NETWORK OF EDUCATORS IN SCIENCE & TECHNOLOGY

Working to Promote Science Literacy in association with the Massachusetts Institute of Technology

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Contents

Co-Chair Report

Eric Klopfer

As I look forward to planning SEPT this summer, the biggest part of my plan involves hoping for no additional blizzards or superstorms that involve pushing the school year further out. Beyond that, we are building on last summer's successful program to create a great program this summer. The presenters last year seem to have enjoyed the experience just as much as the participants, so we have a group of enthusiastic presenters and some new domains to throw into the mix.

One thing that is for sure about SEPT 2013 is that it will be on a different campus than SEPT 2012. Don't worry, it is still at MIT, but the campus is changing rapidly, specifically with respect to teaching and learning. There are many efforts underway to both export some of the great teaching and learning experiences that we have, as well as create more effective teaching and learning on campus through digital technologies. It is both exciting and sometimes frightening how fast this is moving. I hope that we can get a glimpse of that this summer.

In other news, our science and math game Radix (which was going by the name "Cosmos" when last I updated you) is coming along in development and we should be launching it to the public late this summer. We'll be looking for high school biology and 10th grade math teachers to participate. When details emerge, I'll send them along to the NEST discussion list. We'd welcome anyone and everyone's participation.

Finally, for those of you interested in the trials and tribulations of new educational technologies, you might be interested in checking out my new book: "The More We Know: NBC News, Educational Innovation, and Learning from Failure."

MIT-GWU Program in STEM Policy

Ron Latanision

For many years I have thought that it would be useful to expand the orientation of MIT's *Science and Engineering Program for Teachers* to include an opportunity for our members to become involved in the process by which educational policy evolves. I have therefore enlisted a longtime friend, Michael Feuer, Dean of the Graduate School of Education at George Washington University and a senior education officer at the National Research Council prior to joining GWU, to host a 4-day session at GWU in Washington in July of 2013. His faculty, which has been very much involved in the educational policy dialogue,

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Ed Reform: Vision-Impaired

Lois Kenick [NEST '00]

I had the remarkable good fortune to grow up among the results of great educations. I learned from tales of wooden ships and iron men who jury-rigged major parts of their ships and, when necessary, could beach their many-tonned vessels and carry out major projects to rebuild and repair while sustaining themselves on uninhabited islands. I learned from stories and diaries of settlers, hunters and gold seekers of their abilities to connect successfully what they had with what they needed, and I own a couple of the small, blue-covered paperbacks they traded along the trails—Shakespeare, Greek philosophers and the like. They hungered for excellent stories—and wrote a few, too.

I thrilled to stories told by **Bette Bridges [NEST '90]** about her dad's shade-tree mechanics turned soldier keeping Gen. Patton's tanks

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Calendar of Events

June 23-July 29
Science and Engineering Program for Teachers at MIT

June 27
McNamara Workshops (Thursday)

June 28
Teacher Awards are presented at the Annual Dinner (Friday)

June 28-June 29
NEST June Retreat at MIT (Friday & Saturday)

September 1
Submission deadline for the fall newsletter

November
Renew membership

January 15
Deadline for membership renewal

January 18
NEST Executive Meeting

January 29
Deadline to send letter of interest to Lauren McNamara for Research Experience for Teachers (RET) at MIT

Perception of Teachers

[These excerpts are from an article by David Bosso, 2012 Connecticut Teacher of the Year, which appeared in *The Hartford Courant* on April 3, 2012.]

Regardless of where you stand in the education reform debate, in Connecticut or nationally, it is critical to appreciate how perceptions of educators and schools affect the important work that is carried out every day….

Undoubtedly, the most important variable in achieving and maintaining educational excellence is the way in which teachers, schools and education as a whole are regarded. Perhaps the single greatest contributing factor to teachers' effectiveness is their self-perception, which derives from support, respect, feeling valued and having a voice….

One of the constants that becomes obvious when studying international comparisons of educational systems over the decades, no matter the country, is that high achievement corresponds with the positive, even exalted, perceptions of teachers and education.

Teachers are educated, professional experts. Teachers' concerns are valid, and they must be the central part of any reform process. The key to true, enduring educational reform in Connecticut and nationally is a cultural paradigm shift regarding teachers, schools and education. Anything less is counterproductive and a dereliction of the obligation we all have—teachers, parents, community members, politicians, the media, businesspeople and so many others—to ensure that all of our children receive an excellent education.

Editorial

Forty-five years ago, during my freshman year in college, I read *The Teachings of Don Juan* by Carlos Castanada. The following is from page 79:

> When a man starts to learn, he is never clear about his objectives. His purpose is faulty; his intent is vague. He hopes for rewards that will never materialize, for he knows nothing of the hardships of learning.

(Since my high school days, I've been recording meaningful quotes and am now in my sixth notebook. A few of these quotes are scattered through this newsletter.)

This excerpt influences the way I teach, as students repeatedly ask, "Why do we need to know that?" My response is that I estimate that 80% of what is learned in high school will never actually be needed. However, which 20% will be useful varies from student to student.

I try to get them to understand that the facts they learn are not important. They can always look up facts, if they know how to do meaningful research. What is more important is learning how to learn, how to communicate clearly, how to answer questions, how to work together with others, how to push themselves to new levels. If they learn such skills, they will be able to succeed in life. This is why they are in school and why I push them, rather than merely let them pass my classes without gaining something. I often give them choices, but they are responsible for the choices they select.

My philosophy of learning has been condensed into two sentences. They are posted in the central position in the front of the room:

"If you are willing to work, you will learn how to learn and you will earn a good grade. If you are not willing to work, you are in the wrong room."

This has served me well for over 39 years now. If you think it will help you, you are welcome to adopt it and apply it in your class, too.

Clean, Secure Energy Supply

[This excerpt is from an editorial statement in the January 2013 issue of *Scientific American*.]

U.S. energy policy must be guided by two intertwined goals: guaranteeing the security of the nation's energy supply and limiting runaway climate change. A tax on the carbon dioxide emissions of fuels is key to achieving both. A firm carbon price would encourage individuals and businesses to shift away from carbon-heavy fuels such as petroleum and coal. It would also encourage the development of next-generation energy sources that we will need if we are to secure the country's energy supply for the coming decades. The president and Congress must also end the market-distorting subsidies given out like Halloween candy to industries across the energy spectrum—from coal and oil to wind and solar. Without a level playing field and a steady price on carbon, companies cannot assess whether advanced technologies such as "clean coal" power plants or electric vehicles will ever make economic sense.

INFORMATION EXCHANGE

To get the application form for the 2013 NEST Student Award, contact Lauren McNamara at lmcnamara@mit.edu. This year's book will be *Einstein's Dream* by Alan Lightman. If you have any questions, please reply **directly** to Lauren. **Please submit your submissions by Monday, April 8th**.

Two things to note:
1. Please make sure you indicate when your school's student award banquet is, so you can get the certificate and book on time.
2. Lauren will be doing another order of NEST Student Award Plaques. If you need a plaque, please indicate it on the form.

Avi Ornstein [NEST '89] has a website (www.aviornstein.com) and every weekend a new puzzle is posted, plus the answer to the previous week's puzzle. To encourage students to think outside the box and expand their mental abilities, he offers an excused homework pass to the first student in each class who solves the puzzle each week. If a student thinks he or she has the answer, the directions are to write name, period and the answer on a sheet of paper, fold it in half, and hand it directly to him. He writes on the outside the date and time. At the end of the week, he goes through and finds out who (if anyone) earned the excused homework pass in each class. There is a limit of earning five passes per marking period.

Other teachers use this and you are welcome to do so too. If you are unable to come up with the solution one week, that is no problem, as you will not have to admit that to anyone. Remember, the answer will be available during the weekend. As an alternative to an excused homework, you can offer extra credit—which is what he did before the school set a policy of no extra credit on grades. If you have questions, drop him a message at aviornstein@gmail.com.

Bill Smith [NEST '04] is the co-author of The American Chemical Society Guidelines and Recommendations for the Teaching of High School Chemistry which just came out. Copies can be downloaded at the www.acs.org. The ACS will also mail physical copies.

Ken Brody [NEST '91] advocates NO weapons in schools. He also believes in taxing or placing excessive fees on bullets, as our society is too macho to give up their weapons. If you want to discuss this with Ken, contact him at kwbrody@mit.edu.

Teresa Caracciolo [NEST '02] suggests that if you have not seen a video of Nick Vujicic, the man with no arms and no legs, you should do so. A good example is the video at www.youtube.com/watch?v=AW579icDRSA. You should then show it to your students, as it can help them put aside the things they view as limitations and difficulties and may instead have a positive outlook and meaningful goals.

Jenn Rubow [NEST '98] had taught a summer engineering enrichment program to students who they were trying to encourage taking more challenging classes. The idea was that, if shown that they have the ability to be successful on these design projects during the summer, they should try harder classes during the school year. It worked, as students who were regular level students opted for chemistry and physics honors classes. They struggled, but they stuck it out.

So she wanted to incorporate some of the projects into her physics and chemistry classes. The materials needed were expensive, so she wrote a grant that would cover the cost of the materials and she wound up receiving $850.00. They have thus far done the first two scale projects (scale drawing of the classroom and making a "mini-me") and are now building a scale model of a deck that must support 10 textbooks. The students are given limited resources. (In this case they have 6 foam strips 1"x12", 3 paper clips, 3 straws, 12" of masking tape and a piece of paper.) The other two projects will be building a straw two-story building that can support one kilogram and a tooth pick bridge that can support one kilogram.

The purpose of the projects is to foster an appreciation and understanding of the human-made world by infusing engineering into the physics classes. They will follow the engineering design process that consists of the following general steps: define a problem, design a solution, build the model, test the model, identify and analyze the problems or failures with the model, rebuild the model and retest. Using these steps, they will investigate scale, build an elevated floor, build a building and build a bridge. Each of the nine weeks has started off with a new project. It hits different types of learning and gives the creative students an opportunity to shine.

If interested in more information, please contact her at jenn.rubow@palmbeachschools.org.

Worthwhile Websites

Susan Kelly [NEST '10] brought these to our attention:
www.youtube.com/watch?v=i_f3SkxTWxc&feature=fvwrel
www.youtube.com/watch?v=BYK3W9WqbGw&list=UUvGMGQC8gNkd4gwxSbABIlw&index=8&feature=plcp

American Museum of Natural History answers FAQs about dinosaurs: http://bit.ly/PGWkfN

MIT has a website of student-made videos at http://k12videos.mit.edu

An intro to chemistry at MIT is at http://ocw.mit.edu/bootcamp

A set of chemistry tutorials that may help your students is available at www.chemteam.info/ChemTeamIndex.html

A petition regarding "Test Score Mania" is at www.LearningIsMore.org

Julianne Opperman [NEST '97] identified this NSF survey of math and science education:
www.horizon-research.com/2012nssme/wp-content/uploads/2013/02/2012-NSSME-Full-Report1.pdf

Continued from page 1 "MIT-GWU Program in STEM Policy"

will make available sessions at the University and also arrange visits to Capitol Hill and to other offices in Washington that deal with the evolution of education policy and its implementation in our schools. During this inaugural extension of the program we are planning to bring a group of twenty NEST members to Washington for meetings and discussions with people involved in science education policy. This would happen during the week of July 14, and as in the case of SEPT we would house everyone either in GWU dormitories or in nearby hotels. At this stage, we are still working on finding the resources to make this work. My purpose now is to give you a heads up and to identify 20 people who would be interested in attending, provided that we do find funding sources. I am confident that we will find the resources to make this work. **So, if you are interested in participating, please contact Lauren promptly at lmcnamara@mit.edu.**

Below is a working schedule for this program. The schedule is in development, but will generally follow the themes listed.

I am very enthusiastic about the collaboration with Michael Feuer and his colleagues at GWU. It seems to me that teachers are not often enough included in the decision making processes that affects their profession and their classrooms. We have members among our NEST crew who could become genuine contributors in this process and I would like to give them the tools to take up that opportunity. I hope that you will become one of those members during the coming summer.

Washington, DC
July 14 to July 18, 2013

Partnership Program invites NEST middle and high school science, engineering and technology teachers to engage with GW's Education School leadership, faculty and students and policy and practice partners concerning new and ongoing federal STEM initiatives.

Participants will visit Washington, DC where they will have presentations, lectures and conversations related to innovations in research related to science, engineering and technology offered by members of federal departments and agencies, STEM policy advisors, leaders of organizations associated engaged in the development of teaching and learning standards and K-12 student assessments. Every effort will be made to establish Congressional visits with elected officials (from participant's districts) and/or their key staff members.

Sunday, July 13

Participant travel to DC: Casual Evening Welcome Gathering

Monday July 14

Opening Breakfast

Welcome by GW University leadership and Co-hosts: Ron Latanision and Michael Feuer

Introduction to the week, guests and schedule of seminars, meetings and visits—Federal Policy and STEM Education: Goals and Challenges—Representatives from the Executive Branch, Department of Education, related Departments and Agencies

Morning Lecture and Panel Discussion

Remainder of Day—visit to the National Science Foundation—Meetings and Roundtable with Program Officers and Policy Appointees

Tuesday, July 15

K-12 STEM Dilemmas: Building School's Capacity

Morning Lecture and Panel Discussion—American Association of Teacher Education, the NEA, AFT representatives

Lunchtime Preparation for Afternoon Congressional Visit

Afternoon—Scheduled time with Congressional Staff Members on STEM-related Committees and possible Congressional office visits

Roundtable debrief of Congressional Visits: Setting agendas

Wednesday, July 16

Morning—The Role of the National Academies
Guests from the National Research Council

Afternoon—Shaping and Informing the Government and the Nation
The Work and Role of Membership Organizations & NGOs

Presentation and Panel Discussion by the American Chemical Society and Related Guests

Visit to the American Chemical Society

Chemical Society Meetings & Possible Reception

Thursday, July 17

Next Steps and Issues in Science Policy Impacting Educators
Michael Feuer & Ron Latanision, Moderators
Guests TBD

Thinking about Learning

[These extracts are from an article by Nicholas Negroponte that appeared in the November/December 2012 issue of *Technology Review*.]

I believe we get into trouble when knowing becomes a surrogate for learning. The meteoric rise of modern instructionism, including the misguided belief that there is a perfect way to teach something, is alarming because of the unlimited support it is getting from Bill Gates, Google, and my own institution, MIT.

…if a child can learn to read, he or she can read to learn….

…If kids in Ethiopia learn to read without school, what does that say about kids in New York City who do not learn even with school?

The message will be very simple: children can learn a great deal by themselves. More than we give them credit for. Curiosity is natural, and all kids have it unless it is whipped out of them, often by school. Making things, discovering things, and sharing them are key. Having massive libraries of explicative material like modern-day encyclopedias or textbooks is fine. But such access may be much less significant than building a world in which ideas are shaped, discovered, and reinvented in the name of learning by doing and discovery.

Kudos

Beate Brase [NEST '11] worked at the CERN LHC (Large Hadron Collider) in Geneva, Switzerland, last autumn. She also participated in a German program equivalent to SEPT. In addition, she has received the "MINT (Math, Informatics, Nature, Technology) Teacher of the Year" award from the Minister of Education of Lower Saxony, Germany for bringing the latest research to school, initiating a students' lab and successful participating in science competitions and international networking with NASA, ESA, MIT and CERN. The award includes a donation of $6700 for her future schoolwork.

Bette Bridges [NEST '90] and **Harvey Gendreau [NEST '95]** were the only non-commercial live demo presenters at the NSTA San Antonio conference.

Joyce Gleason [NEST '92] will be serving on the Program Committee for the NSTA Boston National Conference in April of 2014. She also continues to serve on the Judging Panel for NSTA's New Science Teacher Academy.

Eric Klopfer has become a full professor at MIT. He also coauthored a new book last September—*The More We Know*.

The school where **Sue Matthews [NEST '95]** teaches, University High School of Science and Engineering [Hartford, CT], was voted the #1magnet high school in the U.S. by the Magnet Schools of America.

Peter McLaren [NEST '95] was selected to serve as a member of the National Academy of Science's Assessment Framework Committee for Performance-Based Assessments.

Elly-May O'Toole [NEST '10] will have a photography show at the Marion Art Center in Marion, MA, from April 26 to June 1, 2013.

Bhavna Rawal [NEST '09] received the Wilhelmina C. Robertson Excellence in Science or Mathematics Teaching Award from the Houston Museum of Natural Science. She also collected oceanographic data in south Florida as an NOAA Teacher at Sea, which came from the Japan Fulbright fund.

Steve Rocketto [NEST '90] received the Wright Brothers Master Pilot Award from the Federal Aviation Administration for 50 years of contributions to aviation safety.

The Guilford High School physics team of **Raisa Roginski [NEST '02]** won the Yale Physics Olympics against 50 teams from throughout the state and beyond.

Science in Europe

[These excerpts are from an editorial by Maire Geoghegan-Quinn that appeared in the June 29, 2012, issue of *Science*. She is the European Commissioner for Research, Innovation and Science.]

Science is a necessity, not a luxury. The world is facing challenges on a scale not encountered before, including climate change, geopolitical upheaval, and demographic shifts. This has made policy-making more complex than ever, and informed decisions require the best evidence-based knowledge and advice we can produce. Science is also the key to our economic recovery. In Europe, countries that have invested in research are weathering the recent crisis much better. Innovative companies are more resilient, continuing to attract customers with the best products and services. So investment in science is investment in competitiveness and jobs…

The challenge now is to make sure we bring everyone along for the ride. The European project is based on progress, and science means progress. But the old models of doing science from on high are obsolete. We have to collaborate more widely across countries and across disciplines to meet our current challenges. We have to explain better what science is doing and why, in language that nonscientists can understand. We need to encourage more children to study science, not just so they can participate in the knowledge economy, but because a basic understanding of science is essential for living in an ever more complex and technological world.

The Science Pipeline

[This excerpt is from an article by Jeffrey Mervis that appeared in the July 20, 2012, issue of *Science*.]

The metaphor of a leaky pipeline is a fixture in discussions of whether enough U.S. students are pursuing careers in science and engineering. And scholars have explored in great detail why so many who profess a passion for science lose the inclination as they move through the education system.

However, a new book on the over-all health of the U.S. scientific enterprise argues not only that the pipeline isn't leaky, but that it's the wrong metaphor. "There is little evidence that science suffers a 'leaky pipeline' during the college years that disproportionately steers students away from scientific fields and toward non-scientific studies," write Yu Xie of the University of Michigan, Ann Arbor, a sociologist and longtime analyst of the scientific workforce, and Alexandra Killewald, his former doctoral student, who this month joined the faculty at Harvard University.

Xie and Killewald argue that the pipeline paradigm ignores two important variables: students who obtain an undergraduate science degree after switching from a non-scientific field, and those who drop out of school before earning any degree. Those omissions, the authors assert, make the pipeline a fatally flawed description of a system that they believe is actually doing a pretty good job of meeting the country's need for scientific talent.

While that conclusion goes against the accepted wisdom, experts find the new book persuasive….

How to Bring Why to Generation Y Science Education

Helen Flavin [NEST '10]

As an overworked educator sitting at yet another PD day, have you ever said to yourself, "Science as inquiry—enough with the education buzz words! My time is valuable. Cut to the chase and show me how and why this is important. Even better, show me how to make this happen in my classroom in the here and now!"? If so, you have gained insight into the mind of a Generation Y student. Via Internet and social media, such students have instant access to all facts and knowledge known to mankind. However, what is not immediately apparent in their ocean of facts is "why this knowledge is important for me in my world right now." Once we answer their "why" with a challenging puzzle they come to life, ready to assemble the facts and then find their own solution. Even better, we harness their competitive spirit so that the "work" of learning is now "fun" for them. If you would like some ideas about how to design and create your own such activities, this article is for you.

Let's start with the image of a young teacher completing a project for his master's degree. He was asked to tape one of his pre-lab and lab exercises. I was in my second or third year of HS teaching and had a "free" period that time slot, so the camera was in my hands. He gave the students excellent directions; they entered lab with the lab report sheets; the lab began—and the students only half paid attention to the lab and, to be honest, started fooling around. I thought to myself that this isn't fair to him. He has done a great deal of work with the lesson. I will not tape students disregarding what a colleague has taught them. I killed the sound on the recording. I said to the group in front of me, "You are scientists. Please explain to the camera what you are doing, what you will determine and why this is important." I clicked the sound back on and, yes, you guessed it. That group, then the ones on either side and soon each member of the class wanted to be the scientist explaining it all to the viewer.

I am not saying it is as simple as bringing in a camera to science class each day. However, what we need to do to elevate science education can be described simply as creating opportunities that, as above, allow students to highlight and show off their knowledge. The only thing that this requires is that we, as educators, design problems and assignments that demand students to be scientists who decipher the data then explain it to the world.

Believe it or not, a great place to start with developing these types of questions is the landmark or defining experiments for science. These are the experiments that set the stage for what we now know about topics. Traditionally, we present this information to students, have students memorize these experiments and, finally, ask students to repeat/explain them. Part of that scientific emphasis is respecting the great researchers who faced the unknown and found a way to do an experiment that revealed a new scientific truth. Another reason for the emphasis on these landmark experiments is the simple truth that they drove further scientific inquiry which then determined those "facts" now so easily found on the Internet. However, appreciation for all of that depends upon one's ability to perceive context. This traditional approach, designed to foster admiration and respect often precipitates the diametrically opposed response of a generation Y student, whose words "everyone knows the genetic material is DNA, so who cares what those ancient scientists did?" suddenly seem at first glance disrespectful and reflective of disinterest in science.

Part of that may be related to the specifics of Generation Y. However, it is my opinion that a significant part of that relates more to the developing adolescent brain—a brain just beginning to be able to utilize context to acquire deeper understanding. Thus, as educators, we need to either focus some time and thought to putting the student back in time and in the context of the original question or be creative. Move the original experimental question to a modern setting where the answer to a Generation Y student is as yet unknown. With this, we guide those students to be the scientists making the discovery. As they do so, they also experience for themselves both the context of and effort required to resolve the question.

For one specific example of how to design a project like this, let us consider how to design an assessment (for freshman biology students) based upon the 1950s landmark experiments of Hershey and Chase that resolved the question of whether proteins or DNA were the genetic material. The first step in the process is to break down the experiment into smaller, "essential understanding" pieces. The Hershey and Chase experiments require that students understand: pathogens (disease-causing organisms) inject something into cells that then makes those infected cells produce more pathogens; the injected materials could be one or more of the biological chemicals DNA, RNA, proteins or carbohydrates; scientists need a way to label each of those chemical types so they can "see" what was injected; and, finally, scientists need a tool to measure what was injected. Our next step is to review the conclusions of the Hershey Chase experiments. The experiments were important because they allowed scientists for the first time to correlate transfer of a chemical (DNA) with genetic activity (converting infected cells to factories for pathogens). The final step in the process is the creative part for us. We need to use the above analysis to find a way to translate that landmark science experiment into a question students can examine, utilizing what first year biology students know about molecules of life, cell culture and microscopes.

Traditionally, students learn about the lytic cycle as they learn about Hershey and Chase. So, fine, let's call point 1 background material that we need to provide. Let us utilize a black and white electron microscope image of a disease organism injecting something into a host cell. Next, explain or review the host cell undergoing the lytic cycle, or have the exercise incorporate a figure illustrating this. With this, the Generation Y student now knows we can use a microscope to "see" something injected into a cell. Further, this gray thing that is injected—what is it? How can we figure that out?

Suppose we could color each of the four possible molecules of inheritance? Suppose our microscope could detect those colors? Our Generation Y student could then use the "color injected" into the cell to determine the molecule! Even better, since we are taking the liberty to create this model, there is nothing for them to try to find on the Internet to shortcut having to think it all out for themselves!

First year biology curriculum emphasizes building blocks of macromolecules. In addition, our students take biology before chemistry, so emphasizing the building block as an individual characteristic for a class of macromolecules is a bit easier for the Generation Y student to use in the science experiment. In addition,

those students who are ready (and interested) in the knowledge will say something like: "Colored pieces of molecules! How do scientists really do this?" They have been challenged, have become invested in their learning and are now willing to look deeper into chemical structures and molecular modeling. These students now have a mind ready to understand (not just memorize) radioactive tracers in phosphorous (DNA) and sulfur (proteins), so guide them to it.

For the rest of the students who are content with colored tags for chemicals, let us create an active problem for them to solve. Our problem will be the raging debate about this new infectious agent from Mars. Earthlings finally sent a vessel to and from Mars. However, it came back from Mars contaminated with something. This pathogen is very infectious and, eventually, deadly. The only hope for mankind is that it takes some time for the pathogen to take over human cells and make them into "pathogen factories" (via lytic cycle). It is hoped that scientists can identify the genetic material for this pathogen so that they can then use this knowledge in order to develop drugs to protect mankind. The pathogen has been found to contain four classes of chemical compounds: carbohydrates (label the sugar/glucose - red); proteins (label the amino acid cysteine - blue); RNA (label the uracil - yellow); and DNA (label the thymine - purple). For HS freshmen it is sufficient to suggest the compound labels are fluorescent color tags visible with their electron microscope. They can imagine/view their human cell culture cells being infected by the disease agent and then see which label(s) are injected.

You do not have to duplicate the data from the defining experiment. That is part of the power of the assessment tool you have created. The Generation Y students will be looking to the landmark test as a resource (or, if your assessment is a question on a test instead of an independent project, students will be remembering the defining experiment). Initiate their work with the question "Using the vocabulary of science, sketch and/or explain an experiment that will allow you to determine whether the Martian organism is similar to earthly plants and animals in using DNA as the genetic material." Later, if you make the Martian organism inject "green stuff" into the cell being infected, the students will conclude the Martian genetic material is a mixture of RNA and protein.

After grading the assignment, as you debrief, you can go further by introducing a "planet Earth" retrovirus and the enzyme reverse transcriptase. Yes, HIV sends both RNA and protein into an infected cell! An excellent resource is the HIV coloring book page at www.biologycorner.com/worksheets/HIV_coloring.html. In completing this assignment, students will be examining HIV RNA, DNA and then mRNA. It thus serves as a bridge to the next biology curriculum unit on DNA to proteins. In addition, bringing in the HIV aspect to the inquiry assessment project readily leads to project extensions either with biology curriculum work with enzymes, research on HIV drugs and how they work, or even just a thinking question about how to try to block retrovirus use of DNA while still allowing the human (infected) cells to use their own DNA. The answer to this last question brings us to the answer to the original assessment theme we created regarding the Mars pathogen. In addition, the blockade of retroviral production in infected T-cells allows human T-cells to remain active, meaning the immune system remains active, meaning a slowing of disease progression to AIDS.

From this one exercise, Generation Y students now have an appreciation for the context of the original landmark experiment. They have found that they are "as smart" as those "ancient scientists", have assembled and creatively utilized facts and knowledge to solve a new question on the materials; and in doing so, have learned Biology curriculum that meets or exceeds state standards, have had that self-esteem boosting moment of "I can do this" and, most importantly, have had a glimpse into trying to solve some of the current unknowns or cutting edge issues of the scientific world.

This first article presented step by step guidelines for designing and creating exercises that place Generation Y students as scientists who must solve a problem. The second column in this series will highlight selected Internet resources and project ideas for freshman biology through AP biology. Topics will include: Nobel Prize winning research (such as the 2006 work with RNA Interference); MSOE Center for BioMolecular modeling Jmol Molecular stories; National Center for Case Study Teaching in Science (NCCSTS) Resources; MIT Opencourseware; and virtual labs such as the Drosophila virtual fly lab (genetics and chromosomal basis of inheritance), transgenic fly lab and the Design Studio (where students work on a rational drug design program).

Sleep and Academic Performance

[This article is a report on a study that appeared in the October 2012 issue of *The Science Teacher*.]

Regardless of how much a high school student studies, if he sacrifices sleep to do it, he's more likely to have academic problems the next day, according to a study by the University of California, Los Angeles (UCLA). The results appear in the journal *Child Development*.

"Sacrificing sleep for extra study is counterproductive," says Andrew J. Fuligni, professor of psychiatry and behavioral sciences at UCLA, who worked on the study. "Academic success may depend on finding strategies to avoid having to give up sleep to study, such as maintaining a consistent study schedule across days, using school time as efficiently as possible, and sacrificing time spent on other, less essential activities."

For 14 days in each of the 9th, 10th, and 12th grades, 535 students from several Los Angeles-area high schools reported in diaries how long they studied, how long they slept, and whether they experienced two academic problems—not understanding sole thing taught in class or performing poorly on a test, quiz, or homework.

Although the researchers expected that extra hours of studying that ate into sleep time might create problems in students' understanding of what's taught in class the next day, they were surprised to find that diminishing sleep to study was actually associated with doing more poorly on a test, quiz, or homework.

Fuligni said the study's findings do not suggest that teens should spend less time studying overall, but that those teens who give up sleep to study more than usual are more likely to have academic problems the following day.

Education's Future

[This editorial by Norman R. Augustine appeared in the January 25, 2013, issue of *Science*.]

Recently, a highly regarded newspaper publisher, perhaps thinking of dinosaurs while speaking of his own profession, remarked to me that "We are all dead; some of us just don't realize it yet." He is of course not alone in his lament: Remember videocassette recorders, carbon paper, and mechanical typewriters? Various writers have warned that it is not the strongest of the species that survives, or the most intelligent, but rather the one most adaptable to change.

Which brings us to what may be America's greatest asset after its democracy and free enterprise system—and also the most resistant to change: its higher education system. Indeed, with the exception of religious institutions, it is difficult to think of any more intransigent entity. The canonical student, professor, book, blackboard, and piece of chalk have survived for centuries as the ingredients of pedagogy throughout the world.

But then came the technological revolution, accompanied by declining U.S. financial support for higher education and the advent of globalization. Given those pressures, one could postulate that, for example, the university of the future will have no library because students will carry it in their pockets; and that there will be no classes, as adaptive, interactive, computer-taught lessons will have taken their place. Lectures will be provided, courtesy of distance learning, by a few world-class professors located around the globe. Biometric identity verification will permit examinations to be held far away from any campus, with instant grading accomplished by teaching-assisted computers. Universities will operate 12 months a year. Departments will cease to exist and tenure will disappear, the victim of mounting financial pressures. The great state universities, responding to continually reduced government funding, will become quasi-private institutions, with most unfortunately lacking adequate endowments. For-profit firms will be created to conduct examinations based on course material placed online without charge by the world's most renowned universities and will award certificates of completion. Players in intercollegiate athletics will be unionized and highly paid, as are their coaches today, and perform before small crowds that serve as studio audiences for multimedia production. And many more individuals will be able to afford what passes for a college education.

Awful? Perhaps. Possible? Probably. The lack of face-to-face interactions among students and faculty will certainly diminish the educational experience. But with tuition now ranging from $10,000 to $50,000 per year, all but the wealthiest of parents and students may get used to the idea. Most damaging will be the further bifurcation between the wealthy and the poor, with children in the former group attending the best campus-based institutions that manage to survive and the others relegated to a computer screen. Even today, the best predictor of the extent of a child's education is its parents' educational level (and, implicitly, wealth).

Technology is good, but it is important to control it so as to benefit and not harm higher education. This will require that national leaders recognize the enormous return from investments in research. It will also require state leaders to embrace the huge payoff realizable from supporting higher education. And it will require university leaders to better control the cost of education. Also urgently needed is a rethinking of such matters as the balance of emphasis or research and teaching in our great universities; the balance of academic and intercollegiate athletics; the sustainability of universities serving as a backstop for a failing precollege education system; the efficacy of U.S. immigration policies, particularly as they affect students; and the impact of the 15-hour study-weeks revealed by recent surveys of university students.

When I became the chief executive officer of a large aerospace company, the Berlin Wall had just collapsed. Had I been told that within 6 years 40% of all the people in the industry and three-fourths of its companies would be gone, I would have said, "Not possible." It happened.

RECOMMENDED READING

[The following articles are highly recommended to be read, by both those reading this newsletter and also appropriate students.]

Editors; "Can the U.S. Get an "A" in Science?"; *Scientific American*; August 2012; p. 12.

Anderson, Mark; "Bring Back the Cold Fusion Dream"; *Discover*; October 2012; p. 16.

Carey, John; "Global Warming: Faster Than Expected?"; *Scientific American*; November 2012; pp. 50-55.

Falk, Dan; "Time Warped"; *Smithsonian*; January 2013; p. 16.

Fertik, Michael; "A Tale of Two Internets"; *Scientific American*; February 2013; p. 13.

Gopnik, Adam; "Moon Man"; *The New Yorker*; February 11 & 18, 2013; pp. 103-109. [Note: This article is about Galileo.]

Lovejoy, Thomas; "A Tsunami of Extinction"; *Scientific American*; January 2013; pp. 33-34.

Lowe, Derek; "America Does Not Have a Scientist Shortage"; *Discover*; November 2012; pp. 10-11.

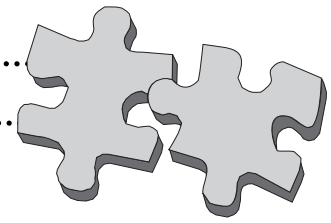
Miller, Jon D.; "The Value of Bringing Science Home"; *Scientific American*; August 2012; pp. 64-65.

Tanenbaum, Jacob; "Creation, Evolution and Indisputable Facts"; *Scientific American*; January 2013; p. 11.

Willingham, Daniel T.; "Brain Science in the Classroom"; *Scientific American*; September 2012; p. 14.

Zimmer, Carl; "Can Boosting Immunity Make You Smarter?"; *Discover*; March 2013; p. 66.

PUZZLE CORNER



#1) What color is grass?

#2) On a piece of paper, draw two small circles about five inches apart from one another.

O O

Close (or cover) your left eye and hold the paper at arm's length, having the left circle in front of your right eye. Slowly bring the paper toward yourself, focusing on the left circle. At a particular distance, the right circle disappears. If you come closer, it reappears. Why?

Solutions to the previous problems:

#1) When you view a rainbow after it rains, the rainbow is actually inside your eye! The light is diffracted by the raindrops that are in the sky, but the diffracted light must be focused by a lens to create a rainbow. That lens is in your eye. Your brain perceives the sky you are viewing and the superimposed rainbow and interprets the rainbow to be in the sky. This is why the rainbow seems to move away when you try to approach it.

People have raised the question of why rainbows can be photographed. Like the eye, a camera has a lens, so the rainbow also exists inside the camera and is similarly superimposed on the film!

#2) The arrival of the brown rat may have saved Europe. It is larger and more aggressive than the black rat and may have displaced it, moving the black rat (and its fleas) out of households.

Fracking

[This excerpt is from an article by Michael McElroy and Xi Lu that appeared in the January-February 2013 issue of *Harvard Magazine*.]

The first step in extracting gas from shale involves drilling vertically to reach the shale layer, typically a kilometer or more below the surface. Drilling them continues horizontally, extending a kilometer or more from the vertical shaft, and the vertical and horizontal components of the well are lined with steel casing, cemented in place. The horizontal extension of the casing is then perforated, using explosives; thereafter, water, carrying sand and proprietary chemicals, is injected into the well at high pressure. The water encounters the shale through the perforations, generating a series of small fractures in the rock (hence the nickname, "fracking"); the sand in the water keeps the cracks open, while chemicals enhance release of gas from the shale. The injected water flows back up to the surface when the pressure in the well is released following completion of the fracking procedure. Then the well starts to produce natural gas.

As many as 25 fracture stages (per horizontal leg) may be involved in preparing a single site for production, each requiring injection of more than 400,000 gallons of water—a possible total of more than 10 million gallons before the well is fully operational. A portion of the injected water flows back to the surface, heavily contaminated with the fracking chemicals and others it has absorbed from the shale. Depending on the local geology, this "return water" may also include radioactive elements.

Drillers developing a well must take exceptional care to minimize contact between the wellbore and the surrounding aquifer—often the source of nearby residents' fresh water. Serious problems have arisen in the past from failures to isolate the drilling liquids, including cases where well water used for drinking becomes so contaminated that human and animal health was threatened. It is essential that monitoring be in place to ensure the continuing integrity of the seal isolating the well from the aquifer even *after* the well has been fully exploited and abandoned.

A fraction of the contaminated water that returns to the surface is recycled and reinjected into the well to facilitate the next phase of the fracking process. But a large portion is stored temporarily in lined ponds on site for eventual transfer (most commonly by truck) to conventional water-treatment facilities. Care must be exercised to protect groundwater from spillage and to guard against potential leakage from the ponds. Moreover, the facilities to which the contaminated water is eventually transferred may be ill-prepared to deal with the challenges posed by its unusual chemical composition; for instance, conventional treatment facilities are not equipped to deal with radioactive materials—which under the circumstances could be transferred to the water bodies receiving the treated effluent.

Finally, careless drilling and production from fracking wells can result in fugitive emissions of methane from the shale below. Such inadvertent releases of methane could more than offset the advantages otherwise realized by reducing emissions of CO_2 through substituting natural gas for other fuels.

The International Energy Agency (IEA) recently proposed steps to ensure responsible extraction of gas from shale. If these procedures are implemented, the IEA concluded that the increase in production costs should be relatively modest—7 percent or less—and that the integrity of the environment could be protected. The IEA conclusions appear overly optimistic in the U.S. context: the costs for design and implementation of sensible regulations for the domestic shale-gas industry are likely to be significantly greater—but still tolerable. The problems are neither technical nor economic, but essentially political.

Two Perilous Metals

Avi Ornstein [NEST '89]

The neighbors of thallium on the periodic table have been known since antiquity. One is lead and the other is mercury. Both have historical roles that have influenced our lives that are worth knowing.

The symbol for lead is Pb, based on the Latin name for lead, which is plumbum. It was used to make pots and other common items, as the metal is very malleable. It was also used in making plumbing, explaining the etymology of that word.

Lead is harmful to our health. Lead poisoning is the accumulation of lead in the body. As it builds up over time, it damages organs and tissue, including the heart, the reproductive and nervous systems, the bones and the kidneys. At higher levels, it is toxic and can result in death. In the case of lead-poisoning in children, who are especially sensitive under the age of six, the damage to the nervous system results in permanent learning and behavioral disorders.

One of the most common forms of exposure has been lead-based paints. White lead, which is lead (II) carbonate ($PbCO_3$), and chrome yellow, which is lead (II) chromate ($PbCrO_4$), are the two most commonly used of these poisonous oil-based paints. Their bright colors have made them very popular and they have been used for ages. (The first description of how to prepare white lead was in the 750s by the Arabic alchemist Abu Musa Jabir ibn Hayyan.) These chemicals have been used regularly by artists and in painting houses, until the latter use was banned in 1978, though they are still allowed for painting road lines. House paints can chip and then may be ingested by small children. The lead from these paints can also get into our bodies in the form of dust or by getting into the soil and thus being taken into the food we eat.

Thirty years ago, in 1983, Jerome Nriagu wrote a controversial book relating the fall of the Roman Empire to lead poisoning as it caused a deterioration of the members of the upper class, who ingested more lead. Lead was present in the water piping, but that was not the only source. They cooked in lead pots and lead therefore contaminated the foods. For example, vinegar can leach out lead (II) acetate ($Pb(C_2H_3O_2)$). It was known as sapa or the sugar of lead. It was the first artificial sweetener and was added to food and wine and was also used as a perfume.

As a counterpoint to the idea of lead in the plumbing causing the decline in Rome, Roman literature of the time included statements showing their awareness that lead piping was injurious. Nonetheless, lead can get into our own water from old lead pipes and from the solder used in piping. As a health precaution, everyone should let water run until it is cold before using it for drinking. In addition, hot water should not be used for drinking or cooking.

Looking at lead from a different perspective, lead is the end product of several chains of radioactive decay. This dense, stable metal is therefore used for x-ray shielding. It is what accounts for the weight of the protective 'cloth' that is placed over your body when you have dental x-rays.

Mercury, like lead, was one of the seven metals known in ancient Rome. Seven 'planets' (including the sun and moon) were known at that time, and one 'planet' was matched with each metal. Alchemists used the symbol for each planet to represent the corresponding metal. While lead was identified with Saturn, mercury was identified with Mercury, which is how it got its name. The symbol for mercury is Hg, again based on a Latin name. Hg is short for hydrargentum—quicksilver. The name refers to the fact that mercury is silvery in color and is the only metal that is a liquid at room temperature.

Over time, mercury has had many uses. The fact that it is a liquid led to it being used in thermometers and barometers. It is also used in every fluorescent bulb. The metallic mercury vapor inside the bulb conducts electricity that then excites the fluorescent paint on the inside of the tube. Since heat does not need to be generated to produce the light, it is more energy-efficient than incandescent bulbs. A much higher percent of the electricity goes into creating light and the bulbs last far longer. If you use a spectral tube to observe a fluorescent bulb, besides seeing the complete spectrum produced by the fluorescent paint, you will see the colors produced by the excited electrons of the mercury—purple, blue, green and yellow-orange.

Starting in the mid-seventeenth century, mercury was used in curing felt. A process called carroting was used to make high-quality men's hats. The extended exposure affected those working in the profession, leading to the phrase "as mad as a hatter" and, in turn, to the Mad Hatter, a main character in *Alice in Wonderland*. Mercury poisoning can cause sensory impairment (including speech), a lack of coordination and disturbed sensation—hence the 'mad' hatters.

The medical hazard of mercury poisoning was discovered in 1956 in Minamata, Japan. Methylmercury (CH_3Hg^{+1}) was present in the wastewater released into Minamata Bay by the chemical factory of the Chiso Corporation. It got into the fish in the food cycle. One impact of this poisoning was that cats virtually disappeared as they died due to eating contaminated fish. Fish was a major part of people's diets, and they suffered tightened muscles that led to a crippling effect and difficulty in both walking and speaking. It also causes convulsions and came to be known as the Minamata disease. Over 2200 victims have been certified in the past half century.

Mercury poisoning can be treated if it is identified early enough. Chelating agents can be used to remove the mercury from the body. The fear of mercury poisoning has grown since then. As an example, it caused a shutdown at one high school where I formerly worked when a student brought in and then dropped a mercury thermometer. Mercury from fluorescent bulbs and from batteries is a small but measurable source of mercurial environmental contamination. This should be kept in mind when fluorescent bulbs no longer work. Rather than throwing them in the garbage, they should be returned to a store where they are sold so they can be handled properly.

> ...no set of ideals, no constellation of institutions, is so hallowed by tradition that it should stand outside the possibility of critical scrutiny and, if necessary, substantial alteration. Institutions exist to serve human welfare, and when they fail to do so they should be changed or abolished. Tradition is not the only criterion of value for assessing the worth of institutions. The real test of their worth is how they serve human beings.
>
> —G. Max Wingo
> The Philosophy of American Education

Serendipity

"Where observation is concerned, chance favors only the prepared mind."
—Louis Pasteur, 1854

[Despite the clearly organized, sequential pattern of the "scientific method," many great advances in science have NOT followed that pattern. They were due to tangential aspects of the research or accidental discoveries that were noticed by researchers with prepared, observant minds. This column shares such fortuitous accidents with you so that they then may be shared with others—especially students—to gain a better, more honest picture of how science has progressed. Perhaps it may alter their attitude in the lab, looking at what actually occurs, rather than just looking for what they expect will happen.]

Serendipity does not only apply to science. An accident made Ruth Graves Wakefield one of the most famous women inventors of the 20th century.

Born in 1905, she graduated from the Framingham State Normal School Department of Household Arts in 1924. With her degree, she first worked as a dietitian and lectured on food. This changed when she and her husband, Kenneth, bought a tourist lodge in Whitman, Massachusetts, named the Toll House Inn. Her role included preparing the recipes for the meals served to their guests.

She gained local notoriety for the deserts she prepared. Butter Drop Do cookies were one of her favorite recipes. Baker's chocolate was a necessary ingredient for these chocolate butter cookies. However, when she was preparing some in the 1930s (the actual year is open to debate), she found that she was out of that ingredient.

She had a semi-sweet chocolate bar that had been a gift from Andrew Nestle of the Nestle Chocolate Company. Cutting the bar into bits, she added it to the mixture, thinking they would melt into the batter when heated. However, the bits softened, but they did not melt. Wakefield published the recipe in several newspapers. As the cookies became very popular, sales of Nestle's semi-sweet chocolate bar increased. Andrew Nestle bought the recipe, agreeing to print it on its packaging and, in addition, Ruth Wakefield would have a lifelong supply of Nestle chocolate.

The resulting cookies got to be known as Toll House chocolate chip cookies, the most popular cookie in America. Seven billion are eaten annually and they account for an estimated half of all homemade cookies!

Mobilizing Scientific Societies

[These excerpts are a sequel to "Skin-Deep Learning" and appeared in the December 14, 2012, issue of *Science*.]

…The situation has proven highly resistant to change, and it continues to have a disastrous, long-lasting effect on the attitudes of students toward science (millions of whom are now adults). The main culprit is the strong demand for a broad "coverage" of each subject, which kills student interest and makes genuine comprehension almost impossible. At the precollege level, this push is driven by state-based textbook adoption policies, by high-stakes examinations, and—inadvertently—by a scientific community that largely fails to understand teachers' needs. How might science be mobilized to support a much more inspiring, in-depth form of science education?

Many beautiful stories lie at the heart of science. Consider, for example, the beginning of life for an animal like ourselves. Somehow a single fertilized egg cell is able to multiply to give rise first to a tiny embryo and then, through many cycles of cell growth and division, to an adult animal composed of thousands of billions of cells. This process requires that cells behave like tiny computers that store a memory of where they have been in the embryo, selectively expressing only those genes appropriate for their time and place in the giant "cell cooperative" that is a multicellular organism. Amazing time-lapse videos have been produced by researchers that could be enhanced with age-appropriate narrations to make this biology come alive….Yet, a 700-page life science textbook for 12-year-olds selected by the state of California (with a glossary of 500 words) never challenges students to consider the fascinating question of what cells must be produced by an embryo, focusing instead on introducing them to many hundreds of dry "scientific" terms and a multitude of associations to memory.

If funds were devoted to quality research in schools to ascertain what students actually learn from curriculum materials, a textbook like this could never survive. Badly needed are materials for teachers that guide students to confront a phenomenon such as embryo development and then, working in small groups with skillful coaching, to imagine potential ways to explain it….

To facilitate such teaching, scientists will need to work in close partnership with outstanding teachers and other education experts—not only to research the effect of current curriculum materials and teaching methods on students (thereby advancing the science of education), but also to develop new, validated, Web-based curricula that address the critical national (and international) need for inspiring, in-depth lessons.

I propose that a set of scientific societies in different disciplines (covering biology, chemistry, physics, earth, and space sciences) be recruited for the above validation purposes….

The deadline for publication
in the next issue is: **September 1**

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Continued from page 1 "Ed Reform: Vision-Impaired"

wheeling and roaring across Europe, the secret soldiers keeping the Nazis guessing about where the D-Day invasion would occur and Marine aviation mechanics in the Pacific theatre making serviceable planes out of cannibalized wrecks to be flown against the well-equipped and entrenched Japanese. Women, too, from all these eras did what was needed: they made planes and flew planes; they ran businesses and did all kinds of necessary caring and manufacturing activities; they grew the groceries that were used on the table, even killing and preparing small animals for cooking.

My Mum made children's coats by cutting down and reassembling discarded adult ones (as had her Mum). My Dad moved a two-story barn to the land next door and made a house out of it. He used railroad tie cribbing, bottle jacks, pipe rollers, a small Ferguson and my ten-year-old cousin (for communication). Most of the men and women I grew up around were actively participating citizens and, while they were proudly American, they were also Polish, Italian, Shoalers and all the other tribes, with the mores and beliefs I didn't grow up around but know are there from reading the authors they produced and meeting them and their children here and there around America. These men and women were ready for whatever workplace their lives took them to—their work built and saved America. Their creativity and thinking built a world-leading nation.

So tell me again why the children and grandchildren of such people need to be Number One in the world only at some kinds of math or science. Tell me again why those children and grandchildren need to be tested again and again to see if they can color in little circles, even if they learn and perform better with real stuff in their hands? Tell me again why they have to be deprived of some kinds of knowledge and experiences in order to race to the top of yet another mountain of little circles. Tell me again why children with budding interests and skills in performing and visual arts should be hammer-fitted into—or is it onto?—STEMs where their spirit will likely wither and die.

Especially tell me these things when a number of well-designed and carefully done studies strongly indicate that, once the number of children who receive subsidized lunches at a given school is accounted for in the data treatment, many of these "failing" schools equal or surpass the "winning" schools in TIMMS, PIRLS and other acronymically named test scores. And a study by a leading university shows that many jobs are being moved offshore by businesses, not because there are more, better-trained engineers or workers available at the new address, but because the new address is closer to intended and expected markets. Go ahead! Tell me, because I think that perhaps, just perhaps, the proof of the efficacy of education is in what its recipients do in *their* world with *their* life and gifts, and many of us who contribute to what they do probably won't live to see them at it. How then will we be able to count their correctly chosen circles?

Even conceding that the new core and new generation curricula and standards are well constructed by thoughtful, highly educated and, in a few cases, classroom-experienced teachers, the question must be asked whether the things of those reforms are the things we should be doing. Do these well-intentioned people show any indication of what sort of education their designs, if implemented, will produce? We know so much more about how and when and under what circumstances people learn, the documents produced by these people, at least the supporting array, should give us some vision of the education the standards will engender and what unintended consequences and collateral damage might occur to individuals and America.

Here's my alternative. Especially in its mission statement, it presents the education that the people I have described got from somewhere, most of them not from much formal schooling. We need to find a way to incorporate that effective education into at least some of the schooling our society provides to the children and grandchildren (and beyond) of those people. We need to identify what they need to attain to achieve that education, and use our new-found knowledge of learning to help their attainment. The present new stuff is a good start on that. Then we need to figure out where we fit into the process and live by it—even be evaluated on it.

A mission statement is the broadly stated vision of the purpose of an organization's existence.

A. It is the mission of American education to develop the use of their minds sufficiently to:

1. Equip our sons and daughters to live in and cope with a rapidly changing and increasingly complex world.
2. Enable them to contribute to the common good.
3. Enable them to find joy in their own existence.

Sometimes called objectives, these B-level statements identify specifically what the organization must attain or produce to accomplish its mission. Often an acceptable, measureable level is quantified. Within each B-level statement are many specific sub-components; for example, what constitutes communication, what constitutes acceptable writing, video production, etc.?

B. Fulfillment of this mission requires that our schools enable the successful attainment of:

1. A high level of competence in general skills applicable to the work of any discipline. Among these skills are communication, the gathering, organizing and interpreting of numerical and non-numerical information, critical and creative thinking and the skills of efficient and effective learning.
2. A sense of one's self within his or her physical, socio-economic, cultural and historical environments.
3. A respect for the value and contribution of individuals of diverse races, creeds and abilities.
4. A sense of the planet—the patterns of relationships between its biotic and abiotic components and the effect of humankind's activities upon them.
5. A sense of the workplace and how it functions as well as the ability and interest to acquire specialized skills as the need arises.

Often key personnel or groups identify their contribution to each applicable objective. Here is a sample.

C. My Mission as a Teacher:

I work in support of the mission of American education. I am in the business of helping people to grow in their understanding of my subjects, to grow in their ability to see and use my subjects in their lives and their society and to grow in their willingness and ability to challenge themselves and judge their own performance honestly and fairly.

To accomplish this mission, I must:

1. find ways to involve each student in the material of the course
2. seek examples of applying my disciplines to all disciplines to bring to my classes
3. renew my delight and improve my competence in my disciplines
4. provide for each student an appropriate challenge that will enable them to attain some new mark in their life and celebrate that achievement with them
5. communicate a clear expectation of personal best performance from myself and my students
6. provide an atmosphere of respect—both extended and expected
7. temper demanding standards with compassion and task-centeredness with delight

In conclusion: "If you don't know where you're going, any road will take you there" (George Harrison) and "Make no small plans…" (Daniel Burnham, displayed in Union Station, Washington, DC, also attributed to Goethe and Machiavelli in slightly differing forms). If the education reformers working today do know where they're going and planning a road to get there, they are severely vision-impaired.

Included among many other resources in my preparation for writing this are:

Thirty years as a participant-observer in the American education system and processes, a doctoral study in change and change processes and most of a lifetime as a member and participant-observer of an extended Polish-American community.

The *TIMSS 2011 International Results in Mathematics*, posted at http://timss.bc.edu by Mullis, I.V.S., Martin, M.O., Foy, P., & Arora, A. (2012). Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College. Chapters 4 & 6 are particularly interesting.

http://dianeravitch.net/2012/12/14/exclusive-pasi-sahlberg-on-timss-and-pirls

http://nces.ed.gov/programs/coe/analysis/2009-sb3.asp

http://sitemaker.umich.edu/salas.356/more_money__better_grades

www.artofteachingscience.org/2012/12/14/timss-media-reports-missing

Gardner, John W., *Self-Renewal: The Individual and the Innovative Society*, Norton (1963).

Gerard, Phillip, Secret Soldiers: The Story of World War II's Heroic Army of Deception, Penguin Books, (2002).

Drucker, Peter, various books and articles on management of organizations and enterprises.

"Where the Engineers Are," a Duke University study accessible through Jack Hassard's http://www.artofteachingscience.org Jan 13, 2013, article, "The Next Generation Science Standards: In the Service of the STEM Imperative or Students?"

Tobias, Sheila, They're Not Dumb, They're Different, Research Corporation (1994).

Machine and Mind

[This excerpt is from an article by John Bakeless that appeared in *Technology Review* in 1931 and was reprinted in the September/October 2012 issue.]

Consider the mental equipment of the average modern man. Most of the raw material of his thought enters his mind by way of a machine of some kind—often through the agency of several machines. Newspapers, magazines, moving and talking pictures are the clearest examples.

All these create an almost incalculable difference between the modern mind—the scholar's in his study, the technologist's in his laboratory, the engineer's in the field, as well as the giggling, gum-chewing shop-girl's on her way down town in the subway—and the mind of the Eighteenth of early Nineteenth Centuries. For the first time, thanks to machinery, such a thing as a world-wide public opinion is possible.

Quite as significant as the machine-made power of the press and the mechanically reproduced art upon our minds, are the various mechanical devices developed during the last two decades for pouring ideas into our eyes and ears—movies, talkies, radios, and television. Some of these mechanical devices probably have more effect upon the less literate levels of modern society than the printed word could ever hope to have.

The danger is that our minds may be tied down to the machine. Our art may some day be restricted (as advertising art always has been) to that capable of mechanical reproduction, our music to the requirements of radio, talkie, and phonograph….All because we have misused the machine, or allowed it to misuse us.

Time

[These excerpts are from an article by Joshua Keating that appeared in the January 2013 issue of *Smithsonian*.]

…Historically, countries have not eagerly embraced the global clock—they've felt compelled to do so because of the demands of commerce. The U.S. national time standards, for instance, didn't emerge until 1883, when it was adopted by the railroads, which needed to maintain common timetables. Before that, cities largely kept their own local time, and many were not happy to have big government and big railroads force standardization on them. "Let the people of Cincinnati stick to the truth as it is written by the sun, moon and stars," editorialized one newspaper when the changeover was going into effect.

…many of these differences are based on whether a country is "monochromic" or "polychromic." In monochromic societies, including Europe and the United States, time is perceived as fixed and unchanging, and people tend to complete tasks sequentially. In polychromic societies, including Latin America and much of Asia, time is more fluid and people adapt more easily to changing circumstances and new information.

Global Warming

[This excerpt is from a commentary by Larry J. Schweiger in the December/January 2013 issue of *National Wildlife*.]

…We've had heat and drought before, but the past year, from July to July, was the warmest in this nation since record keeping began in 1859.

Parched lands and raging mega forest fires are not limited to the United States. The United Nations World Meteorological Organization reported in November 2011 that, according to data dating back to 1850, the planet's "13 warmest years have all occurred in the 15 years between 1997 and 2011." Russia is experiencing its worst drought and excessive heat in 40 years—conditions that have destroyed crops on about 20 percent of its tillable lands. Thirteen of China's 22 provinces are struggling with water and food shortages, and last year the Chinese suffered through their worst drought in 50 years, with rainfall levels down 40 to 60 percent. The same is true for parts of Australia and both Koreas.

The Arctic region, meanwhile, is warming twice as fast as the average temperature globally. Greenland shed a 45-square-mile iceberg in mid-July and spilled a record 100 billion tons of ice and meltwater in 2011. Numerous wildlife species are suffering from the same severe droughts, overheated rivers and lakes, huge forest fires and heat waves.

With all of these planetary threats rolling out concurrently, Rex Tillerson, the CEO of ExxonMobil, would like us to believe that we can simply adapt to climate change. In a recent speech before the nonprofit Council on Foreign Relations, he acknowledged that burning oil, coal and natural gas for fuel is warming the planet, but he rejected peer-reviewed studies, sophisticated predictive climate models and science-based warnings about the need to curtail carbon pollution.

In a surge of hubris defying even the very laws of nature, Tillerson urged society to keep burning fossil fuels. "We'll adapt," he said. "It's an engineering problem, and it has engineering solutions." ExxonMobil and its merry band of carbon polluters are trying to convince us that they and their army of petroleum geologists and engineers have the planet's energy problems under control. Don't believe them.

Along with the coal industry, oil and gas interests have spent billions of dollars in advertising to mislead consumers. With unrestrained political spending stemming from a 2010 U.S. Supreme Court decision—in which the justices ruled that government cannot limit political expenditures by corporations—polluters also have enjoyed a restricted-access highway to policy makers. That access may explain why the U.S. House of Representatives passed anti-environmental bills on more than 280 occasions during 2011, threatening regulations that would have curbed dangerous carbon pollution and protect our air, water and other vital resources.

Strange as it may sound, the power of mathematics rests on its evasion of all unnecessary thought and on its wonderful saving of mental operations.

—Ernest Mach

Global Warming II

[These excerpts are from an article by Richard A, Kerr that appeared in *Science* on November 30, 2012.]

Glaciologists are still far from divining the fact of Earth's ice in a warming world, but they have finally agreed on what the past century's warming has done to the great ice sheets, and it isn't pretty. Researchers had been sizing up the millions of cubic kilometers of ice stored in Greenland and Antarctica using four different techniques applied to different regions at different times, but they just weren't getting it together. So 47 experts put their heads together over all the data to arrive at a community consensus.

The globe's icy bottom line: a current annual loss of 344 billion tons of glacial ice, accounting for 20% of current ice level rise. Greenland's share—about 263 billion tons—is roughly what most researchers expected, but Antarctica's represents the first agreement on a rate that had ranged from a far larger loss to an actual gain. The new analysis…also makes it clear that losses from Greenland and West Antarctica have been accelerating, showing that some ice sheets are disconcertingly sensitive to warming….

Glaciologists are especially concerned about the acceleration of losses. The acceleration in the north shows that "Greenland is pretty sensitive to [air] temperature," [Richard] Alley says. "If we make it too hot, Greenland is in real danger of melting away." In West Antarctica, the accelerating loss comes from the accelerating rush of glaciers to the sea, probably brought on by warmer seawater melting the underside of the glaciers' floating ice shelves. "That shows the real sensitivity of these [glacier] flows to ocean temperatures," Alley adds. The next chore for glaciologists is to incorporate this new understanding into models that can predict future ice sheet behavior in a warming world. None can today.

Global Warming III

[This excerpt is from an editorial in the January 2013 issue of *Nature Climate Change*.]

Despite the notable commitment of the scientific community, policy discussions at UN meetings have not been driven by science. The leaders of nearly 200 countries attending the 18th Conference of the Parties of the UN Framework Convention on Climate Change in Doha, Qatar—which began 26 November 2012 and is half-way through as this Editorial is being written—are unsurprisingly divided in their positions. The urgent call from many climate scientists is clearly insufficient to bring them onto the safe footing. The first commitment period of the Kyoto Protocol—the world's only legally binding treaty for reducing greenhouse-gas emissions—comes to an end in 2012, and a second phase should start in January 2013 to avoid gaps. The new commitment period would serve as a bridge between the first Kyoto phase and the new binding global treaty to be implemented by 2020, as agreed in Durban in 2011. Talks in Doha will only succeed if the terms of the second Kyoto period are settled, without which the treaty envisaged in Durban will never see the light.

Global Warming IV

[This brief article by David Biello appeared in in the February 2013 issue of *Scientific American*.]

The remote northern corner of Alberta is home to the tar sands, a sprawling deposit of thick, heavy oil that is among the most greenhouse gas-intensive forms of petroleum to produce. In the past decade Canada has become the U.S.'s primary supplier of imported petroleum—ahead of Saudi Arabia—and more than half of it comes from this Florida-size reserve, the only place in the world where oil is mined, not drilled. Should President Barack Obama sign off on construction of the Keystone XL pipeline this year, the flow of the tar sands oil, known as bitumen, into the U.S. would be intense.

Sourcing more oil from Canada achieves the politically desirable goal of making the U.S. less dependent on OPEC. But bitumen exacts a heavy toll on the environment. As compared with conventional Saudi oil, it emits twice as much greenhouse gas per barrel because of the resources needed to process it. And although it is net-positive—providing between 7 and 10 Btu (British thermal units) of energy for every 1 Btu put into the tar sands—it is less so than conventional petroleum. Once it is mined, bitumen requires large amounts of gas-heated water to melt and separate it from the coarse grains of sand to which it is bound. At that point, the bitumen is still too tarry to flow, so it has to be chemically manipulated with heat and pressure to become yellowing crude oil, diesel, jet fuel or other typical hydrocarbon products. Or it can be diluted with light hydrocarbon liquids to become pitch-black "dilbit" (for "diluted bitumen"), capable of traveling via pipeline to the U.S.

Some environmental scientists see tapping the tar sands as a disastrous tipping point for global warming. In an analysis of how to restrain warming to an increase of two degrees Celsius or less above preindustrial levels, the International Energy Agency suggested that tar sands production should not exceed 3.3 million barrels a day. Yet approved tar sands production would surpass five million barrels a day—a fact that NASA climatologist James Hansen calls "game over for climate change."

Of course, the true challenge is reducing the use of all fossil fuels, not just oil. U.S. coal-fired power plants produce 10 times more carbon dioxide that Albertan oil sands. Even so, power plant emissions have begun to decline, while the Canadian Association of Petroleum Producers notes that CO_2 pollution from oil sands has risen 36 percent since 2007. As the U.S. weighs construction of the Keystone XL pipeline, the problem of tapping the oil sands is only getting stickier.

Global Warming V

[These excerpts are from an article by Richard A. Kerr that appeared in the January 25, 2013, issue of *Science*.]

Breathing the sooty plume from the maladjusted diesel energy or a smoldering cooking fire has always been ill-advised. But a new study finds that soot is warming the climate about twice as fast as scientists had estimated.

With roughly 8 million tons of soot produced each year by burning everything from coal in power plants to oil in ship's boilers, that's bad news for the planet. And the same study for the first time points policymakers to the soot sources that will make the best targets for climate regulations….

Scientists began the 232-page study—published last week in the *Journal of Geophysical Research: Atmospheres*—4 years ago in response to calls for drastic reductions in emissions of soot, called black carbon in the scientific literature. Soot particles roughly 100 nanometers in diameter were obviously absorbing solar energy and passing it on to the atmosphere, adding to the warming caused by greenhouse gases. But "there wasn't a deep scientific basis" for reducing soot emissions….

That shortcoming has now been remedied. Under the auspices of the International Global Atmospheric Chemistry Project, 31 researchers from nine countries in a range of disciplines came together to assess the climate effects of soot. Working from published field observations, the authors looked at all the effects of soot on the planet's retention of solar energy as well as the effects of other products of soot-producing combustion. They then tried to understand why different researchers got different answers from their climate models….

For soot itself, the remaining work is considerable. The uncertainties calculated in the studies are still large. That is due largely to the dearth of data from the major soot-producing regions and to the poorly understood interaction of all kinds of particles with clouds. But then clouds have been the bugaboo of climate scientists for half a century.

Communicating Science

[These excerpts are from an editorial by Alan I. Leshner that appeared in the August 17, 2012 issue of *Science*.]

There is no shortage of topics where policy-makers or other members of the public seem to persistently misunderstand, misrepresent, or disregard the underlying science: climate change, genetically modified foods, vaccines, or evolution, among others. Consequently, the call for scientists to do a better job of communicating both the meaning and the nature of their work is getting louder. Public understanding of science not only affects people's ability to appreciate and make full use of the products of science, it also contributes to the extent of public support for scientific research….

Public understanding and support of science and technology have never been more important, but also never more tenuous. Today they are embedded in an increasingly politicized environment where ethical, legal, and social implications are emerging at a rate that seems to be outpacing society's capacity to make sense of the science. The science of science communication will be essential to help guide new and more effective efforts at engaging productively across the science/society interface.

NEST Board Meeting Minutes
Saturday, January 19, 2013

The NSTA conference is in Boston next year (April 2014)

- We are guaranteed a spot
- Proposal submission deadline is April 15, 2013
- Peter McLaren [NEST '95] can prepare the proposal, but he needs to know what we want to do:
  - "Best of NEST" presentation? Demos? Workshop?
- A banner is needed.

SEPT 2012 recap

- This was the 3rd year of the new format—half lectures, half hands-on activities
- Topics:
  - Introduced Aero- and Astrophysics
  - Computer Programming, Engineering, edX
  - All-day Friday, with NEST: Brain and Cognitive Science (featuring Media Lab)
- Feedback:
  - + Good balance of evening activities
  - – Not enough Math
  - + "Citizen science" presenter was a highlight
  - + Links to presentations/webpages of presenters on SEPT website is helpful

Suggestions for SEPT 2013 topics

- **Koch Center** (http://web.mit.edu/ccr) - intersection of engineering and medicine, with exploration of controversy, ethical issues in cancer research/treatment, personalized medicine, alternative treatment. It may include "showman" or "celebrity" presenters such as Donald Sadoway, Mike Cima, Eric Lander, Robert Langer and Philip Sharp and the Koch Outreach program.
- Controversial topics—science and ethics:
  - GMO's
  - Doping in sports
  - Nuclear power
  - Personalized Medicine
- **Energy** (new, campus-wide MIT Energy Initiative)
  - Green Chemistry, Green Energy—Vicki McKenna, vsm@mit.edu
  - MIT Energy Initiative—Vicki Ekstrom
  - Earth Resource Lab
- **Water** (or feature nexus of WATER, ENERGY, FOOD)—MIT Water Initiative, EAPS
  - SeaPerch (www.seaperch.org) - oceanography, technology, engineering, discovery -competition to make submersible, semi-automatic robots that perform tasks
- Highlight as an example of a project that shows how students can take different approaches to solve the same problem, but don't promote the competition.
  - Slingshot device—thermodynamics (math, science) to purify water (Coca-Cola supported) with Dean Kamen as the speaker.
  - Water Management
- **Oceanography**—Penny Chisholm Presidential Scholar - http://chisholmlab.mit.edu/
- **European Space Project**—Beate Base SEPT 2011 - demonstrates international involvement—Friday evening talk
- **Data *math focus***—MIT has a center focused on data analysis. Incorporate D3?
- **MIT Student Panel Discussion** as an evening event
  - What got the students (especially women?) interested in science?
  - Local NEST Members—possibly bring a student
  - Videotape?
- **Sebastian Seung**
- **Center for Collective Intelligence**—http://cci.mit.edu/research/measuring.html
- **Harvard Smithsonian & Glass Flowers**
- **Astronomy—Curiosity Rovers**

SEPT 2013 Format

- More "Citizen science"
- As in past, have Friday as a full-day with a single theme (Cognitive Science, Global Warming, Mars were past topics).
- 2 common "themes" during the other 4 days, spanning topics that cover most/all teachers' subjects
- Consider shortening lectures (to 40-45 min.) with more time to discuss/ask questions (w/ or w/o speaker)? Or keep format as-is and let teachers talk over meals and between scheduled activities?
- Manage expectations—make sure participants (esp. K-6 teachers) know SEPT is not about classroom management or a single subject. K-6 teachers must be go-getters.
- Kathy's Biology Lego session—include explanation of how models could be made w/ other materials.
- Number of participants: ask for 25 teachers; invite 30 teachers.

McNamara Workshops recap

- Gifts for speakers
- Only 2 speakers (otherwise too few people in audience—not worth the work to present)

SEPT & NEST Promotion/Development

- When giving a presentation, share the existence of SEPT & NEST
  - Can STEP have a banner that NEST members can borrow?
  - Cards that NEST members can pass out (smaller than brochure)?
- 25th anniversary approaching—an occasion to get attention; remind funders that we did STEM before STEM was a thing!
- Reminder to listserv members who do not pay dues
  - Tell them what dues-paying membership offers (student awards - plaque, certificate, mailing)
  - Remove non-paying members from listserv

Other projects and noteworthy topics

- ***New***—create options for the teachers Eric Klopfer works with to network with local NEST members who are willing to be resources
  - In-person networking sessions

- Opportunity to find out/share information about jobs (email/online platform, too?)
- Newsletter—Deadline March 1st for submissions to Avi Ornstein [NEST '89]
- Student Awards—Deadline April 1st

Ron Latanision's George Washington conference

- Experiment with 20 teachers
- Lectures at GWU, visits to Capitol Hill Offices as well as to other educational organizations in Washington
- General announcement will go to all of NEST

Executive Committee clarification and nominations

- Two year terms (1 year left):
  - Haia Spiegel [NEST '07], Ken Ludwig [NEST '07], Steve Rocketto [NEST '90]
- Current nominees for new two year terms:
  - Bhavana Rawal [NEST '09], Michael Carbone [NEST '12], April Lanotte [NEST '08]
- Teacher Awards Committee—Ken Brody [NEST '92], Bette Bridges [NEST '90] and Steve Cremer [NEST '90]
- John Steczak [NEST '02]—Co-Chair Elect for 2013 - 2014

Funding Education

[These excerpts are from an editorial by Joan Richardson that appeared in *Phi Delta Kappan* in May 2012.]

We've moved from believing that schools should be supported exclusively by tax dollars to a system that now seems incapable of sustaining itself with public money alone. But, let's be aware of that important corollary of taking handouts: "He who holds the purse strings calls the tune." That means grant seekers must be vigilant about ensuring that their goals align with those who are funding them, and, perhaps more importantly, vice verse.

Foundation money is still just a small amount of the money spent on public education overall—by one calculation, well under 1% of the $600 billion that the U.S. spends on K-12 education. But those dollars carry a special aura because schools, districts, and nonprofits must compete with others in order to get the check. And they fund things that tax dollars can't stretch enough to cover, such as school and district turnarounds, new programs and equipment, and more adult bodies in schools to help students learn. In our competition-driven world, the winner always comes out looking like he or she is smarter than others in the race—or those who have chosen to sit out the race….

Smart expenditures of foundation dollars can enhance schools, districts, and non-profits that have thoughtfully approached these partnerships. And these are partnerships in which each side wants something from the other. Before you jump into bed with a funder, be clear about what you want and why you want it so you can respect yourself in the morning.

NEST Board Meeting Summary
Saturday, January 19, 2013

Lauren McNamara

Eighteen members of the NEST executive committee and SEPT staff met in January to share updates and ideas about SEPT and the NEST community. Updates ranged from a review of SEPT 2012 to Peter McLaren's overview of his work on Next Generation Science Standards, and everyone gave input on the year ahead—for SEPT 2013, Student and Teacher Awards, McNamara Workshops, and new programs to involve NEST members. Those who attended were: Bette Bridges, Ken Brody, Len Bugel, Teresa Caracciolo, Betty Catelli, Steve Cremer, Ron Latanision, Peter McLaren, John and Susan Matthews, Avi Ornstein, Dan Record, Steve Rocketto, Haia Spiegel, John Steczak, Eric Klopfer, Lauren McNamara, and Emily Martin. The current members of the board also came up with nominations for next year's executive committee, and gave their votes for John Steczak (NEST '02) as the Co-Chair Elect for 2013-2014. More details from the meeting are outlined in the minutes included in this newsletter, and some important dates that were discussed are listed below.

Friday, March 1 - Extended deadline to renew NEST membership ($20 due)
Monday, March 4 - Deadline to submit SEPT 2013 applications
Monday, April 8 - Deadline to submit applications for 2013 Student Awards
Friday, May 31 - Deadline to register for the NEST Reunion
Sunday, June 23 to Saturday, June 29 - SEPT 2013
Thursday, June 27 to Saturday, June 29 - NEST Reunion

Information about the deadlines above was sent by email via the NESTD-L listserv and can also be found on the NEST website: http://web.mit.edu/scienceprogram/nest/index.html. If you have any questions or feedback, please contact Lauren McNamara at lmcnamara@mit.edu. We're happy to have such a dedicated and insightful group of members—thanks to all who participated in the board meeting, and everyone else for following the ongoing updates from NEST.

Schools can be humane and still educate well. They can be genuinely concerned with gaiety and joy and individual growth and fulfillment without sacrificing concern for intellectual discipline and development. They can be simultaneously child-centered and subject- or knowledge-centered. They can stress esthetic and moral education without weakening the three R's. They can do all these things if—but only if—their structure, content, and objectives are transformed.

—Charles S. Silberman
Crisis in the Classroom

Antiscience Philosophy

[This excerpt is from an article by Shawn Lawrence Otto that appeared in *Scientific American* in November 2012.]

If both Democrats and Republicans have worn the antiscience mantle, why not just wait until the pendulum swings again and denialism loses its political potency? The case for actions rests on the realization that for the first time since the beginning of the Enlightenment era in the mid-17th century, the very idea of science as a way to establish a common book of knowledge about the world is being broadly called into question by heavily financed public relations campaigns.

Ironically, the intellectual tools currently being used by the political right to such harmful effect originated on the academic left. In the 1960s and 1970s a philosophical movement called postmodernism developed among humanities professors displeased at being disposed by science, which they regarded as right-leaning. Postmodernism adopted ideas from cultural anthropology and relativity theory to argue that truth is relative and subject to the assumptions and prejudices of the observer. Science is just one of many ways of knowing, they argued, neither more nor less valid than others, like those of Aborigines, Native Americans or women. Furthermore, they defined science as the way of knowing among Western white men and a tool of cultural oppression. This argument resonated with many feminists and civil-rights activists and became widely adopted, leading to the "political correctness" justifiably hated by Rush Limbaugh and the "mental masturbation" lampooned by Woody Allen.

Acceptance of this relativistic world-view undermines democracy and leads not to tolerance but to authoritarianism. John Locke, one of Jefferson's "trinity of three greatest men," showed why almost three centuries ago. Locke watched the arguing factions of Protestantism, each claiming to be the one true religion, and asked: How do we know something to be true? What is the basis of knowledge? In 1689 he defined what knowledge is and how it is grounded in observations of the physical world in *An Essay Concerning Human Understanding*. Any claim that fails this test is "but faith, or opinion, but not knowledge." It was this idea—that the world is knowable and that objective, empirical knowledge is the most equitable basis for public policy—that stood as Jefferson's foundational argument for democracy.

By falsely equating knowledge with opinion, postmodernists and antiscience conservatives alike collapse our thinking back to a pre-Enlightenment era, leaving no common basis for public policy. Public discourse is reduced to endless warring opinions, none seen as more valid than another. Policy is determined by the loudest voices, reducing us to a world in which might makes right—the classic definition of authoritarianism.

Postmodernism infiltrated a generation of American education programs, as Allan Bloom first pointed out in *The Closing of the American Mind*. It also infected journalism, where the phrase "there is no such thing as objectivity" is often repeated like a mantra.

Reporters who agree with this statement will not dig to get to the truth, and will tend to simply present "both sides" of contentious issues, especially if they cannot judge the validity of scientific evidence. This kind of false balance becomes a problem when one side is based on knowledge and the other is merely an opinion, as often occurs when policy problems intersect with science. If the press corps does not strive to report objective reality, for which scientific evidence is our only reliable guide, the ship of democracy is set adrift from its mooring in the well-informed voter and becomes vulnerable once again to the tyranny that Jefferson feared.

"Facts," John Adams argued, "are stubborn things; and whatever may be our wishes, our inclinations, or the dictates of our passion, they cannot alter the state of facts and evidence." When facts become opinions, the collective policymaking process of democracy begins to break down. Gone is the common denominator—knowledge—that can bring opposing sides together. Government becomes reactive, expensive and late at solving problems, and the national dialogue becomes mired in warring opinions.

In an age when science influences every aspect of life—from the most private intimacy of sex and reproduction to the most public collective challenges of climate change and the economy—and in a time when democracy has become the dominant form of government on the planet, it is important that the voters push elected officials and candidates of all parties to explicitly state their views on the major science questions facing the nation. By elevating these issues in the public dialogue, U.S. citizens gain a fighting chance of learning whether those who would lead them have the education, wisdom and courage necessary to govern in a science-driven century and to preserve democracy for the next generation.

The Human Factor of Climate Change

[This excerpt is from an editorial in the August 2012 issue of *Nature Climate Change*.]

Understanding climate change has traditionally been the domain of natural science. Climatologists and modellers along with other researchers in the Earth sciences have documented past and present climate and established underlying mechanisms. Although many uncertainties persist, there is now a wide scientific consensus that our activities are changing the global climate. It is also widely appreciated—not least at the governmental level—that future climate change has the potential to impact humanity, both directly and indirectly, posing large and complex challenges to the ways that societies operate and are governed.

Largely, it is this realization that documenting the nature of the 'problem' is only the start of the challenge of resolving it that has led to the upsurge in interest from the social scientists who seek, among many other things, to understand peoples' perceptions of climate change risks, what it will take to change behaviours, and the roles that science education and communication should play. At the same time, economists are trying to get to grips with the effectiveness of carbon trading as a mitigation strategy, how rich nations will help the developing world adapt, and indeed whether standard economic models will remain visible into the future. Meanwhile, politicians grapple with how to translate all of this into action, and how to sell often controversial policies to the people they represent.

Understanding climate change is one thing, but doing something about it is quite another.

The Microbiome

[This excerpt is from an article by Michael Specter that appeared in the October 22, 2102, issue of *The New Yorker*.]

We inherit every one of our genes, but we leave the womb without a single microbe. As we pass through our mother's birth canal, we begin to attract entire colonies of bacteria. By the time a child can crawl, he has been blanketed by an enormous, unseen cloud of microorganisms—a hundred trillion or more. They are bacteria, mostly, but also viruses and fungi (including a variety of yeasts), and they come to us from all directions: other people, food, furniture, clothing, cars, buildings, trees, pets, even the air we breathe. They congregate in our digestive systems and our mouths, fill the space between our teeth, cover our skin, and line our throats. We are inhabited by as many as ten thousand bacterial species; these cells outnumber those which we consider our own by ten to one, and weigh, all told, about three pounds—the same as our brain. Together, they are referred to as our microbiome—and they play such a crucial role in our lives that scientists like Blaser have begun to reconsider what it means to be human.

"I love genetics," Blaser said. "But the model that places our genes at the root of all human development is wrong. By itself, it simply cannot explain how rapidly the incidence of many diseases has risen." He stressed that genes matter immensely, but that one must take into account more than just the twenty-three thousand genes we inherit form our parents. The passengers in our microbiome contain at least four million genes, and they work constantly on our behalf: they manufacture vitamins and patrol our guns to prevent infections; they help to form and bolster our immune systems, and digest food. Recent research suggests that bacteria may even alter our brain chemistry, thus affecting our mood and behavior.

Test Score Mania

[These excerpts are from an AFT article that appeared in the January/February 2013 issue of *American Teacher*.]

…more and more evidence points to threat test score mania poses to effective teaching….

Rote recitation of fill-in-the-bubble information can table the more creative and effective learning tools teachers want to use. Worse, too many standardized tests can rob students of deeper learning opportunities. "Instructional time is lost to overtesting; planning time is lost to data collection," says Janet Bellamy, a teacher in New Mexico. "The richest and most joyous aspects of teaching and learning are lost—investigation, critical thinking, creativity, interpersonal interaction, exposure to good literature and cultural awareness."

Entire subjects fall away as testing subjects are kept front and center: "Social studies is completely gone from the curriculum," says Helen Gym, a parent in Philadelphia. "There's very little science, and laboratory work is almost nonexistent…."

Teaching to the test can discourage young, passionate teachers, too….

- The world's top-performing school systems approach learning and testing completely differently than we do.
- American students are taking more tests and learning fewer subjects in school.
- Recess and physical education are being cut to make time for test-focused academics—even though many experts agree these are essential for kids; health and learning.
- When families feel they have a choice, many opt for learning-focused instead of test-obsessed schooling.
- Growing numbers of Americans agree that too much testing is hurting public education.

Skin-Deep Learning

[These excerpts are from an editorial by Bruce Alberts that appeared in the December 7, 2012, issue of *Science*.]

There is a disconnect at the heart of the U.S. education system that is having a devastating effect on how and what children learn. Research shows that the most meaningful learning takes place when students are challenged to address an issue in depth, which can only be done for a relatively small number of topics in any school year. But the traditional process of setting standards tends to promote a superficial "comprehensive coverage" of a field, whether it be biology or history, leaving little room for in-depth learning. The curricula and textbooks that result are skin-deep and severely flawed.

The factoid-filled textbooks that many young U.S. students are assigned for biology class make science seem like gibberish—an unending list of dry, meaningless names and relationships to be memorized. Take, for example, my 12-year-old grandson's life science textbook….When my grandson and his classmates successfully complete that book and the class based on it, it is clear that they will know nothing of the kind of biology that inspires passion in the souls of the scientists working in the labs around me at the University of California, San Francisco. How might we instead give schoolchildren the gift of experiencing the profound joys that of science, or history, or literature?

…At all levels of schooling, we need to replace the current "comprehensive" overviews of subjects with a series of in-depth explorations. To do so, we will need to abandon the one-size-fits-all textbooks used in schools in favor of a large set of much shorter curriculum units, each designed to facilitate the active exploration of one important topic in depth for a month or so. Importantly, the teachers in each school district should be empowered to cover only a fraction of the topics available for their grade level. Rather than attempt to cover an entire subject such as biology, an impossible task, the goal of each unit should be to challenge students to explore one narrow topic deeply. To this end, it will be important to avoid the fatally flawed, state-based textbook-adoption process.

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