them the opportunity to demonstrate their creativity. I am grateful that John Roeder wrote about Modeling in the Fall 2013 issue of the Teachers Clearinghouse *Newsletter* and encourage everyone to consider learning more about the method and using Modeling in their classrooms.

Frank Lock

Clearinghouse Update

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

Update on Biosphere 2

In our Fall 1997 issue Earth Sciences correspondent Michael Passow's description of the Columbia Earth Institute cited its inclusion of the Biosphere 2 complex in Arizona, which Columbia had taken over in 1994 after problems with its original design did not allow it to operate as initially intended. In an article on page 146 of the 8 July 2011 issue of *Science*, Erik Stockstad reported that Columbia University's use of Biosphere 2 to study "effects of elevated carbon dioxide levels on oceans and terrestrial ecosystems" ended in 2003 because of high expenses and lack of government grants. His report added that this research was resumed in 2007 by the University of Arizona (only 50 km away) and that this research escalated in 2011 as a result of major gifts, including $20 million from the original Biosphere 2 funder, Edward Bass, and donation of the property to the University of Arizona to be the Landscape Evolution Observatory. Meanwhile, Biosphere 2 continues to be a significant tourist attraction: a hundred thousand tourists per year pay up to $20 to visit it.

Adapting to Climate Change

A special section on "Natural Systems in Changing Climates" in the 2 August 2013 issue of *Science* offers projections of Earth's future climate and our ability to adapt to it in comparison with the past. In their article on "Critical Terrestrial Climate Conditions," Noah Diffenbaugh and Christopher Field present results of Phase 5 of the Coupled Model Intercomparison Project (CMIP5) for forcings ranging from 2.6 W/m^2 to 8.5 W/m^2, noting that the last represents actual greenhouse gas emissions since 2000 and leads to substantial changes in temperature and precipitation through the 21st century, especially in the north polar region, with the concentration of atmospheric carbon dioxide exceeding 925 parts per million (ppm). Diffenbaugh and Field also write that "combustion of all remaining fossil fuels could lead to CO_2 concentrations on the order of 2000 ppm, with concentrations remaining over 1500 ppm for 1000 years." They also note that the migration of species to stay within habitable climates is further complicated by having to match desired ranges in both temperature and precipitation and that the rate of having to do this with a forcing of 8.5 W/m^2 would be 100 times as great as that required during the approach of the Paleocene Eocene Thermal Maximum (PETM) 55 million years ago, when global temperature changed 5°C in 10,000 years.

In their article on "Marine Ecosystem Responses to Cenozoic Global Change," R. D. Norris, S. Kirtland Turner, P. M. Hall, and A. Ridgwell write of the PETM in reporting that atmospheric carbon dioxide concentration reached 800 ppm between 34 and 50 million years ago and sea level temperature reached between 30°C and 34°C between 45 and 55 million years ago, with sea level 50 meters higher. Citing IPCC IS92a, they project an atmospheric carbon dioxide concentration of 1000 ppm by 2100, which is consistent with the projection of Diffenbaugh and Field from CMIP5.

Writing about the interaction of species in their article, "Climate Change and the Past, Present, and Future of Biotic Interactions," Jessica Blois, Phoebe Zarnetski, Matthew Fitzpatrick, and Seth Finnegan state that "Knowledge of how climate change has altered interactions among organisms in the past may help us understand whether consistent patterns emerge that could inform the future of a warming and increasingly human-dominated planet." They continue by observing that "The geologic record provides unambiguous evidence that some past episodes of climate change have altered biotic interactions by driving extinction and speciation and altering the distributions and abundances of species."

(continued on page 22)

Climate Change Impacts in the United States

In addition to the periodic reports of the Intergovernmental Panel on Climate Change (IPCC), which bring to bear the consensus and wisdom of climate scientists all over the world, the United States also produces its own reports on climate change, the most recent being the third, *Climate Change Impacts in the United States*. Weighing in at 829 pages, this report "assesses the science of climate change and its impacts across the United States, now and throughout this century. It documents climate change related impacts and responses for various sectors and regions, with the goal of better informing public and private decision-making at all levels."

It was written by "a team of more than 300 experts, guided by a 60-member National Climate Assessment and Development Advisory Committee . . . the largest and most diverse team to produce a U.S. climate assessment. Stakeholders involved in the development of the assessment included decision-makers from the public and private sectors, resource and environmental managers, researchers, representatives from businesses and non-governmental organizations, and the general public. More than 70 workshops and listening sessions were held, and thousands of public and expert comments on the draft report provided additional input to the process.

"The assessment draws from a large body of scientific peer-reviewed research, technical input reports, and other publicly available sources; all sources meet the standards of the Information Quality Act. The report was extensively reviewed by the public and experts, including a panel of the National Academy of Sciences, the 13 Federal agencies of the U.S. Global Change Research Program, and the Federal Committee on Environment, Natural Resources, and Sustainability."

Climate Change Impacts contains 30 chapters, the most important of which is the first, because it gives an overview of the report and spells out its 12 findings. Next in importance is the second chapter, whose title, "Our Changing Climate," gives the general thrust of the report through its 12 key messages. Next come seven chapters, each detailing the consequences of climate change for seven environmental sectors: water, energy, transportation, agriculture, forests, ecosystems, and human health. These chapters are followed by six more – on particular ways in which the seven environmental sectors interact: energy, water, and land; urban, indigenous peoples; land use and land cover change; rural communities; and biogeochemical cycles.

(continued on page 24)

ACT Reports the Condition of STEM

The most recent of the annual ACT reports on *The Condition of STEM* has tabulated data on what ACT considers "expressed" interest in STEM (choosing a major or occupation corresponding with STEM fields) and "measured" interest (indicated by the ACT Interest Inventory). The data used to do this come from ACT test scores and the ACT Aspire program that evaluates students in grades 3-10 to determine achievement in English, reading, math, science, and writing (the subjects evaluated by the ACT).

Of the 1,799,243 students taking the ACT in 2013, 293,306 were found to have both an expressed and measured interest in STEM; 421,584 were found to have an expressed interest only in STEM, 153,303 to have a measured interest only in STEM, and 931,049 no interest in STEM at all. The percentages of students in each category meeting ACT College Readiness Benchmarks were found to be the following:

	English	Reading	Math	Science	All Four
expressed and measured interest in STEM	76	56	58	51	39
expressed interest only	64	43	47	38	28
measured interest only	64	45	41	37	26
no interest	61	41	38	31	22

The percentage meeting the ACT College Readiness Benchmark in Science was found to be distributed as follows:

	Afr.-Amer.	Native Amer.	Asian	Hispanic	Pac. Isl.	White
expressed and measured interest	18	25	64	33	41	59
expressed interest only	11	20	56	23	31	48
measured interest only	9	17	49	20	28	46

The Condition of STEM presents this type of data analysis also for students expressing interest in four key STEM areas: science, computer science and math, medical and health, and engineering and technology. From this analysis the following key findings are set forth:

1. "Interest in STEM is high." In the "2013 ACT-tested graduating class" 48.3% "have an interest in STEM majors or occupations" – but 23.4% have an expressed interest only and 8.5% have a measured interest only – and "more must be done to *keep* these students engaged in STEM fields."

2. "Achievement levels in math and science are highest when expressed and measured interest match." (Curiously, though, math is cited as an exception to this statement.)

3. "Surprisingly, more female than male students are interested in STEM, although the opposite is true among higher-achieving students." Of the 46% of females interested in STEM majors an occupations 24% are interested in nursing. Except for females interested in Engineering and Technology, males outperformed females in math and science.

(*continued on page 15)*

Two Sci Ed Reforms addressed by NJAAPT

Under implementation of the Next Generation Science Standards, in addition to asking questions and defining problems, planning and carrying out investigations, using mathematics and computational thinking, and obtaining, evaluating, and communicating information (behaviors which now predominate in science laboratories), science students will also be busy developing and using models, analyzing and interpreting data, constructing explanations and designing solutions, and engaging in argument from evidence. These constitute the Standards' eight science and engineering practices, which along with seven cross-cutting ideas (patterns, cause and effect, scale, proportion and quantity, systems and system models, energy and matter: flows, cycles, and conservation, structure and function, and stability and change) and a set of disciplinary core ideas, constitute the Standards. The core ideas were chosen for their broad importance in all the sciences or for their role as a key organizing principle in one science, for their use in understanding other ideas, for their relevance to students' lives, and for their teachability. (Our Winter/Spring 2013 issue listed the Standards by disciplinary core ideas.)

Based on the *Framework for K-12 Science Education* developed by the National Academies, the Next Generation Standards take into account our best understanding of how students learn and workplace needs of the twentieth century rather than have us teach as we were taught – or do something else if we don't like how we were taught. At the same time, the College Board is revamping its Advanced Placement Physics B course by replacing it by two one-year courses, AP Physics 1 and 2, designed to take into account the best practices of teaching first-year college physics, as learned from physics education research. The motivation to replace the AP Physics B course by two courses came from the realization that the AP Physics B syllabus had become more than could be taught in a single year with genuine understanding (students showed the ability to manipulate expressions without realizing what they were doing). In addition to spreading out the coverage of former AP Physics B topics over a longer time, the new AP Physics 1 and 2 exams will have fewer problems and more testing of conceptual understanding in order to de-emphasize "plug-and-chug" and to emphasize inquiry and experimental design. There will also be fewer questions (50 instead of 70), because these questions will require more thought. About five of them will also be "multicorrect" questions, the number of choices will be reduced from five to four, and the penalty for guessing will be removed.

This pair of reform efforts in science education constituted the theme of the spring 2014 meeting of the New Jersey Section of the American Association of Physics Teachers at Princeton University on 15 March 2014. Speaking on behalf of the Next Generation Science Standards was Wil van der Veen of Raritan Valley Community College, and speaking on behalf of the replacement of AP Physics B by AP Physics 1 and 2 was AP Physics Consultant Joe Stieve.

Van der Veen also faulted U.S. science curricula for focusing too much on factual information. Although it was once difficult to look up, he said, it is now as accessible as the touch of a computer key. He pointed out that students in Singapore are taught only a fifth as much factual information as is taught in the U.S., yet excel on international tests because they know how to apply the information they are taught. Other curious facts cited by van der Veen included that students graduate high school knowing 4% of what they need to know and that for every scientist we need four engineers and 100 technicians (hence a large number of STEM jobs that need to be filled).

In writing the Standards, van der Veen said that feedback from two prepublication drafts led to rewriting 95% of the performance expectations and removing 33% of them (because teachers claimed they didn't have enough time to teach them). As noted in the Winter/Spring 2013 issue of this *Newsletter*, the Standards are organized by both topics and disciplinary core ideas – some states prefer one over the other, van der Veen said. He added that the Next Generation Science Standards are expected to last the same twenty-year period the previous *National Science Education Standards* have lasted. He likened them to the blueprint of a house, curriculum development to building a house, and instruction to living in the house. He added that nothing has yet been done on assessment and noted a trend to teach physical science earlier than biological and earth-space science later (at both middle and high school level), because the physical science is prerequisite to learning the others.

Stieve, who pointed out that the current academic year is the last for the AP Physics B course, stated that AP Physics 1 can be a first-year high school physics course (but not a PhysicsFirst course), covering mechanics (including rotation), mechanical waves, and an introduction to electric circuits. AP Physics 2 covers fluids, thermodynamics (including elementary probability), the rest of electricity and magnetism, geometric optics, and mod-

(continued on page 8)

China gaining in science and engineering by imitating U.S.

It is said that imitation is the sincerest form of flattery, and many other nations, recognizing that investment in science and engineering research and development has elevated the U.S. to "a preeminent position in science and engineering in the world," have increased their funding of the same in order to challenge the leadership of the U.S. This is the most salient message of the 2014 Science and Engineering Indicators, published every other year by the National Science Board.

The chief nation flattering the U.S. in this way is China, with South Korea not far behind. While the percentage of the world's research and development performed by the U.S. fell from 37% to 30% from 2001 to 2014, China's 4% of worldwide research and development in 2001 increased to 15% in 2014. (Midway in that period the recession caused business-funded research and development in the U.S. to decrease, but this was offset by government stimulus funding; after industrial research and development rebounded, government contributions were restricted by the sequester.) China's 8% share of high tech manufacturing in 2003 tripled by 2102, just slightly less than the 27% contributed by the U.S. China's $61 million investment in clean energy in 2012 is also more than twice the $29 million invested by the U.S.

These Chinese gains are reflected by the 200% increase in research workers in the dozen years beginning in 1995, while the U.S. scientific workforce increased by only 36%. And while the percentage of bachelor's degrees in natural science and engineering has remained stable at 16% in the U.S., the percentage of Chinese bachelor's degrees in natural science and engineering has now blossomed to 44%. China also leads the U.S. in percentage of first university degrees in science and engineering, 24% to 10%.

At the doctorate level, the U.S. is dependent on those born abroad – for almost half the science and engineering doctoral students in its graduate schools and for almost half the science and engineering doctorates in its workforce. And while the U.S. still awarded more science and engineering doctorates than China in 2010 (33,000 *vs.* 31,000), this can be said only because (unless otherwise specified) "science" in the Indicators includes the social sciences (China has awarded more doctorates in natural science and engineering than the U.S. since 2010). Of those doctorates writing refereed journal articles, 30% of those articles came from the U.S., as opposed to 6.5% in China in 2001. A decade later the American percentage had slipped to 26%, while that from China almost doubled (to 11%). The percentage of Chinese articles in the 1% most cited articles increased from 0.1% in 2002 to 0.6% a decade later, while the percentage of U.S. articles in this category held steady at 1.7%.

Another interesting feature of the Indicators is what it reveals about public attitudes and understanding. Almost half (48%) supported the statement that "humans . . . developed from earlier species of animals"; but when the statement was prefaced by "according to the theory of evolution," it received the support of 72% of Americans. Likewise, only 39% supported the statement that the universe began with a "big bang," but 60% supported the statement when it was prefaced with "according to astronomers." (See also the Infusion Tips column on page 15 of this issue in this regard.)

The average American score on a test of nine factual multiple choice questions was 5.8, a level comparable to that of Europeans. Most Americans could answer questions about probabilities in drug trials and conducting a drug trial but could not explain the reason for a control group or what made something scientific.

More than half of Americans rejected astrology as not scientific in 2012, but in 2010 two-thirds did. Most Americans were found to be concerned about the environment and worry about climate change, but only 30% thought that climate change should receive high priority. Three quarters of Americans had no problem with genetically modified crops, and three fifths of Americans felt that using embryonic stem cells was morally acceptable.

A final chapter on "State Indicators" consists of a series of maps indicating such data as science and math proficiency in grades 4 and 8, higher education degrees, workforce composition, and costs.

Sci Ed Reforms

(continued from page 7)

ern physics topics (including half life). AP Physics 1, Stieve added, also allows for time to cover additional state requirements.

Although the AP Physics 1 and 2 exams will not be offered until the spring of 2015, already sample questions are available. One asks a student to compare the gravitational force between two steel spheres of radius R with that between two steel spheres of radius $3R$. (Here, in addition to recognizing the difference in separation, students also need to recognize the effect of increasing R on mass.) Stieve suggested that Paul Hewitt's "Figuring Physics" questions in *The Physics Teacher* are good practice, also the book, *Ranking Tasks*.

Science-Related Careers for the 21st Century

a report on The Professional Science Master's program

by Sara F. Anderson

"Why do we have to learn this?" "This class is boring and useless!" Such comments are familiar to anyone who has taught middle or high school students. While we know adolescents are notoriously unable to see beyond tomorrow's game or party, we educators also know we need to give our students concrete reasons why they will find our science and math courses useful in their futures.

We explain the need to know basic science and math in order to be savvy consumers of health and beauty aids, to balance our checkbooks, to know when an advertisement is overstating the value of a product, and other such goals. We support the ideas put forth in Project 2061's *Science For All Americans*. However, we want as well to nurture our students who show particular interest in our science or math courses. What can we tell them about why they might benefit from majoring in science, engineering, or mathematics in college? In the past, our answer would have focused on research or teaching, or some combination of these. Now we can say, "Get a BA or BS in one of these fields, then enter a Professional Science Master's (PSM) program."

What? A Master's degree in science, math or engineering? What good is that? The answer is that a PSM degree is science PLUS. And the PLUS component is whatever the student may want to do — marketing, business organization, ethics, communications, and many other areas not commonly associated with science degrees.

Sheila Tobias and others started the development of Professional Science Master's programs in 1997, responding to a 1990 study by Elaine Seymour and Nancy Hewitt ("Talking About Leaving") that showed young people leaving their science majors because they saw better career options outside of science. When Tobias and colleagues in their study asked PhDs in science and mathematics who were struggling to find research positions what they wished they'd studied to make themselves more employable, they listed computer science, communications, business fundamentals, regulatory affairs, project management, and foreign languages. (This has been documented in Tobias's books such as *Rethinking Science as A Career: Perceptions and Realities in the Physical Sciences*, *Overcoming Math Anxiety: They're not Dumb, They're Different* (reviewed in the Spring 1992 issue of this *Newsletter*), and (with teacher Anne Baffert) *Science Teaching as a Profession: Why it Isn't. Why it Could Be* (reviewed in the Winter 2010 issue).)

With funding from the Alfred P. Sloan and the William M. Keck Foundations, Tobias and Hank Riggs began working on installing Professional Science Master's programs in institutions such as the Keck Graduate Institute in Claremont, CA, and at universities. As Tobias explained in a talk at the Clearinghouse on Women's Issues in Washington, DC, on 28 January 2014, they chose the Master's level deliberately in order to avoid conflict with science departments over 'tinkering' with the PhD, and because making the new program a two-year Master's degree would enable students to finish without taking on a large debt.

The next time a student asks why he or she needs to learn what you are teaching, you can say science is the foundation for a wide range of 21st century jobs.

Since 2000, the Sloan Foundation has worked with the Council of Graduate Schools (CGS) to expand the number of schools offering PSM programs around the country, develop guidelines and quality assurance processes for those programs, and conduct research on best practices, enrollments and outcomes. PSM programs offer post-Bachelor's degrees for 21st century young people that link their interest in science, math and technology with their passions to make a difference in the world through a rewarding occupation.

So, the next time a student asks why he or she needs to learn what you are teaching, you can say science is the foundation for a wide range of 21st century jobs. If they start with a major in a STEM field followed by a more applied a PSM degree, they will be ready to grasp onto one of those jobs after only two years of post-college study. That's because PSM programs are based on known needs of employers in their community and include an internship which very often leads immediately to being hired after graduation. Many SUNY branches offer PSM programs [see www.suny.edu/psm]. To obtain information and a list of PSM programs outside of New York State log on to <www.sciencemasters.com>.

(*Editor's Note*: Sara Anderson is a frequent contributor to this *Newsletter*.)

USEPA spearheads sustainable communities

Sabina Pendse is the Sustainable Communities Coordinator for the United States Environmental Protection Administration (USEPA) Region 2 (NY and NJ). As such, she works in the Sustainable Communities Initiative of the EPA and their Partnership for Sustainable Communities which links the efforts of the EPA with those of the US Departments of Transportation, Housing and Urban Development, and Agriculture, and local sustainable action plans such as PlaNYC. On 28 March 2014 she came to give a presentation on "Sustainable Schools and Sustainable Communities" to the Physics Club of New York at New York University.

Using the definition of sustainable development developed by the 1987 United Nations Commission on Sustainable Development chaired by Gro Harlem Brundtland ("Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs"), Pendse portrayed sustainability in terms of three overlapping aspects: Environmental, Social, and Economic. The overlap of Environmental and Social is Bearability; the overlap of Social and Economic is Equitability; the overlap of Environmental and Economic is Viability. Sustainability results from the overlap of all three.

"Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

- Gro Harlem Brundtland

Pendse then turned to describe the characteristics of a sustainable community. A sustainable community balances economical and natural assets and uses resources efficiently. It does not require owning a car, can be walked or navigated with a variety of other transportation options, contains a range of housing types and blends a mix of uses.

Next came the heart of Pendse's talk: How can students and schools make their communities more sustainable? This can be done by Green Teams and by working with the school's Sustainability Coordinator and requires communication among the school's principal, parents, staff, teachers, students, custodians, and food managers. She focused on three examples of specific project areas that are integral to sustainable communities and could be undertaken with students, for which EPA and other agency resources are available:

1. stormwater management. This is needed because of runoff from impervious surfaces. To reduce flooding from this runoff, many student groups have installed rain gardens between downspouts and curbs.

2. zero waste. Here the goal is to minimize the amount of waste going to landfills. Materials management, Pendse pointed out, produces 43% of our greenhouse gas (GHG) emissions. In order of decreasing cost, she listed potential strategies to reduce the emission of greenhouse gases: use of wind energy, increased energy efficiency, curbside recycling, and pay as you throw (pay for garbage collection by how many bags you set out for collection). It was shown that curbside recycling and pay as you throw are very cost effective techniques for reducing GHG emissions. Pendse also shared successful strategies from NYC schools achieved by compacting garbage (*e.g.,* by stacking disposable food trays) or reducing the amount of garbage. Both reduce the number of bags used and the amount of labor required to carry them. Another approach is to set up a cafeteria waste station.

3. sustainable food management. This is based on the following hierarchy from most to least preferred: reducing waste (source reduction), feeding hungry people, feeding animals, using waste industrially, composting, and disposing in landfills or incinerating. Thirty-five million tons of food are sent to landfills or incinerators every year. To reduce food waste and track progress schools can join EPA's Food Recovery Challenge and get support and recognition for their achievements in food recovery strategies like donating and composting food. (Visit <www.epa.gov/foodrecoverychallenge>.)

Pendse pointed out that the EPA has programs for schools on many other environmental topics, such as air quality, integrated pest management, and chemical cleanouts. Most EPA grants, she observed, go to programs addressing community issues. Pendse herself can be reached at <Pendse.Sabina@epa.gov>.

Returns from Publicly Funded Research

by H. Frederick Dylla

As Congress remains entrenched in budget appropriations for 2015, we are reminded that federal support for science research has changed dramatically over the years. Mid- and late-career scientists recall several decades of steady increases in federal science funding. From 1983 to its peak in 2004, nondefense R&D spending more than doubled.[1] Since 2005, however, federal support of scientific research has declined in real terms by 12.6%.[2]

Much of the recent discussion surrounding funding for science has to do with return on taxpayer investment. One measure of the economic benefits associated with federally funded research is the number of patents and licenses that are transferred to the business sector. This is an indication of potential new discoveries and inventions that can be commercialized. Both basic research and applied research have been successful in seeding commercial ventures.

In the first few decades following World War II, when the federal government first significantly invested in scientific research, little attention was paid to the commercial prospects of research. Despite the fact that most research was being conducted at universities and national labs, researchers and institutions had little incentive to seed commercial applications through patents and spin-off companies. Although culture played a role, the problem was in large part legislative in that any resulting intellectual property resided with the federal government. This all changed with passage of the landmark Bayh-Dole Act of 1980, which provided patent ownership rights to the inventor and the inventor's institution. The consequences of this legislation have been significant.

In June 2012, the House Science, Space and Technology Committee took stock of the legacy of the Bayh-Dole Act in a hearing. One of the hearing witnesses, Todd Sherer, the president of the Association of University Technology Managers (AUTM) shared impressive testimony based on an AUTM member survey of licensing activity. The latest survey data shows that in 2012 *university income* from patent licensing activities was $1.89 billion, and the estimated boost to the US economy was more than $80 billion through technology transfer to over 700 companies. To put this into perspective, fewer than 400 patents were awarded to the university community in the year prior to Bayh-Dole. By 2010, nearly 4500 such patents were issued, according to AUTM.

A particular success story is the federal investment in biotechnology, which has seen significant commercialization of these research expenditures. Basic research in this field has led to important commercial applications in vaccines and therapeutics for cancer and many other human diseases. The biotech industry accounted for approximately eight million jobs in the US economy in 2012. According to the 2012 AUTM survey, more than 75% of these companies based their technology on patents from US universities. [3]

It would be a gross simplification to assume that short-term commercialization is the only measure of the return on investment in research. There is no simple formula for predicting the value and impact of new scientific knowledge for future generations. One study by the Center for American Progress estimates the return for each federal research dollar invested in research ranges from 30 to 100% — an impressive return compared to typical investments.

However, the timescale for returns on many worthwhile scientific endeavors can be decades. For example, only in the last decade have we seen significant commercial returns from Einstein's theory of general relatively, which is absolutely necessary for the accuracy of our valued GPS location devices. Along that same vein, we have 60 years of research to thank for the recent introduction of gene-targeted pharmaceuticals, progress-in-the-making ever since Watson and Crick solved the structure of DNA in 1953.

With every dollar that Congress puts into research — basic or applied, short-term or long-term — we benefit, both tangibly and intellectually. It is up to us to make sure our elected officials are aware of this fact.

References

[1] AAAS Report XXXVIII: Research and Development FY 2014. Matt Hourihan, Historical trends in federal R&D. Available: http://www.aaas.org/sites/default/files/migrate/uploads/14pch02.pdf
[2] AAAS. See: http://www.aaas.org/spp/rd.
[3] AUTM US Licensing Activity Survey FY 2012 Highlights. Available: http://www.autm.net/AM/Template.Cfm?Section=FY2012_Licensing_Activity_Survey&Template=/CM/ContentDisplay.cfm&ContentID=11435

(*Editor's Note*: Fred Dylla is the Executive Director and CEO of the American Institute of Physics. This article is excerpted from the 14 July issue of *AIP Matters* and reprinted with permission.)

EARTHSCOPE

by Michael J. Passow,
Earth Sciences Correspondent

When we want to know what's going on inside our bodies, we use X-rays or MRIs. When we want to know what's going on inside our planet, we use EarthScope.

EarthScope (http://www.earthscope.org/) is a massive project sponsored by the National Science Foundation that focuses on deep geoscientific exploration of the entire North American continent. It is enabling us to extend our understanding of the entire Earth — we are learning more about the materials composing it, how it has been assembled through time, and how it works. Of special interest are gaining new knowledge about recurring earthquakes and volcanoes.

The EarthScope "Mission" encompasses using North America as a natural laboratory for studying how the Earth operates. EarthScope brings together thousands of scientists who work both individually and as part of multidisciplinary collaborative teams to study Earth in innovative ways. The ultimate goals include new insights into our planet's past, present, and future.

To accomplish these goals, EarthScope scientists employ vast arrays of state-of-the-art instrumentation to collect data generated by seismic waves, crustal movements, Earth's magnetic field, soil and rock samples, and remote sensing from satellites and aircraft. Analyzing these data, as well as lab experiments and theoretical modeling, may produce new knowledge about geological processes, the location of vital resources, and protection against natural hazards.

EarthScope is nearing the midpoint of the 2010-2020 Science Plan (http://www.earthscope.org/information/publications/science-plan/). Among current highlights are

- USArray, a network of seismologic stations moving systematically across the continent from the west coast to the east. Published results include innovative understandings about the nature of the lithosphere, as well as the lithosphere-asthenosphere boundary.
- The Plate Boundary Observatory, designed to gain new insights about the dynamic processes creating the San Andreas fault system, Yellowstone caldera, and Cascadia and Alaska faults.
- The most detailed investigations to date into the High Lava Plains, Oregon; Salton Trough rift processes and earthquake hazards; Basin and Range mantle dynamics and magnetism; lithosphere-sedimentary interactions; and much more.

Integral with the scientific mission are EarthScope's education programs. Much is now available online. "For Students" (http://www.earthscope.org/resources/students) provides animations and videos of lectures about pertinent topics. The "Seismic Monitor" provides real-time monitoring of global earthquakes. Two interactive programs to foster interest and understanding are available: "Jules Verne Voyager Jr." (http://jules.unavco.org/VoyagerJr/Earth) provides an interactive map tool that allows students and scientists to increase their understanding of geophysical and geological process and structures using high-precisions GPS data. "EarthScope Voyager Jr." provides a similar interactive tool with links to specific EarthScope projects and discoveries.

Scientists and educators working with EarthScope make available hand-outs on a variety of pertinent topics, along with "Teachable Moments" <http://www.iris.edu/hq/retm>. These are brief explanations about current events that can be used to enhance student interest in our world. The EarthScope website also provides many videos, animations, maps, photos, illustrations, blogs, and more.

Would you like an electronic subscription to the

***Newsletter*?**

All you need to do is to e-mail Editor John Roeder at JLRoeder@aol.com with a request and your e-mail address.

You can also request electronic copies of all issues back to 2009.

PRCST Develops Environment and Health Initiative

by Jane Konrad

It is important that students enter the global economy with the ability to apply what they learned in school to a variety of ever-changing situations that they couldn't foresee before graduating. The student's ability to apply high-rigor knowledge in a relevant, real-world setting needs to be the true finish line. A rigorous and relevant education is a product of effective learning, which takes place when standards, curriculum, instruction, and assessment interrelate and reinforce each other.

The understanding of health in the context of the diverse types of complex environments in which we live is essential to informed decision making. It is vital, therefore, for students to develop a framework for thinking and learning how to seek relevant information and use it in the best way. An approach that frames these discussions in an interdisciplinary way as the system of environment and health is helpful in learning; as well it gives the students a mental model which enables them to seek and place new information in context, and to bring various skills to making good decisions. Thinking of the environments local and global, indoors and outdoors, urban, suburban and rural, their interrelationships, and how the different environmental aspects promote good health and healthy habits can be a powerful approach to teaching science and environment, health sciences, social studies, technology and even economics.

The Environment and Health Initiative (EHI) program of the Pittsburgh Regional Center for Science Teachers (PRCST) uses a systems approach to understanding environment/health issues. A systems approach enriches the existing curriculum, builds connections across disciplines, enhances conceptual meaning and understanding, emphasizes inquiry learning, encourages development of mental models, engages students, and aids in attaining academic standards. A systems approach enables students to understand concepts and issues and their interrelationships. A systems approach uses the educational paradigm of active student interaction in constructing their knowledge base. It makes possible deep understanding that transforms a set of facts into usable knowledge, mastery of concepts to facilitate transfer of learning to new problems/situations, and a focus on the implication for teachers to make those connections, or "big ideas" evident to students.

The EHI builds understanding of the connections among the disciplines of environment and science, health, physical activity, and social studies. Daily reports bring these reciprocal impacts and current issues before us and into students' lives, along with concomitant economic impacts. Yet the reciprocal impacts of our health and the environment are seldom built into the current curricula, even though the Pennsylvania Environment/Ecology Standards already have a strand of Environmental Health (as well as Environmental Laws and Regulations and Humans and the Environment). The national standards apply here too, along with related Pennsylvania Academic Standards for Health, Family and Consumer Science, Physical Education, Social Studies, Mathematics, and Economics (and other PA state academic standards).

Today the free flow of content and ideas across the disciplines of environment and science, health, social studies, and economics requires a new paradigm in teaching and learning. Not all educators may see the interrelationships. We need clearer concepts and examples of meaningful connections including some key ideas, curricular adaptations, and structural frameworks. The EHI stands as a model for development of interdisciplinary work across a number of disciplines. Skills involved include risk assessment and decision-making, inquiry and critical thinking, analysis and synthesis of data, building mental models, resource gathering, organizational and writing skills. Ancillary skills may include effective teamwork, leadership, and conflict resolution.

The EHI was based on the Logic Model found in participatory education essentials. Many environment/health problems have connections that people do not address; rather the health and the environmental issues are viewed as separate entities. Deeper understanding occurs by making meaningful connections across disciplines and linking to everyday problems. The EHI approach also helps students apply the learning that occurs in each of the disciplines.

Risk assessment

We are faced everyday with situations that involve risks. Some are personal and others involve societal risks. Risk is the probability "that a harmful consequence will occur as a result of an action and is a function of hazard and exposure." Nothing is 100% risk free. "Risk assessment is the process by which one attempts to evaluate and predict the likelihood and extent of harm (in quantitative and qualitative terms) that may result from a health or safety hazard." (*Focus on Risk - Project Learning Tree*) With a specific focus theme such as those in the

(continued on page 14)

(continued from page 13)

EHI Program – The Obesity Crisis, Air Pollution including Fine Particulates and Mercury Levels, Water Quality, and Climate Change – brainstorming and concept mapping can elicit ideas about the associations related to the organizing hub – people, ideas, materials, and questions. The relevance of connecting ideas becomes clearer, students become more engaged, and they are empowered for future learning.

Cultural and Economic Constraints: Media Influences

In the education community health is typically not thought of as having a science, environment, or economic connection. These areas really overlap one another and there is a clarion call for them to be taught in this new way. The Howard Hughes Medical Institute (HHMI) has provided excellent resources such as a CD and videotape of "The Science of Fat," documenting the research and findings current today. The National Institutes of Health (NIH) and the National Institute of Environmental Health Science (NIEHS) also provide free and outstanding resources addressing the chemistry and biology of nutrition and metabolism. This project provides access to and awareness of these and other outstanding resources for use in the curriculum.

The Role of Economics

Many manufacturing changes were based in economics and protection of the product FROM the environment. Today more companies are working to reduce their waste stream and also the customer's. The move to "Greener" processes and materials is becoming pervasive in the culture. This imposes both cultural and economic constraints on lifestyles and production. The move to greater use of organic produce/products brings economic decisions about the relative costs versus the benefits received. The role of advertising and commercial promotions needs to be reviewed and the data sources identified.

In the area of nutrition/foods this is a nexus for multiple disciplinary connections. Who can afford these foods? What is organic? How available are the products? What foods are traditional and sometimes even required in certain cultures? In selection of cosmetics, what ingredients might be toxic? What is the cost of "greener" cosmetics? Is the label information complete? How does the selection of building materials, furniture, and even clothing depend on the costs and/or the peer pressures faced in various cultures (*e.g.*, designer shoes)? What are the consequences of the promotion of "bargain" offers such as "supersizing" meals/foods?

Not often considered are the health risks of construction workers as they are daily in contact with construction materials and products potentially harmful to health. The costs of their health care may not have been figured into production or construction costs by those companies hiring the workers. After a literature search published in 1995 in both Dutch and English, the Dutch Collective Labor Agreement for construction workers and related professions entitled every construction worker to a periodic medical examination every two to four years, depending on age.

The report of 2008 in the *Journal of Applied Occupational Sciences* looked at the health effects of construction materials and products exposure to hazardous substances. These included such areas as working with cement, asphalt (bitumen), wood dust and preservatives, mineral wools (glass, rock wool and slag wool), asbestos, epoxy resins, and others. (An earlier focus area was the condition of coal miners and the resulting respiratory disease, including the legislation that has resulted – a rich historical connection.)

Green design of these products and materials can have a beneficial impact on workers' health and also on the economic components of their production/use. The production of green products for the home (cleaning, furniture, clothes), foods, and even cosmetics has increased as the populace becomes more aware of the health risks. Even higher costs of these products has not resulted in lower sales. And in many cases the cost of production is actually lower than before. However, the inequity component should be considered at this point, in terms of higher and lower income consumers (Environmental Justice connection).

The Science-Technology-Society (STS) by Green Design instructional strategy developed by PRCST, highlights the good fit for use with an EHI. It is design for the environment, defined as design that attempts to minimize environmental burdens without comprising functionality. The use of Green Design in the classroom fits well into the STS (or EIC) approach where environmental issues or concerns are the focus of units or modules in the various content areas. Exploring Green Design opens a wider window for understanding the complex interrelationships of human activities and our environment. Design itself is an engineering approach to teaching/learning and is a catalyst for learning. Design

(continued on page 15)

PRCST

(continued from page 14)

technology education promotes the use of systems thinking: Input – Process – Output – Feedback.

This approach goes beyond hands-on activities. A growing interest in the environmental implications of various aspects of our lives has generated a number of "green" campaigns. Whaling and fishing controversies, habitat destructions, and environmental pollutions are a few. More recently "green labeling" has become a marketing technique used to convince customers of the ecologically correct nature of the product – that it is not harmful to our environment. Promotions such as "natural" or "made from recycled materials" prod consumers into making choices that they believe to be protective of the environment. Guided or open inquiry student work opens the door for reaching beyond "hands on" activities into areas of critical thinking.

The EHI is designed to fit these new approaches to learning and assessment, asking students to participate in risk assessment and decision-making, utilizing the content drawn from multiple disciplines. Further information concerning the PRCST programs is available via email to <Konrad@pitt.edu>.

Recent References

Linda Booth Sweeney, *When a Butterfly Sneezes: A Guide for Helping Kids Explore Interconnections in Our World Through Favorite Stories* (Systems Thinking for Kids, Big and Small, Vol. 1) [Paperback] (2001)

Donella H. Meadows, *Thinking in Systems: A Primer* **(**Chelsea Green, 2008)

Heidi Hayes Jacobs, *Curriculum 21*: *Essential Education for a Changing World* **(**ASCD, 2009)

(*Editor's Note*: Jane Konrad is the founding director of the Pittsburgh Regional Center for Science Teachers.)

NEW CLEARINGHOUSE ADDRESS

The Clearinghouse has moved — to 17 Honeyflower Lane, West Windsor, NJ 08550-2418 — and the Clearinghouse apologizes for the delay in this issue caused by the move.

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:

For two decades the National Science Foundation's scientific literacy survey in the biennial *Science and Engineering Indicators* has asked a sample of the public to rate as "true" or "false" the following statements: 1) "Human beings, as we know them today, developed from earlier species of animals" and 2) "The universe began with a huge explosion." In the 22 July 2011 issue of *Science*, Yudhijit Bhattacharjee reported that the National Science Board, which oversees the NSF, dropped these questions in the 2010 survey because of their "flaws." Critics alleged that this was done to preclude the outcome that a majority of Americans believe in neither evolution nor a big bang, a criticism enhanced by announced intention to reinstate the questions in 2012, but with the first prefaced by "According to evolutionary theory" and the second by "According to astronomers." Two subsequent workshops gave further consideration to these issues for the 2012 survey. If you were a member of the National Science Board, how would you vote to present evolution and the origin of the universe on the NSF scientific literacy survey? Why?

ACT Reports

(continued from page 6)

4. "The academic achievement gap that exists in general for ethnically diverse students is even more pronounced among those interested in STEM fields." The number of African-Americans, Hispanics, and Native Americans interested in STEM and their achievement levels in math and science are low.

5. "Students interested in STEM have higher educational aspirations, and their parents are more likely to have attended college than those not interested in STEM." Student achievement level in math and science is connected to their parents' level of education.

For more on College Readiness Benchmarks, see the article on *The Condition of College and Career Readiness* 2013 in our Fall 2013 issue. The *Condition of STEM* is available online at <http://www.act.org/stemcondition/13/pdf/National-STEM-Report-2013.pdf>. For reports for individual states insert the state name in place of "pdf/National-STEM-Report-2013" in the URL for the national report.

Methane

(continued from page 1)

Unintended consequences of actions by previous generations haunt our time. Surely we can pause long enough to consider how our own choices may create future hardships. The earliest North Americans may have considered inexhaustible the megafauna they eliminated. Salt water drains into creeks from century-old oil fields and methane still vents from even older abandoned coal mines. A century ago, automobiles were welcomed as the *solution* to urban air pollution at a time when horses each produced 25 pounds of manure daily.

In 1857, a bill was brought forth to the Ohio State Legislature seeking protection for the passenger pigeon. A Select Committee of the Senate filed a report stating, "The passenger pigeon needs no protection. Wonderfully prolific, having the vast forests of the North as its breeding grounds, traveling hundreds of miles in search of food, it is here today and elsewhere tomorrow, and no ordinary destruction can lessen them, or be missed from the myriads that are yearly produced." (http://en.wikipedia.org/wiki/Passenger_Pigeon). Half a century later, from flocks of three billion or more they had become extinct. In other bad decisions, house sparrows and starlings were introduced here *by choice* by the American Acclimatization Society as a tribute to Shakespeare. Surely we can pause long enough to consider how our decisions may create future hardships.

The separate and also related effects of methane and carbon dioxide on the planet deserve thoughtful discussion now. In the words of H. L. Mencken: "For every problem there is a solution which is simple, clean and wrong." The following considerations may at least help us avoid that kind of oversimplification.

1. Both gases are *natural* as well as human – abundant, generated, and produced from many sources.
2. Each can benefit in various ways and at the same time serve as a harmful greenhouse gas.
3. While methane exists as an abundant fossil fuel, it also qualifies as a renewable fuel. CO_2 is a product both of combustion and animal metabolism, serving as a vital nutrient for plant life. Each is dissolved and stored in the colder ocean depths.
4. "Natural gas***es***" better describes the variety of methane-dominated mixtures found deep underground, in municipal solid waste (MSW), and from livestock production. Other wastes result from agricultural operations and timber harvesting. Often the gases compose a mixture from anaerobic and semi-anaerobic processes such as digestion by grazing animals or biomass decay at the bottom of a pond. Output from commercial gas wells, too, may contain several substances, but for this article the terms methane, CH_4, gas, and natural gas will be considered interchangeable and distinct from other gases. Landfill emissions of methane can serve directly as fuel but removal of the water vapor and CO_2 upgrades the output to the more valuable utility pipeline standard. Methane itself is a versatile feedstock for products ranging from carbon black for car tires to printer toner and methanol. Gas from wells may also contain natural gas liquids (NGLs) such as ethane and propane, which can be removed and sold as chemical feedstocks.
5. One form of ice, methane hydrate or methane clathrates, underlies much of the ocean floor. Continued warming of ocean water could liberate quantities of this solid into gaseous form. The accelerated release would compound global warming in what climatologists called a "positive feedback mechanism." How much exists? ". . .methane hydrates are by far the largest store of methane on the planet and account for 53% of all fossil fuels on earth" (http://www.eci.ox.ac.uk/research/energy/downloads/methaneuk/chapter02.pdf).
6. Heat trapped in the atmosphere by the two "greenhouse gases" CH_4 and CO_2 may contribute to greater production of many life forms while at the same time weakening, even destroying others.
7. Converting electric generation plants from coal to cheaper, cleaner gas reduces CO_2 but may delay or even prevent shifting to solar, wind, and other choices that now seem more benign.
8. Extracting coal or petroleum requires considerable effort, whereas warming of oceans passively liberates dissolved and frozen methane without human action. Melting of long-stable permafrost in the Arctic and sub-Arctic regions also frees up significant amounts of gas in a short time.
9. Almost none of the methane now being generated from biomass or released from ocean and land surface supplies is being harvested for use. Most ends up in the atmosphere, where it remains for decades. The warmer the climate becomes, the more of these ancient gases will be released in a kind of chain reaction, accelerating the warming of the atmosphere worldwide. Long-term changes caused by their presence and their breakdown products remain unknowable. Historic records of climate changes yield little guidance about the extreme speed of current transitions, and even less about

(continued on page 17)

Methane

(continued from page 16)

unprecedented population numbers and growth rates.

10. Unlike denser CO_2, lightweight methane rises to the troposphere where it reacts with hydroxyl radicals in a reaction involving ozone and sunlight. The breakdown products include two other greenhouse gases, CO_2 and water vapor. Some analysts estimate a half-life of seven years for methane in the upper layers and others predict much longer times.
11. Major oil fields lacking pipelines must somehow dispose of vast amounts of gas that accompanies oil to the surface. For safety, most is just "flared," *i.e.,* burned in dirty yellow-orange flames atop large towers. Night-lit flare fields in the Middle East were photographed by astronauts and shown by NASA to a surprised public. Wasteful and damaging as it may seem, flaring is preferable to releasing methane into the air.
12. Despite existence of a similar plant in Boston Harbor, in 2008 efforts to build import facilities for liquified natural gas (LNG or CNG) met vigorous, successful opposition against the Broadwater plant in Long Island Sound. Discovery of huge fields of gas obtainable by new "fracking" (hydraulic fracturing) and horizontal drilling methods has reopened discussion of facilities for the *export* of natural gas from North America. This technology is distinct from liqufied petroleum gas (LPG or LP gas), *i.e.,* conventional propane and butane fuels.
13. North America's combined fossil fuel resources have ballooned in size since 2000, although this has not been recognized by the public. Hydraulic fracturing ("fracking") for oil and gas is just one of many "enhanced oil recovery" (EOR) methods used to transform the western Gulf of Mexico fields, the Eagle Ford Shale in Texas, the Bakken/ Williston Formation in North Dakota and Saskatchewan, the gigantic Alberta Tar Sands ("Oil Sands" is the emerging term) and the Marcellus Shale in the US Northeast. These have the converted this continent into the largest producer *and* exporter of oil and gas in the world. These areas flare, or worse, *leak* significant volumes of gases, both methane and carbon dioxide. EOR techniques include water flooding from the 1950s plus modern gas injection, plasma-pulse, miscible solvents, polymer flooding, microbial injection, liquid carbon dioxide superfluids, hydrocarbon displacement, steam flooding, and fire flooding.
14. The gas-fracking industry has yet to satisfy many objections to their secret formulas for pumping fluids, heavy demand on limited water resources, inadequate cementing of well pipes, leaking toxins into nearby aquifers, and creating hundreds of earthquakes in Arkansas, Texas, Oklahoma, Colorado, Ohio, Poland, and the UK. Critics say that proprietary formulas become matters of public concern because they can migrate laterally or upward and cause harm to people and wildlife. If such occurs, the local authorities and not long-gone polluters will inherit the problems. Waste lagoons of pumping fluids on the surface can be difficult to manage over time. Damage to deeper aquifers is almost impossible to track or treat. Because the fracking industry is so new, one question still open is how long the wells will produce usable gas to pay royalties to land owners.
15. Extractive industries such as mining, petroleum, and ocean fishing have a dismal record of cleanup and restoration. Having grown up amid enormous canyons called open-pit copper mines, ranges of sterile hills of mine tailings and slag, dried-up streams poisoned by smelter wastes, piles of white asbestos dumped on the roadside by the processing mill on US Highway 60, spoil banks left by coal stripping, and from visiting a dozen ghost towns, this writer is perhaps too suspicious. While at least some of kind of trees may replace a clear-cut forest on an eroded hillside, underground and surface mine sites are rarely restored by nature or people. There can be exceptions: I have seen surface mines in western Pennsylvania nicely re-contoured and converted into good pasture land. Similar restoration can be seen at The Big Brown lignite-fired mine and power plant in Freestone County, Texas. Those are the only commendable jobs I have seen in 48 states, perhaps one per cent of the sites I have observed or studied. My opinion for what is next: [a] We should go forward slowly and with close monitoring for any technology as new as fracking. We already know some of the hazards of increased methane in the atmosphere. [b] We need much greater supervision by unbiased personnel who spend a few years of observing small pilot plant operations before a major expansion. [c] We need objective records about how long production lasts, who cleans up and when and how well. Funds for restoration should come from the earliest profits and wait in escrow. The leakage and collapses of waste lagoons for coal ash in the past 20 years alone should make us cautious about management of a less-familiar industry. As in the case of la-

(continued on page 18)

Methane

(continued from page 17)

goons, the real harm may occur long after the original operation shuts down.

16. One of our largest, richest corporations dumped 1.3 million pounds of PCB carcinogens into the Hudson River over 30 years ago and then resisted and delayed a cleanup of the site through decades afterward. Looking just across the border into Pennsylvania, it is understandable that smaller, little-known operators doing the fracking with secret materials and too few inspectors arouse suspicions in western New York. Equally understandable is the desire of people there with economic struggles amid rural poverty to lease their land to fracking companies. The Marcellus Shale lies beneath several states along the northern Appalachians where horror tales about ignited gas coming out of kitchen faucets are matched with grateful accounts of how much the royalties for fracking have helped family finances.
17. As a fairly devout carnivore, I hate to admit that our fondness for red meat contributes to the surfeit of methane in the atmosphere. Cattle and other grazing animals expel surprising volumes of methane and piles of their manure continue to generate more. The carbon-hungry forest of the Amazon has been severely cut back and even burned in favor of cattle production. Not only is the carbon dioxide failing there to form lignin and foliage, but the cattle that replace the trees are themselves methane factories. "Enteric fermentation . . . takes place in the digestive systems of ruminant animals such as cows, sheep and water buffalo. It represents 28%, the largest percentage of contribution to methane in our environment. The majority of methane emissions come from large swine and dairy farms." (http://www.dulabab.com/climate-change/methane/). According to the EPA, "Globally, over 60% of total CH_4 emissions come from human activities." Agriculture, including feed lots for beef, comprises one of those major activities. We meat-eaters contribute part of that percentage, and then our cooking on the grill in the backyard adds to the CO_2 as well. (http://www.epa.gov/climatechange/ghgemissions/gases/ch4.html).

For generations petroleum geologists made a rolling prediction of a mere 30-year supply of recoverable petroleum, at least in the United States. They based their regularly-wrong forecasts on existing technology, not allowing for new methods of discovery, extraction, conversion, refining, or growing of liquid fuel, such as from sugar cane, switchgrass, or algae. We may be equally wrong about methane's effects on climate change. We may dispute the causes — whether humans or just natural cycles — but the hemisphere already warms at a rate that has unfrozen the North Pole region part of the year, during which there is now a Northwest Passage. More methane emission clearly means more warming. Considering the success in limiting DDT, lead and VOCs in paint, CFCs, and ads with doctors endorsing Camels, there may be hope that we can limit greenhouse gases to reduce global warming.

History notes: Ethane (C_2H_6) was also synthetically created in 1834 by Michael Faraday. In November 1776, methane was first scientifically identified by Italian physicist Alessandro Volta in the marshes of Lake Maggiore straddling Italy and Switzerland, having been inspired to search for the substance after reading a paper written by Benjamin Franklin about "flammable air." Volta captured the gas rising from the marsh, and by 1778 had isolated the pure gas. He also demonstrated means to ignite the gas with an electric spark (http://en.wikipedia.org/wiki/Methane).

For other references for the article above see

http://www.scientificamerican.com/article/call-of-the-reviled/

http://www.aphis.usda.gov/wildlife_damage/nwrc/publications/10pubs/avery102.pdf

http://ecen.com/eee55/eee55e/growth_of%20methane_concentration_in_atmosphere.htm

http://arctic-news.blogspot.com/p/decomposing-atmospheric-methane.html

http://www.licor.com/env/applications/methane_analysis.html

FORTHCOMING SCIENCE & SOCIETY EDUCATION MEETINGS

10-12 September 2014, World Nuclear Association, Central Hall Westminster, London. Visit <www.world-nuclear.org>.

8-10 October 2014, Triangle Coalition for STEM Education 14th Annual STEM Education Conference, The Sphinx Club at Franklin Square, 1315 K Street, NW, Washington, DC. Visit <www.trianglecoalition.org>.

3-6 January 2015, American Association of Physics Teachers, San Diego, CA. Visit <www.aapt.org>.

Gore's "Turning Point"

(continued from page 3)

from wind and solar, a percentage expected to reach 50% by 2020, and that nine of ten European coal and gas plants are losing money. Worldwide, capacity for 17 gigawatts of solar electricity was installed in 2010, for 39 in 2003, with expectations of 55 in 2014. China claims it will have a capacity of 70 solar gigawatts by 2017. (A gigawatt is the power generating capacity of a standard electric power plant.)

Gore states that in the U.S. 166 coal-fired plants have closed or announced closings in the last 4.5 years, and 183 proposed coal-fired plants have been canceled since 2005. He acknowledges that some of this shift from coal is to natural gas obtained by hydrofracturing ("fracking") but focuses on the emergence of "on-site and grid battery storage and microgrids," noting that the Edison Electric Institute (the U.S. utility trade group) has labeled this trend as the "largest near-term threat" to the present electric utility system. He likens this threat to that posed by cell phones to the landline telephone system. He cites Citigroup's recognition of the decreased cost of solar and wind electricity and battery storage (long seen as a barrier to intermittent energy from renewable). In addition, he notes a reduction of 49% in energy intensity (energy input per dollar output in gross domestic product) since 1980.

Gore observes that the Koch brothers have led the fight against rooftop solar electricity and for keeping the present fossil-fueled electric plants, one of their arguments being that net metering allows producers of solar electricity to benefit from the grid without paying for it. Although Gore neglects to mention that in net metering the utility pays the generator only the wholesale price for the surplus generation, he does note that solar electricity generation has the advantage of peaking with electricity demand, thereby saving utilities from having to install new peak generation capacity (a point also made by keynoter Perez at the kickoff to develop the solar lessons for School Power Naturally, reported in our Winter 2003 issue).

Gore likens global warming to a fever for planet Earth and notes that the presently-gathering El Niño is expected to result in a pronounced global temperature increase. (Coverage in our Winter 2010 issue of a talk to the American Physical Society and the American Association of Physics Teachers on 15 February 2010 by Judith Lean of the Naval Research Laboratory attributes this to the phase of the 22-year solar cycle.) He correlates the destruction from Supertyphoon Haiyan and Superstorm Sandy with greater surface water temperature (5.4^{o}F for the former, 9^{o}F for the latter). He notes that higher water temperatures also mean higher sea level and disruption of water supplies that depend on snowmelt. And he adds that even more severe catastrophes are in the offing, like the irreversible collapse of a portion of the West Antarctic ice sheet. In addition to heightened sea level, warmer climate also means an atmosphere capable of holding more water vapor and delivering more severe storms, as have been seen in Pensacola (FL), and Nashville (TN). At the same time, global warming will exacerbate the dryness of the drier parts of the Earth through greater evaporation of what little water there is in the ground. Gore also observes that climate change brings concern to the military for both the safety of its bases and the new types of world conflict it will have to deal with.

Gore concedes that these many "knock-on consequences of the climate crisis" are enough to cause anyone to despair. But, as he writes in his opening paragraph, "we will have to take care to guard against despair," lest we become deterred from the action we must pursue. Though there be light at the end of the tunnel, he points out that we are *in* the tunnel. Among the things he says we need are "a price on carbon in our markets" and "green banks" to finance "green" projects.

"Damage has been done, and the period of consequences will continue for some time to come, but there is still time to avoid the catastrophes that most threaten our future."

Though U.S. greenhouse gas emissions had decreased from 2008 to 2012, due to recovery from the recession, they increased 2.4% in 2013. Gore calls for the U.S. to match the European Union's commitment to reduce carbon dioxide emissions 40% by 2030.

Gore's concluding reasons for optimism are that "Rapid technological advancements in renewable energy are stranding carbon investments; grassroots movements are building opposition to the holding of such assets; and new legal restrictions on collateral flows of pollution . . . are further reducing the value of coal, tar sands, and oil and gas assets." "Damage has been done," he adds, "and the period of consequences will continue for some time to come, but there is still time to avoid the catastrophes that most threaten our future."

future energy options

(continued from page 3)

flicts over the acquisition and distribution of hydrocarbon fuels.

Wagner recently published an important study on an optimal mix of renewable and conventional energy sources based on a unique and ongoing experiment in his home country of Germany. Germany is not only the economic powerhouse of the European Union; it also is the world's renewable energy kingpin. Germany's sophisticated energy infrastructure and its interaction with the rest of the EU power grid draws attention to the need for balancing energy production with demand, and for achieving stability in the power transmission interconnections across political boundaries.

Why is Germany so interesting as a test case for these important problems? With an installed renewable energy (RE) production capability of 36 GW photovoltaic (PV) and 32.5 GW wind, the total renewable energy production now exceeds the typical base electrical load (40 GW) for the entire country. Since there is very little energy storage capability in Germany (nor anywhere else for that matter), the peak energy production from RE generation sources must be shipped to other countries through the European grid, and the production level of existing thermal energy plants must be turned down. Transporting the power to other consumers on the EU grid often leads to a situation where Germany is paying other countries to absorb the power — leading to the strange situation of negative electricity prices. The alternative of turning down a thermal plant is restricted due to technical and economic considerations. Such plants basically operate between two limits, and the start-up and turn-off costs are high because large thermal plants are not designed for intermittent use. The problem of localized energy production exceeding demand could also be dealt with if technology existed for large-scale energy storage. Presently, in Germany, the existing storage capacity based on pumped hydroelectric facilities is only 50 GWh, which is a factor of 660 less than is needed in an ideal situation for load balancing with the present demand curves. In addition, the prospects for any new high-capacity energy storage capability based on batteries or chemical conversion technologies are far from near-term use, with respect to both scalability and cost.

Wagner published his analysis of the present energy situation in Germany in a recent paper,[i] which he also highlighted at the International School on Energy sponsored by the European Physical Society and the Italian Physical Society.[ii] He outlines an option for both Germany and the rest of the European Union that entails optimizing the mix of renewable energies versus conventional sources, and taking full advantage of strengthened interconnections within the EU-wide power grid. The analysis attempted to minimize the necessary backup needs, with consequent reductions in the required storage capacities and CO_2 production. Wagner's analysis shows that such an optimum mix for Europe has an installed capacity of RE that is about 40% of the residual base load. In addition, there is an optimal mix of PV- to wind-produced energy because of the diurnal and geographical production variation of these two energy sources. By balancing the geographic variations across the very different environments of Northern and Southern Europe, overall variations are minimized in a case optimized for the entire continent. Given that there are no near-term prospects for scalable storage capacity, other options are possible — such as using price variability to influence the night/day demand variations. Somewhat surprising is that with the optimal installed RE capability, daytime becomes the time of larger production capability and thus offers the lower cost of delivery to consumers. Larger scale use of electric cars may offer some storage capability, and given the need for a roughly equal capacity for large-scale thermal plants, options for heat cogeneration and electrolytic generation of hydrogen or methane may also be viable options.

This analysis could be extended to North America. The continent has large areas suitable for PV plants (the American West) and significant capability for wind generation. Moreover, there is a much more economically favorable conventional generation capability based on the recent exploitation of natural gas captured by hydraulic fracturing of shale gas reserves. However, it is difficult to imagine that the present US political environment would yield anything like the power feed-in tariff benefits offered by the German government to propel the nation forward to become a world leader in renewable energy. The basis for nuclear-based energy generation is zeroed out in Wagner's analysis, given the post-Fukushima political liabilities and the subsequent actions by the German government to phase out power generated by existing German fission plants by 2022. The other nuclear option (fusion) is neither part of the near-term nor the mid-term equation. Both Dr. Wagner and I began our scientific careers in fusion research, and Wagner spent his entire professional career working in this frontier field of research. We both agree that for inclusion in any analysis of energy generation, this technology is not part of the world's energy sources for the foreseeable future. However, its prospects to minimize the waste and fuel cycle concerns of fission and to avoid the deficiencies of intermittent electricity sources — which become increas-

(continued on page 21)

Changing Energy Future

(continued from page 3)

disaster in 2011, has changed the evidence. Fukushima is history's worst nuclear accident and is permanently changing Japan's energy economy.

World nuclear power grew quickly during 1960-1989, grew slowly during 1989 to its peak in 2002, and then slowly declined. Germany shut 8 of its 17 reactors in 2011 following Fukushima, and will close the rest by 2022. The leading nuclear-energy nation, France, is under pressure to reduce its nuclear commitment. France's AREVA, the largest nuclear builder in the world, has been filing yearly losses due to high costs and delays. This reflects a global trend that was only amplified by Fukushima. Nuclear generation has declined by 12 percent since 2002, and nuclear power's share of electricity production has declined from its maximum of 17 percent in 1995 to 10 percent today.

The U.S. could duplicate Germany's success, but our fossil-fuel industry makes this difficult. Solar energy accounts for three-quarters of new U.S. electricity generation, thanks partly to rooftop solar. But more rooftop solar means customers buy less electricity from utilities, so utilities are pushing back by opposing feed-in-tariff incentives and charging their solar customers additional fees.

The U.S. Supreme Court's 7-2 ruling allowing the Environmental Protection Agency to regulate greenhouse gas emissions from power plants is major good news. Coupled with the EPA's new regulation to cut carbon pollution from power plants by 39 percent from 2005 levels by 2030, this implies real changes in U.S. power generation and furnishes a good example to other nations. The new rules affect coal-heavy Arkansas more than most states, and demonstrate the foolishness of new coal plants such as Swepco's Turk plant near Texarkana. Environmentalists, along with one of the three Arkansas Public Service Commission judges, recommended in 2008 that the proposed plant be replaced by efficiency, renewables, and natural gas. This would have greatly eased EPA's regulation of Arkansas' carbon emissions. Swepco was terribly wrong about this.

In a major new development, conservatives are finally coming around to the conservative view that we should insure ourselves against future disaster by taking action now on climate change. Former New York Mayor Michael Bloomberg, former Secretaries of the Treasury Henry Paulson and Robert Rubin, former Secretary of State George Shultz, and others have authored a wake-up call titled *Risky Business: the economic risks of climate change in the United States*.

This report's lead author, Henry Paulson, wrote in a New York Times op-ed column: "The solution can be a fundamentally conservative one that will empower the marketplace to find the most efficient response. We can do this by putting a price on carbon dioxide emissions – a carbon tax. . . . Putting a price on emissions will create incentives to develop new, cleaner energy technologies." Better yet, we need a carbon tax and dividend, with all income from the tax going back to consumers as dividend checks. Most consumers would break even between the tax and the dividend, or reap a net profit.

Further good news: climate activism is blooming. The excellent Citizen's Climate Lobby is active in Fayetteville and around the nation, and the People's Climate March will take to the streets of New York City and cities all over the world on 21 September to press for such action as campus divestment of fossil fuel investments. This tactic, by students, was notably effective in changing the former apartheid government of South Africa.

I'm hoping that, with all this upbeat activity, our dear mother Earth is beginning to smile again.

(*Editor's Note*: Art Hobson, Professor of Physics Emeritus, University of Arkansas, is a frequent *Newsletter* contributor. This piece was originally published in the *Northwest Arkansas Times*, 20 July 2014.)

future energy options

(continued from page 20)

ingly obvious from the German "real experiment" — are so great that worldwide research efforts in this energy frontier should be continued, if not intensified.

References

[i] Friedrich Wagner, *Eur. Phys. J. Plus* **129**, 20 (2014); DOI 10.1140/epjp/i2014–14020–8.
[ii] Friedrich Wagner, "Features of an intermittent energy supply," lecture at the EPS-SIF International School on Energy, Varenna, Italy, July 2014.

(*Editor's Note*: Dr. H. Fred Dylla is the Executive Director and CEO of the American Institute of Physics. This article is reprinted from the 4 August 2014 issue of his weekly electronic newsletter, "Physics Matters.")

Adapting to Climate Change

(continued from page 5)

One example they cite of a consequence of rising temperature from climate change is increased insect herbivory. While change in species abundance and distribution *indicate* changes in biotic interactions, they note that only evidence of food web reconstruction is *concrete*. Moreover, consequences of climate change can also lead to further change. And changes in two interacting species might not keep pace with each other.

But "The Future of Species Under Climate Change" according to Craig Moritz and Rosa Agudo might not be so dire, as these authors note that "Whereas forecasts of changes in species' geographic ranges typically predict severe decline, paleoecological studies suggest resilience to past climate warming," as a result of buffering climatic alterations *in situ* by their reactions or genetic adaptation or by moving to a more optimal environment. The last requires the greatest amount of travel in flat terrain, they write, though climates can disappear at the top of mountains, while new climates are expected in the tropics. "So far . . . direct evidence of genetically based adaptation to climate change remains sparse."

Except for "recent megafaunal extinctions, where climate change and human impacts likely combined with devastating consequences," Moritz and Agudo write that there is no paleological evidence of "elevated extinction through periods of rapid change." Even in the twentieth century "it is very difficult to establish causative relationships between warming and population declines or extinction, due to the interaction with other anthropogenic factors such as habitat loss or previously unseen pathogens." Given that geographic change is the predominant response of species to climate change, Moritz and Agudo argue that it is important to preserve ecological refuges for them, especially "potentially sensitive species with long generation times." But they also reiterate that it is important to understand "the capacity of species to buffer effects of climate change *in situ*."

Tim Wheeler and Joachim von Braun address the subject of "Climate Change Impacts on Global Food Security" in terms of the United Nations Food and Agriculture Organization's four criteria:

1. *Availability*. Of the importance of "the *availability* of sufficient quantities of food and appropriate quality" they write that "there is a robust and coherent pattern on a global scale of the impacts of climate change on crop productivity, and, hence on food availability and that climate change will exacerbate food insecurity in areas that already currently have a high prevalence of hunger and undernutrition."

2. *Access*. Of the importance of "*access* . . . to adequate resources . . . for acquiring appropriate foods for a nutritious diet" they write that "access to food is largely a matter of household and individual-level income and of capabilities and rights," studied by top-down macromodels and bottom-up microdata that complement each other. Key elements are preservation of land and water rights.

3. *Utilization*. Of the importance of "*utilization* of food through adequate diet, clean water, sanitation, and health care to reach a state of nutritional well-being, where all physiological needs are met," they write that "Food utilization, to attain nutritional well-being, depends on water and sanitation and will be affected by any impact of climate change on the health environment." Climate change can also bring about "ecological shifts of pests and diseases." Related nutritional stresses include excess caloric intake and reduced physical activity leading to obesity.

4. *Stability*. Of the importance of "*stability* . . . access to adequate food at all times," they write "the stability of whole food systems may be at risk under climate change, as climate can be an important detriment for future price trends as well as the short-term variability of prices." One climate-related shock to food markets came from diverting corn to production of biofuels.

They then formulate "six precepts of the impacts of climate change on food security":

1. "Climate change impacts on food security will be worst in countries already suffering high levels of hunger and will worsen over time."

2. "The consequences for global undernutrition and malnutrition of doing nothing in response to climate change are potentially large and will increase over time."

3. "Food inequalities will increase . . . because the degree of climate change and the extent of its effects on people will differ from one part of the world to another. . . ."

4. "People and communities who are vulnerable to the effects of extreme weather now will become more vulnerable in the future and less resilient to climate shocks."

5. "There is a commitment to climate change of 20 to 30 years into the future as a result of past emissions of

(continued on page 23)

Adapting to Climate Change

(continued from page 22)

greenhouse gases that necessitates immediate adaptation actions. . . ."

6. "Extreme weather events are likely to become more frequent in the future and will increase risks and uncertainties in the global food system."

Wheeler and von Braun call the "adaption actions" they call for in #5 "climate-smart" agriculture.

The last two articles address health consequences of future climate change. The "rates of replication, development, and transmission of . . . pathogens" are expected to depend more strongly on temperature than on any other climate variable, and this is the climate change variable whose effect has been most thoroughly explored, write Sonia Altizer, Richard S. Ostfeld, Pieter T. J. Johnson, Suzan Kutz, and C. Drew Harvell in their article, "Climate Change and Infectious Diseases: From Evidence to a Predictive Framework." They note that investigating infectious disease transfer requires investigating the effect of temperature change on existing or newly-created pathogen-host interactions or, in some cases, the interactions between pathogen and vector and vector and host, and here the observation of Blois, Zarnetski, Fitzpatrick, and Finnegan that changes in two interacting species might not keep pace with each other becomes pertinent. Altizer, Ostfeld, Johnson, Kutz, and Harvell report that their modeling of the temperature change effect on the caribou-nematode interaction predicted the observed shift from one to two annual peaks in nematode transmission. They also observe that biodiversity loss from climate change can enhance disease transmission by eliminating predators or competitors of pathogens or vectors and that milder winters could change migratory patterns by which hosts avoided pathogens. Still another health-related factor connected to climate change is the amount of arable land and its consequences for food supply.

In addressing "Ecological Consequences of Sea-Ice Decline," Eric Post, Una Bhatt, Cecilia Bitz, Jedediah Brodie, Tara Fulton, Mark Hebblewhite, Jeffrey Kerby, Susan Kutz, Ian Stirling, and Donald Walker write that sea-ice loss means reduced habitat for sea-ice algae and sub-ice phytoplankton, also for vertebrates like seals, polar bears, and walrus. It also eliminates a physical barrier to facilitate hybridization between two formerly separate varieties of a species and possibly eliminate a migration which can "shake off" a pathogen or otherwise change the behavior of a species (with positive or negative consequences). Correlated with reduced sea-ice are increased foliage and industrial access to coastal areas. These concerns about reduced sea-ice are shared by Martin O. Jeffries, James E. Overland, and Donald K. Perovich in their article, "The Arctic Shifts to a New World," in the October 2013 issue of *Physics Today*.

Earth Science Week 2014: "Earth's Connected Systems"

Every fall, the American Geoscience Institute (AGI) hosts "Earth Science Week." Earth Science Week (ESW) 2014 promotes awareness of the dynamic interactions of the planet's natural and human systems. This year's events will take place mainly during the week of 12-18 October. "Earth's Connected Systems," the theme of ESW 2014, will engage participants by exploring ways that geoscience illuminates natural change processes. By deepening understanding of interactions of Earth systems – geosphere, hydrosphere, atmosphere, and biosphere – Earth Science helps us manage our greatest challenges and make the most of vital opportunities. To learn more, please visit <http://www.earthsciweek.org/>.

Teachers, parents, and informal educators can order ESW "toolkits" through <http://www.earthsciweek.org/materials/> or calling AGI Publications at 703-379-2480.

In collaboration with Earth Science Week 2014, the AGI is sponsoring three national contests – a photography contest, a visual arts contest, and an essay contest — based on this year's theme, "Earth's Connected Systems." Students, geoscientists, and the general public are invited to participate in this year's photography contest, "Connections in My Community." Entries must be composed of original, unpublished material, and show where you observe the dynamic interactions of earth systems in your community.

This year's visual arts contest, "Earth's Connected Systems and Me" is open to students in grades K-5. Scientists study, for example, how water shapes the land, how living things use air, and how air and water act on each other. How do such connected systems affect you? Use artwork to show how land, water, air, and living things are connected in the world around you.

Students in grades 6 through 9 may participate in the essay contest. This year's essays must address the idea of "Earth System Science in Today's World." Submissions will be judged by a panel of geoscientists on creativity, relevance, and incorporation of the topic at hand. Selected winners will be awarded for their submissions.

(continued on page 24)

Climate Change Impacts in the United States

(continued from page 5)

After this come ten chapters, each presenting the consequences of climate change in ten different regions: the northeast, southeast and Caribbean, Midwest, great plains, southwest, northwest, Alaska, Hawaii, the oceans, and coasts. The last five chapters of the report are on response strategies: decision support, mitigation, adaptation, research needs, and sustained assessment. Of the response options, two play an especially major role in the report: mitigation, "reducing the amount and speed of future climate change," and adaptation, "prepar[ing] for and adjust[ing] to new conditions." All but the last two chapters are presented in the context of key messages, which serve as an organizational framework for the chapter, as in chapter 2. Concluding the report are seven appendices, on Process, Information Quality, Climate Science, FAQs (which themselves constitute a delightful read), Scenarios and Models, Future Assessment Topics, and Abbreviations and Acronyms.

The report's twelve findings are as follows:

1. *Our changing climate.* "Global climate is changing and this is apparent across the United states in a wide range of observations."

2. *Extreme wealth.* "Some extreme weather and climate events have increased in recent decades, and new and strong evidence confirms that some of these increases are related to human activities."

3. *Future climate.* "Human-induced climate change is projected to continue and it will accelerate significantly if global emissions of heat-trapping gases continue to increase."

4. *Widespread impact.* "Impacts related to climate change are already evident in many sectors and are expected to become increasingly disruptive across the nation throughout this century and beyond."

5. *Human health.* "Climate change threatens human health and well-being in many ways, including through more extreme weather events and wildfire, decreased air quality, and diseases transmitted by insects, food, and water."

6. *Infrastructure.* "Infrastructure is being damaged by sea level rise, heavy downpours, and extreme heat; damages are projected to increase with continued climate change."

7. *Water supply.* "Water quality and water supply reliability are jeopardized by climate change in a variety of ways that affect ecosystems and livelihoods."

8. *Agriculture.* "Climate disruptions to agriculture have been increasing and are projected to become more severe over this century."

9. *Indigenous peoples.* "Climate change poses particular threats to Indigenous People's health, well-being, and ways of life."

10. *Ecosystems and biodiversity.* "Ecosystems and the benefits they provide to society are being affected by climate change. The capacity of ecosystems to buffer the impacts of extreme events like fires, floods, and severe storms is being overwhelmed."

11. *Oceans.* "Ocean waters are becoming warmer and more acidic, broadly affecting ocean circulations, chemistry, ecosystems, and marine life."

12. *Responses.* Planning for adaptation (to address and prepare for impacts) and mitigation (to reduce future climate change, for example by cutting emissions) is becoming more widespread but current implementation efforts are insufficient to avoid increasingly negative social, environmental and economic consequences."

The contents of the report or of a shorter 137-page "Highlights" can be "explored" through linked web pages by visiting <http://nca2014.globalchange.gov>. The complete report and the shorter "highlights" can also be downloaded as a pdf at <http://nca2014.globalchange.gov/downloads>.

Earth Science Week 2014

(continued from page 23)

For details, please visit <http://www.earthsciweek.org/contests/>.

The American Geosciences Institute is a nonprofit federation of geoscientific and professional associations that represents more than 250,000 geologists, geophysicists and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in the profession, plays a major role in strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resiliency to natural hazards, and interaction with the environment.

News from Triangle Coalition

ACT Data Reveals Potential New Pool of STEM Students

ACT released new findings on Wednesday that revealed an untapped group of potential STEM students. By measuring students' interests in STEM compared to their future career intentions, the data revealed a gap that, with the proper attention, could provide opportunities to engage more students in STEM careers. *The Condition of STEM 2013*, which includes the annual national report as well as individual reports for each state, is based on responses of students in the 2013 graduating class who took the ACT exam.

Based on a series of questions about preferred work tasks, nine percent of the students revealed "measured interests" that aligned with STEM work, yet they indicated no plans to pursue STEM majors or careers. While ACT's results show that overall STEM interest is high, "students may not be connecting the dots between their innate interests and a potential STEM-related," says Jon Erickson, ACT president of education and career solutions. By identifying students that fall in this category and providing them with early information and guidance on STEM career options, students may be more likely to pursue STEM careers that align with their interests.

For the sake of consistency, ACT categorized its definitions of STEM based on the occupations and majors listed on the ACT. It defined four key STEM areas: science; computer science and mathematics; medical and health; and engineering and technology. The report shows levels of achievement in each of these areas, as well as the actual number of students interested in specific majors and occupations. ACT intends for this data to assist state STEM coalitions and other officials in measuring the numbers of students in specific areas of the STEM pipeline and in citing progress of STEM initiatives.

The report also addresses college readiness, among other related areas. ACT found that at least half of students intending to pursue STEM majors were not adequately prepared for college-level math or science coursework.

"This report gives educators, business leaders and policymakers access to important new information regarding the condition of STEM education in our country," said Lisa Brady Gill, executive director of education policy and advocacy for Texas Instruments, and a member of Triangle Coalition for STEM Education. "We feel it provides much-needed insight that will help us as we work together towards real and meaningful change in this area."

To download *The Condition of STEM 2013* national report, visit <http://www.act.org/stemcondition/13/pdf/Nationa-STEM-Report-2013.pdf>. For individual state reports, visit <http://www.act.org.stemcondition/13/[statename].pdf>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 7 February 2014, reprinted with permission. Please see additional story of page 6 of this issue.)

NSB Report: US Lead in Science and Technology Shrinking

According to the National Science Board (NSB)'s 2014 Science and Engineering Indicators, the major Asian economies now together perform a higher percentage of the world's R&D than the U.S. Growth among emerging economies, including China and South Korea, over the last decade have led to a shift in the global science and technology landscape, with China now engaged in as much high-tech manufacturing as the U.S. The biennial Indicators report provides a comprehensive analysis on the state of the nation's STEM education (at all levels), the scientific and engineering workforce, domestic and international R&D performance, U.S. competitiveness in high technology, and public attitudes and understanding of science and engineering.

The full report is available online at <http://www.nsf.gov/statistics/seind14/content/etc/nsb1401.pdf> and a digest is available at <http://www.nsf.gov/statostocsseomd14/content/digest/nsb1402.pdf>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 14 February 2014, reprinted with permission. Please see additional story on page 8 this issue.)

NAE Report Examines STEM Integration in K-12 Education

The National Academies have released a new report examining current efforts to connect the STEM disciplines in K-12 education. The report, *STEM Integration in K-12 Education*, identifies and characterizes existing

(continued on page 26)

Triangle Coalition

(continued from page 25)

approaches to integrated STEM education, both in formal and after- and out-of-school settings. It reviews the evidence for the impact of integrated approaches on various student outcomes, and it proposes a set of priority research questions to advance the understanding of integrated STEM education.

STEM Integration in K-12 Education proposes a framework to provide a common perspective and vocabulary for researchers, practitioners, and others to identify, discuss, and investigate specific integrated STEM initiatives within the K-12 education system of the United States. And it makes recommendations for designers of integrated STEM experiences, assessment developers, and researchers to design and document effective integrated STEM education. *STEM Integration in K-12 Education* is available online at <http://www.nap.edu/catalog.php?record_id=18612>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 14 March 2014, reprinted with permission.)

NGSS Rubric Now Available

A rubric for evaluating the quality of educational materials for use with the Next Generation Science Standards (NGSS) is now available. The Educators Evaluating the Quality of Instructional Products (EQuIP) Rubric for Lessons & Units: Science (EQuIP) provides criteria by which to measure the alignment with NGSS and overall quality of lessons and units. The rubric is designed to help provide feedback to curriculum developers, recommendations for existing instructional materials, and to identify examples of best practices.

Resources such as this rubric are currently being developed with the support of the NGSS States and Partners to help educators and administrators as they work towards implementation of the Standards. As more NGSS-aligned lessons are developed, this rubric may be updated and scoring guides will eventually be added. Additional materials to complement the rubric, such as a professional development guide, a criterion discussion guide, and publishers' criteria, will also developed. Access the rubric and more NGSS resources at <http://www.nextgenscience.org/>.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 25 April 2014, reprinted with permission.)

STEM Education Poses Major Hurdles to Stakeholders

The American Society of Mechanical Engineers (ASME) hosted an event in April titled, "Critical Thinking, Critical Choices: What Really Matters in STEM." The discussion focused on the significant points of conflict that government, business, education, and engineering leaders confront in STEM education. John Hockenberry, journalist and host of the National Public Radio program "The Takeaway," moderated the 12 panelists through a series of scenarios that explored creative solutions to the problems facing STEM education, such as the ultimate goals of STEM education, the impact of major reforms like the Common Core, and the struggle to allocate resources to the best advantage of the students.

Panelist Ioannis Miaoulis, President and Director of the Museum of Science in Boston, noted that science and mathematics curriculum require updating. Miaoulis argued, "There is a problem when students are learning how a volcano works, but not how the engine of a car or a plane functions when their chances of needing to know how a car works is much higher than the same for a volcano." Miaoulis also mentioned the importance of incorporating disciplines such as engineering and math to maximize time in a school day.

Pat Wingert, Journalist at Hechinger Institute on Education and the Media, recommended a push-back against the "I'm not good at math" mantra that entraps many students and adults alike; he also highlighted the need for effective teacher preparation in order for STEM programs to be successful.

James Douglas, former governor of Vermont, spoke of the positive impact that the Common Core State Standards can have on STEM education; while the standards do not mandate curriculum, their capacity to raise expectations has the potential to pave the way for an increased focus on STEM fields as early as junior high, Douglas explained.

However, sociologist and professor of Public Policy at Rutgers University, Hal Salzman, expressed concern that fields such as the humanities could suffer as a result of heightened attention and resources dedicated to STEM fields.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 14 May 2014, reprinted with permission.)

(continued on page 27)

Triangle Coalition

(continued from page 26)

NSF Panel Discusses the STEM Workforce

The National Science Foundation (NSF) recently hosted a panel presentation and discussion entitled, "Growing the STEM Workforce of Tomorrow." Presenters included Suzanne Berger, of the Massachusetts Institute of Technology (MIT); Jonathan Rothwell, from the Brookings Institution; and Patrick Kyllonen, of the Educational Testing Service's Center for Academic and Workforce Readiness and Success.

Berger examined the skills gap from a workforce perspective and findings that the pervasive assumption among manufacturers is that there is a lack of skilled American workers. In a recent survey, 75% of manufacturers reported that they were able to fill jobs within a month of vacancies, while the remaining 25% took up to 3 months and reported lack of skills as their major barrier. Berger's research suggests that the skills gap can be attributed to the restructuring of manufacturing companies so that they are no longer vertically integrated and investing in job training, leading to major holes in capabilities both of companies and of workers.

Rothwell suggested that the definition of STEM jobs is so narrow that it excludes many jobs based in STEM, such as the majority of the medical field. His research indicates that up to 20% of the jobs in the U.S. are STEM related if the definition is broadened to more accurately reflect the labor market.

Kyllonen ended the panel discussion by noting that policy makers must support research to assess cognitive, interpersonal and intrapersonal skills to better prepare students for 21st century jobs.

(*Editor's Note*: The preceding item was excerpted from the Triangle Coalition STEM Education Bulletin for 22 May 2014, reprinted with permission.)

Research Opportunities for High School Students: An Untapped Resource

There has been an explosion of interest in secondary students in Science, Technology, Engineering and Mathematics (STEM) research. Academic institutions and business entities are investigating the plausibility and positive ramifications of working together to encourage high school students to discover the excitement and possibilities afforded by STEM research. Many high schools are forming new positions for science faculty that deal specifically with helping students to complete research projects that are instrumental in building a student portfolio with peer reviewed publication experience.

The National Science Foundation (NSF) provides supplemental grant opportunities for high school students, K-12 teachers, community college teachers, undergraduates and veterans to participate in ground-breaking, entrepreneurial research experiences. These opportunities are part of a bigger program called the Small Business Innovative Research (SBIR) grant program. These are grants awarded to high-risk enterprises that provide a dynamic pathway to educate and train human capital. Most people are aware of the research opportunities that are inspired by NSF for teachers and undergraduates, but little is known about the possibilities for high school students.

NSF's Directorate of Engineering in the Division of Industrial Innovation and Partnerships directs the supplemental grant resources necessary for high school students to investigate STEM research at a commercial level. These high school students are participating in authentic research and producing publishable material that is being recognized in peer-reviewed journals. In the beginning, RAHSS experiences were solely coordinated and instructed by research scientist, engineers and sometimes the principal investigators themselves, because of the small nature of these exploratory units.

More recently, the concept of these teenage investigators collaborating with undergraduate students and educators is catching on. Some of these research assistantships for high school students (RAHSS's) are coupled with research experiences for undergraduates (REU's), some with research experiences for teachers (RET's), and some are incorporated into teams of all three types. This is a novel approach that incorporates the problem-based learning which is so highly touted by Next Generation Science Standards (NGSS) and the Common Core. It also provides for added safety and a better management of time, especially for the research scientist or engineer who is mentoring the team.

Over the past few years, STEM major declaration at the university level has been flat-lining and retention is showing little sign of improvement. Inspiring secondary students by involving them in research will create more potential STEM majors and provide the necessary motivation for undergraduates to persevere through the challenges posed to most science and engineering students. The enthusiasm of RAHSS participants will hopefully be contagious to curious peer observers and motivate more

(continued on page 28)

Triangle Coalition

(continued from page 27)

discoveries of the possible options afforded to potential STEM investigators.

Another dilemma facing societal needs in this area is the gender gap and stagnant growth in the participation of underrepresented groups. For example, approximately 1 out of 10 mechanical and electrical engineers are female. The participation of underrepresented groups is similarly stagnant. However, progress in this area could be enhanced by the participation of secondary students from these groups in research projects with business or academia.

Because of the altruistic nature involving high school students in research, it is easy to forget that the relationship is actually symbiotic. These budding investigators provide valuable input and perspective to the creative process involved in design and discovery. Current researchers are incorporating high school students, whether in business or academia, creating the potential for high impact.

Vast resources of human capital can be extracted if research opportunities are provided for students at the secondary level. Partnerships are formed, vision is enhanced and innovation is spawned with the participation of high school students in research, especially in an entrepreneurial context. The transformation of generations of scientists, inventors, engineers and mathematicians is on the horizon.

Learn more about research assistantships for high school students by e-mailing Steve Griffin, 2013-14 Albert Einstein Fellow at <stgriff@nsf.gov>. Steve Griffin is a high school science teacher from Baton Rouge, LA, serving the 2013-14 school year as an Albert Einstein Fellow at NSF, Directorate for Engineering, Industrial Innovation and Partnerships. Griffin wrote this item for AEF Newsletter – Issue V, June 2014.

New report details more geoscience job opportunities than students

In the American Geosciences Institute's newest Status of the Geoscience Workforce Report, released May 2014, jobs requiring training in the geosciences continue to be lucrative and in-demand. Even with increased enrollment and graduation from geoscience programs, the data still project a shortage of around 135,000 geoscientists needed in the workforce by the end of the decade.

"Industry has recognized, and is mitigating the upcoming shortage of skilled geoscientists in their employ, but the federal geoscience workforce is still demonstrably shrinking" report author Carolyn Wilson said, noting that the federal geoscience workforce decreased in all sectors except meteorology; this includes geoscientists skilled in the energy, mining/minerals and hydrology fields. Combined with continued unevenness is the workforce readiness of many geoscience graduates and a regionally hot job market, the geosciences are a dynamic component of the U.S. economy.

Employers have appreciably skilled geoscientists to choose from too. Numbers of graduating geoscience majors who started their degrees at a two-year colleges have increased, as have the number of students participating in a field camp experiences—an important facet of a geoscience degree, where students get experience interpreting the landforms critical to determining where energy or water resources exist, as well as interpreting locations susceptible to hazards like flooding or landslides. Most students graduating from a geoscience degree program have taken math courses up to a calculus-II level, but there is still concern from employers over whether these students are graduating with enough quantitative experience to be completely apt for a career in the geosciences.

Employers underscore the necessity of having enough skilled grads to meet vacancies that will exist in the geoscience sector in the upcoming decades.

"It's important that working knowledge is passed down because losing the institutional knowledge could have negative impacts for the overall productivity of these companies." Wilson said.

"Most importantly there is incredible potential for institutions to recruit from the diverse talent pools arising at two year institutions, and many career opportunities available to students enrolled in geoscience programs, and early-career geoscientists entering the workforce," Wilson said. "Plus, this is the first time we have seen a major shift in employment patterns in over a generation, with increasing number of bachelor recipients securing geoscience positions, and newly minted Master's finding themselves in high demand." The report is available from the following link: <http://bit.ly/GeoWorkforce>. The American Geosciences Institute is a nonprofit federation of 49 geoscientific and professional associations that represents more than 250,000 geologists, geophysicists and other earth scientists. Founded in 1948, AGI provides information services to geoscientists, serves as a voice of shared interests in the profession, plays a major role in

(continued on page 29)

Triangle Coalition

(continued from page 28)

strengthening geoscience education, and strives to increase public awareness of the vital role the geosciences play in society's use of resources, resiliency to natural hazards, and interaction with the environment.

Preparing for a Shortage of Feds in Science and Tech

While the federal government has developed a strategy to close the workforce gap in science, technology, engineering, mathematics and medical fields, little has been done to address specific gaps in these fields in the federal government, according to a new report.

The report, released last week by the IBM Center for the Business of Government, found that there is currently no governmentwide plan to recruit and retain entry-level STEMM employees, nor an effort to train up existing mid-career STEMM employees for senior leadership positions at their agencies.

"While the need for STEMM succession planning is clear, there has been insufficient action on this challenge," the report stated. "It requires a great deal of forethought, planning and adaptability, given the rapid changes and budget cuts faced by agencies."

The IBM Center identified four key drivers that require increased focus on STEMM succession planning at federal agencies: a pending retirement wave of senior STEMM staff, delayed development of the STEMM talent pipeline as positions are left vacant as a result of budget cuts and sequestration, fewer STEMM graduates entering the federal workforce versus the private sector, and a lack of qualified candidates to fill vacant senior-level STEMM positions.

A report released last year by the Partnership for Public Service and Booz Allen Hamilton outlined how agencies can leverage tools already at their disposal to effectively recruit, hire and retain professionals in STEMM fields. That report indicated that STEMM fields are more top-heavy than other federal job fields, with 74 percent of federal STEMM workers over the age of 40, and just 7.6 percent under age 30.

"The cumulative impact of generational trends, such as government employment boosts in the 1970s, federal downsizing in the 1990s after the Cold War, and lack of recruitment of the Millennial generation, have created a need for strategic and effective succession management," the report stated.

The IBM Center identified six best practices for agencies to implement STEMM succession planning:

1) Formulating a strategy for STEMM succession planning to account for rapid changes in STEMM fields;
2) Identifying mission-critical positions to fill in the event of attrition and the knowledge, skills and abilities necessary for success in those roles;
3) Expanding career development for STEMM employees both at the beginning and middle of their careers to better prepare them for senior leadership roles;
4) Tracking and validating the professional development and performance of candidates in the STEMM succession pool;
5) Implementing effective onboarding programs at various career levels that outline the unique aspects of an agency's strategic mission;
6) Developing metrics to track and measure the progress and effectiveness of STEMM succession programs.

Agencies also should not have to start from scratch when beginning STEMM succession planning, instead borrowing best practices from other agencies and customizing procedures to meet their own unique needs. Agencies also should emphasize mentoring, job rotations and project-based learning experiences to help groom up-and-coming STEMM leaders for more senior-level jobs, the IBM Center noted.

"Succession planning programs already in place throughout federal agencies are an underused resource," the report states. "The needs and mission of agencies are a common foundation that can initiate sharing and program development."

(*Editor's Note*: The preceding three items were excerpted from the Triangle Coalition STEM Education Bulletin for 6 June 2014, reprinted with permission.)

GAO Study Examines Relationship between STEM Education and the Workforce

In June, the U.S. Government Accountability Office (GAO) reported that the number of degrees awarded as well as the number of jobs in science, technology, engineering, and mathematics (STEM) have both increased in recent years. STEM degrees increased by 55 percent from 2002-2012, compared to a 37 percent increase in all other non-STEM degrees. In addition, the number of STEM jobs grew 16 percent faster than non-STEM jobs.

(continued on page 30)

REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Emma Ideal and Rhiannon Meharchand (eds.), *Blazing the Trail: Essays by Leading Women in Science* (2013). 265 pp. ISBN 1482709430. $9.15.

As I read this book, I wished it was available during my teaching career. One primary goal for my career was to be successful in helping the girls in my classes to see science in general, and physics and chemistry in particular, as enjoyable. I wanted as many young women to consider careers in science as the number of young men. Female scientist role models are not typical, and I would have liked to have had copies of this book available for my students.

I already had evidence that I had achieved the goal, and this book provided additional evidence. I had the good fortune to have one of the editors, Rhiannon Meharchand, in my high school classes for three years. She is now working as a post doc at Los Alamos National Laboratory.

I became aware of the book while reading an article about self-publishing in the November 2012, issue of *Physics Today*. The decision of Ideal and Meharchand to self publish their book is described in the article. I was very excited to find Dr. Meharchand's name in the article.

The book consists of essays written by thirty-five women who have successful careers in physics or a related field. Each essay opens with Bona Fides, providing evidence that all of them have had extensive experience in their field, and have experienced great success. Each essayist offers advice for young women considering careers in science, and information regarding the reasons for their success. The essays also include stories about challenges they overcame to become successful. Cathryn Carson, currently at UC Berkeley, writes of a lab tech telling her "he didn't believe women belonged in physics." Esther Conwell, now at the University of Rochester, writes that early in her career, she did not get hired for a position at IBM because the company had a rule against hiring married women. Lillian McDermott received a Higgins Fellowship for her first year at Columbia. She writes how later, a Nobel Prize winner in the

(continued on page 32)

Triangle Coalition

(continued from page 29)

In light of recent debate over the level of severity of the STEM workforce shortage, the study was conducted in order to shed light on the degree to which STEM education programs are aligned with workforce needs. GAO classified STEM fields under three areas: core STEM; healthcare STEM; and other STEM. The study examined STEM education trends related to the numbers of degrees awarded and jobs available, the extent to which federal postsecondary programs address workforce needs, and the extent to which federal K-12 programs prepare students for postsecondary STEM education.

GAO found that nearly all 30 of the surveyed K-12 STEM education programs sought to prepare students for postsecondary STEM education. Likewise, nearly all of the 124 participating federal postsecondary STEM education programs addressed workforce needs in some way. While most of the programs reported having some outcome measures in place, GAO found that some programs' performance measures were not aligned with stated objectives.

To read more about this study and its finding, access the report at <http://www.gao.gov/products/GAO-14-374>.

Achieve Releases State Science Education Standards Comparison Tool

Achieve, Inc. has released a new resource for comparing state science education standards. The *State Science Education Standards Comparison Tool* is designed to assist state and district leaders and administrators who are considering adoption or revision of standards. The tool enables users to compare different sets by going through a series of questions that will clarify how each set of standards was developed and how they compare on addressing key aspects of science education. With the structure and purpose of new state science standards, including the Next Generation Science Standards (NGSS), varying greatly from existing standards, traditional comparison tools may not fully reveal the differences between sets. The State Science Education Standards Comparison Tool can be downloaded from the NGSS Resources page.

(*Editor's Note*: The preceding two items were excerpted from the Triangle Coalition STEM Education Bulletin for 2 July 2014, reprinted with permission.)

RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

1. Gautam Dantas and Morten O. A. Sommer, "How to Fight Back Against Antibiotic Resistance," *Am. Sci.*, **102** (1), 42-51 (Jan-Feb 2014).

Following the first clinical use of penicillin in 1946, the development of new antibiotics was a rapidly expanding field through the 1960s. "But starting in the 1970s, a dwindling interest and ability of the pharmaceutical industry to develop new antibiotics resulted in a 40-year period when virtually no new broad-spectrum classes of antibiotics were brought to the market. . . the number of antibiotics approved by the Food and Drug Administration (FDA) hit a record low of one new antibiotic in the five-year period from 2008 to 2012, down from 16 new drugs in the years from 1983 to 1987." But this didn't stop bacteria from developing further resistance to the antibiotics that had been in use.

Although many might think of developing resistance to antibiotics as a matter of "vertical transmission" of mutations, this article tells us "that horizontal transmission may be the dominant force behind growing antibiotic resistance," and that horizontal transmission can result from three types of interactions of bacteria with other bacteria: transformation, transduction, and conjugation. Moreover, there are plenty of other bacteria for bacteria to interact with: not only in the soil and environment around us but also in ourselves – since the number of bacteria in the human microbiota is ten times the number of human cells, "any invading pathogen is more likely to interact with bacterial cells than human cells."

Modern molecular genetics have enabled us to identify the *resistome* (which is defined as "the entire suite of genes from a particular microbe or microbes, which confers antibiotic resistance") of any bacterium or group of bacteria. The goal is to use our understanding of the genetic makeup of bacterial resistomes to understand how these resistomes have evolved and develop strategies to resist them in pathogens that invade our bodies. "Understanding factors that influence resistome evolution and dissemination may both extend the life of current drugs and point toward new disease-fighting strategies."

2. Ashanti Johnson and Natasha D. White, "Ocean Acidification: The Other Climate Change Issue," *Am. Sci.*, **102** (1), 60-63 (Jan-Feb 2014).

While increased atmospheric carbon dioxide increases atmospheric temperature through the greenhouse effect, increased carbon dioxide in the oceans leads to other consequences, largely because more dissolved carbon dioxide means more acidity. Already the decrease of 0.1 in the pH of the world's oceans since the start of the Industrial Revolution has increased the oceans' acidity by 30%, and "estimates based on business-as-usual scenarios from the Intergovernmental Panel on Climate Change (IPCC) suggest that if current trends persist, oceanic pH could drop by another 0.5 unit by the end of this century . . . a 150-percent increase in acidity."

This article points out that transition metals are largely bound up in insoluble carbonates and hydroxides in the ocean, but that increased acidity would release them as soluble ions in the ocean, a result with both favorable and unfavorable consequences. More free ionic copper competes with natural odorants for binding sites in some species, thus impairing their ability to smell. But more free ionic iron could stimulate photosynthesis. Increased carbon dioxide can cause some species to engage in more photosynthetic production, while decreased amounts of insoluble calcium carbonate will make it difficult for species that rely on calcium carbonate shells.

3. Vince Beiser, "The Deluge," *Pacific Standard*, **6**(2), 36 -45 (Mar-Apr 2013).

The "deluge" in this article is of natural gas and oil in the United States, resulting from such new technologies as "fracking." One consequence of it has been to reduce the percentage of oil imported by the U.S. from nearly two thirds to less than half. "Within a decade, the U.S. is expected to overtake Saudi Arabia and Russia to regain its title as the world's top energy producer." Once again economics has played into the hand of continued reliance on fossil fuels, to the detriment of our climate (which receives short shrift in this article) and the development of renewable energy sources (which "are having a harder time than ever competing now that natural gas is dirt cheap").

4. *Discover Your Changing World with NOAA*, 52 pp., available online at <http://oceanservice.noaa.gov/education/discoverclimate>.

This book consists of ten activities for middle-high school students:

(continued on page 32)

TEACHERS CLEARINGHOUSE FOR SCIENCE AND SOCIETY EDUCATION, INC.
17 Honeyflower Lane
West Windsor, NJ 08550-2418

RESOURCES

(continued from page 31)

1) "The Great Glowing Orb" introduces the Sun as a source of energy by having students make a solar heat engine.
2) "The Climate Team" introduces the roles of the ocean, atmosphere, clouds, ice, land, plants, and animals by having students make a solar cooker.
3) "Climate is Our Friend . . . Isn't It?" introduces the interaction between organisms and climate by having students make an extinction polyhedron.
4) "Climate,Weather . . . What's the Difference?" introduces students to temperature by having them make an electronic temperature sensor.
5) "How Do We Know?" introduces other data determining climate by having students make a weather vane, barometer, and rain gauge.
6) "I Didn't Do It . . . Did I?" introduces students to the greenhouse effect but comparing the temperature in bottles containing air and carbon dioxide (produced by mixing vinegar and baking soda).
7) "Why Should I Care?" shows the effect of carbon dioxide by its effect on red cabbage water.
8) "Are You Climate Literate?" is a Jeopardy-type game, with ten questions in each of three categories: climate, system, causes of change, and effects of change.
9) "Communicate!" asks students to communicate by developing messages about climate change.
10) "The Incredible Carbon Journey" has students play the "Carbon Journey" game, in which they insert colored beads onto a pipe cleaner as a consequence of visiting the biosphere, hydrosphere, atmosphere, and lithosphere as the result of rolling cubes to determine where to go next.

5. Richard Van Norden, "The Medical Testing Crisis," *Nature*, **504**, 202-204 (12 Dec 2013).

Most of the world's technetium-99m used in diagnostic scans is made by the Chalk River reactor in Canada and the High Flux Reactor at Petten in the Netherlands. With the former slated to end production in 2016 and the latter to do the same in 2022, new sources are clearly needed. One proposal would be to replace the reactor with a shower of neutrons from the reaction of deuterium and tritium in a linear accelerator. Instead of producing the short-lived (6-hour half life) isotope, another proposal calls for producing technetium-99m from the decay of its longer-lived parent molybdenum-99m directly in a local network of cyclotrons by bombarding molybdenum-100 with protons.

REVIEWS

(continued from page 30)

department commented "the Higgins Fellowship had at least succeeded in promoting romance."
The Bona Fides also provide information about physics research being done by these intelligent women. Christine A. Aidala "presently researches nucleon structure and quantum chromodynamics." Shirley Chiang "specializes in using high resolution microscopy to image solid surfaces with atomic and molecular adsorbates." Janet Conrad "is developing new experiments that use high-power cyclotrons to produce neutrinos at high rates." Esther Conwell "has been researching and publishing on the transport of excess electrons and holes in DNA." Lucy Fortson "studies Active Galactic Nuclei (AGN) using multi-wavelength observations to determine the source of gamma-ray emission from AGN." Ann-Marie Novo-Gradic "led the design team for the laser subsystem in the Mercury Laser Altimeter instrument for the Messenger mission to Mercury."

Ideal and Meharchand selected excellent role models as essayists for this book. This informative and enjoyable book will make a significant contribution toward making the trail blazed by these scientists well worn.

\- Frank Lock