# TEACHERS CLEARINGHOUSE
## FOR SCIENCE AND SOCIETY EDUCATION NEWSLETTER

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# Our Common Purpose

### Recommendations for a fresh commitment to democratic citizenship

Under the auspices of the American Academy of Arts and Sciences, the Commission on the Practice of Democratic citizenship has released a report, *Our Common Purpose: Reinventing American Democracy for the 21st Century*, which "offers a set of recommendations for building a fresh collective commitment to democratic citizenship, to American constitutional democracy, and to one another." (p. 2)

After holding 47 listening sessions across the United States in 2019, the Commission found political division and economic inequity, yet a longing to bridge these gaps. "A healthy constitutional democracy depends on a virtuous cycle in which responsive political institutions foster a healthy civic culture of participation and responsibility, while a healthy civic culture – a combination of values, norms, and narratives — keeps our political institutions responsive and inclusive," they write (p. 3). After a "first founding" under the original Constitution of 1787, they look at the adoption of the thirteenth, fourteenth, and fifteenth amendments right after the Civil war as a "second founding" and the Civil Rights movement as a "third founding." They see the country at the present time in need of a "fourth founding" and have fashioned six strategies and 31 recommendations to achieve it.

### Challenges Faced

But first they present the challenges they faced in developing their report. "The major stressors of the twenty-first century – a fragmented media environment, profound demographic shifts, artificial intelligence and other technological advances, economic inequality, centralized power, and climate change – require a fundamental reassessment of U. S. political institutions, civil society ecosystems, and civic norms," they write (p. 10). They also require "that we find our way back to love of country and one another," with an emphasis "on the word *love*." The motivation for change, they add, is as important as the mechanism of it.

From a survey conducted by the Pew Research Center the Commission found an underlying concern to be lack of trust – in just about everything – but noted that 86% of the people surveyed believed that it could be restored, "particularly if we can reduce political partisanship, make the news more factual and less sensational, spend more time with people instead of on social media, and practice empathy." (p. 12) Related to this underlying concern are the challenges posed by "social and economic inequality, distortions in representation, weak and poorly functioning institutions, and the disruptive information environment." (p. 12) All, the Commission points out, "limited our society's capacity to respond to the [SARS-CoV-2] crisis quickly and effectively." They then elaborate on these factors, as follows:

*"Economic Inequality: A Central Contextual Factor."* The "historic upward concentration of income and wealth in the United States has been both a cause and effect of political disengagement," the Commission observes. (p. 12) Low earners work longer hours and find it difficult to take time to vote, while high earners are heard more because of their contributions. Equalizing the political input, the Commission suggests, can improve economic inequity.

*"Obstacles to Voting."* U.S. voter turnout is twenty-sixth of the 32 OECD nations for which we have data, and the U.S. is only one of nine of these nations to vote on a weekday. Several factors diminishing the effect of the individual's vote in national elections are large donor influence, the Electoral College, gerrymandering, and the media. Yet the Commission observes that voter turnout is greater for national than local elections, which affect people's daily lives more.

*"Distorted Representation."* "The framers of the Constitution designed the Senate and other institutions so they would check the power of simple numerical majorities," the Commission writes (p. 15), adding that in 2020 the 26 least populous states control the Senate but contain only 18% of U.S. population. They do not note that, were the Senate not so constructed, the small states would never

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# AN EDITORIAL: What's an article on constitutional democracy doing on the front page?

What's an article on constitutional democracy doing on the front page of a newsletter whose ostensible purpose is science and society education? It may not at first glance have anything to do with science, but it has a lot to do with the society in which science is done. And that society has taken some hard knocks since the last issue of this *Newsletter* was published. Our planet has been held hostage by biological warfare inflicted by Mother Nature. To protect ourselves from this ravage we have sacrificed doing together many of the things we have traditionally enjoyed. In turn, not being able to do these things has deprived many fellow humans their livelihood and set our economic activity back by percentages not seen in almost a century. And, as if that weren't enough, the needless murder committed by a Minneapolis policeman has reawakened our need to come to grips with a crisis that has festered far longer than SARS-CoV-2 (the name of the coronavirus causing COVID-19): *racism*.

Interestingly, *Our Common Purpose* was not written in response to any of these crises. Although it views its strategies and recommendations in light of the COVID-19 pandemic, its fieldwork was done before the pandemic struck. Although its June 2020 publication came after George Floyd's murder, it was clearly in press before then. But, if timing is "everything," it couldn't have come out at more opportune time, because it addresses issues that we have put on the back burner but should really be a part of a purpose we should all care about. Is the divisiveness of our society in recent years the kind of future we really want for ourselves?

Our nation was founded almost 250 years ago and 11 years after its founding established our Constitution as the world's first experiment in constitutional democracy. As has been repeatedly emphasized in recent days, it was for white men only, and its imperfections were acknowledged in a famous speech by Benjamin Franklin, which is reprinted in full in *Our Common Purpose*. Amendments after the Civil War extended it, on paper, to Black and other nonwhite men, in what *Our Common Purpose* calls a "second founding." The Civil Rights legislation of the 1960s, which added more paper to the cause of racial equality, is characterized as a "third founding."

*Our Common Purpose* seems to recognize, though, in seeking a "fourth founding," that more paper is not the answer to the problem. It talks about *love* – of people for each other and for the institutions that enable our constitutional democracy not only to exist but also to thrive. This requires feelings from the heart that cannot come from printed words in a legal document. It's unrealistic to expect that this "fourth founding" will happen any quicker than the first three – even the first one was not a sure thing. But, can we make a commitment to deal with the issues raised by *Our Common Purpose*, realizing that not dealing with them will cause them to rear up in our faces again on some future day? Only by doing this can we be sure of the future of our constitutional democracy, which, in turn, will provide an environment in which science can thrive and grow with the same respect from humans that we should have for each other.

\- John L. Roeder

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The TEACHERS CLEARINGHOUSE FOR SCIENCE AND SOCIETY EDUCATION, INC., was founded at The New Lincoln School on 11 March 1982 by the late Irma S. Jarcho, John L. Roeder, and the late Nancy S. Van Vranken. Its purpose is to channel information on science and society education to interested readers. To this end it publishes this *Newsletter* three times a year. Thanks to funds from tax-deductible contributions, the Clearinghouse is happy to be able to offer its services for a one-time nominal charge. In order to continue offering its services for a nominal charge, it also solicits underwriting of its publications by interested corporate sponsors. All correspondence should be addressed to the editor-in-chief at 17 Honeyflower Lane, West Windsor, NJ 08550-2418 or via e-mail at <JLRoeder@aol.com>.

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# Reduce, Reuse, Recycle. . .

by Bernice Hauser
Primary Education Correspondent

How can we get this vital message across to our young students? How can we make them our future leaders of sustainability? How can we help them support this important mantra?

Making less waste, litter and trash has become a global objective in today's world. Getting rid of garbage is a growing problem in crowded cities. Human-made dirt is often called ***litter.*** Human-made dirt in air and water is called ***pollution.*** Individuals can help reduce the litter and pollution in private and public environments.

To be innovative in 2020 teachers need to begin where their young charges are situated — in their very *own* classrooms. Educators of young children know that their students will learn by using all their senses in a safe, comfortable environment that they claim as their own. Teachers of these young children spend many days before the onset of school, coordinating the physical setup of their room, choosing the various materials for their room, planning the curriculum for the year, month, and week, plus setting a timetable to introduce new activities and new materials. Perhaps some of the activities described here can shore up their curricular objectives in an informal non-threatening way.

Picture an early childhood classroom with two teachers: a head teacher and an assistant teacher. Let's visit this childhood classroom. The young students have been assigned their specific cubbies. They now have a choice of materials to use to identify their individual cubbies by making *name tags*. They can copy their first name onto a white oaktag strip that had been written upon on one side or they can choose a strip fashioned from colored construction paper. The teachers observe that most of the children were choosing the colored construction paper strips and not the white oaktag strips. One child responds that she loved the color, *purple,* so she chose the purple strip. Another child volunteers that the oaktag strip was "dirty. . .see. . .it was already used. We should put them into the trash bin." He wanted something that was not used.

Eureka! Here was an opportunity to tackle a growing environmental concern right here in the classroom. The teachers temporarily stop the above activity and invite their charges onto the meeting rug where one teacher then proceeds to read to them *The Great Trash Bash,* by Loreen Leedy. A lively discussion then ensues after they have listened to the story. Then, with skillful questioning she helps the children gather and state and share any pertinent or unclear perceptions vital to their understanding of this litter problem.

The assistant teacher records their statements, questions and comments on a huge pad that remains in place as a reference list of what they not only learned but also needed to do to reduce the trash/litter issue plus retain the reminders to clarify any of their misconceptions. Both teachers then guide them back to the name tag issue. The head teacher removes the oaktag strip signifying her name that was placed on the door of this classroom. She turns it over to reveal that a different name was listed on the other side-- the used side of the strip. She refers back to the book's contents and comments, "I needed to reduce the amount of trash that I make—so I *reused* this oaktag strip by putting my name on the side that was not used. I will pass this strip around for all of you to feel it, to hold it, to examine it."

Back to the name tags: Some of the children now volunteered to use the used oaktag strips for their name tags — to encourage them they are permitted to choose whatever colored markers they wished to print their names as they did with those children who still wanted to use the colored construction paper strips. (It is a usual procedure at the beginning of the year to use only primary color markers but in this case they made an exception.)

Three weeks into the term, the children, having chosen their paper choice, discover that their construction paper name tag has frayed and discolored. Those children now have a choice –to reuse a used white oaktag name strip or repeat using the colored construction paper for their cubby's identification.

Several children revert to using the sturdier white board. Others throw their frayed and tattered ID into the trash basket while they opt to again use the colored construction for their ID. The teachers do not discard the frayed construction paper name tags that were thrown into the waste paper basket labeled "paper litter." They place them into a basket situated in the arts and craft corner and later observe several children rolling these strips up to make necklaces and bracelets which they then wore, while others cut them up into shapes that they then used to make individual collages and designs. They compliment the children for their help in *reducing* the paper usage in the classroom.

At story time one teacher reads *Recycle,* by Gail Gibbons. The students learn that every ton of paper that is recycled saves 17 trees, that saving forests protects the homes of people and animals, that every hour in the United States, people use two and a half million plastic bottles plus other pertinent and unusual facts.

The teachers share with their students stories from newspapers and magazines that highlight how individuals

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# Reduce, Reuse, Recycle. . .

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are using trash articles to make art, to make clothing, to make other kinds of paper, to make furniture. One teacher relates a story of a young individual like Greta Thunberg who has galvanized and inspired young people to press for legislation and practices leading to reduction of litter worldwide. She queries, "What can **we** do to help the litter problem in our own classroom?" The students came up with many practical solutions:

- Keep personal water bottles in their cubbies to use whenever they are thirsty.
- Use both sides of paper for drawing and writing.
- Wash and recycle empty containers to store pencils, crayons, scissors, rulers, etc.
- Bring in clean discarded socks to make hand puppets.
- Bring in their own personal cups from home to use at snack time.
- Ask the art department to laminate their paper placemats for better and longer usage. To reduce the use of paper towels, each child will use a personal hand towel that can be washed at home as needed. (Paper towels and tissues are still available in this classroom for health and sanitary reasons…but there is a noticeable reduction in their usage.)
- Label the trash containers in their classroom for glass, paper, plastic, food.

With approval from the administration the teacher shares news of the above activities with parents and asks for their cooperation in making this classroom a more sustainable one. Some parents responded by offering discarded clean t-shirts to use as rags to wipe up spills. One parent reported that the family cuts up the six pack plastic rings with scissors so that animals and birds can't get caught in them. Another said that they make a point of using recycled bags when they go shopping. Several commented that they cooperate with their apartment buildings' rules about separating, glass, cans, plastic and paper products. Others use washable dishes instead of disposable cups and plates when they have company or parties. One parent buys only greeting cards made from recycled materials. Another parent uses plastic coffee containers to repot plants.

The next book shared with these young students is *From Tree to Paper*, by Pam Marshall. The children are intrigued with how paper can be changed into other kinds of paper and that paper comes from trees. With the assistance from the school librarian they access the video that shows the making paper episode from Mr. Rogers' Neighborhood program, *Mr. Rogers Shows How Colored Construction Paper Is Made.*

The teachers decide that they will make recycled paper in their classroom with their students. Dividing the class into two groups, the teachers and the students utilize the paper fragments that are in the recycling bin to make a new batch of recycled paper.

**They used the following supplies:**

- reusable or old sliding window screen
- two plastic tubs (one parent donated a baby's plastic bath tub for this purpose)
- used toweling/used rags/old felt (men's and ladies' hats), old washcloths
- water
- torn paper free from staples and tape-free and about two inches in size cut into strips
- blender

**Working with small groups to ensure that the students would be involved in the hands-on process, they**

- made sure the paper was in tiny strips about two inches wide
- mixed the paper with water in one tub
- placed the window screen on top of the other plastic tub
- added paper to the blender and covered it with enough water to run smoothly on low speed
- spread the pulp thinly and uniformly across and over the screen, then layered a cloth diaper or cloth towel on top to absorb the extra water while also pushing and squeezing the water through the screen into the tub
- (done by teacher only) placed one hand firmly on top of the cloth while flipping the screen onto a table or extra tub that can handle water or into a sink
- removed the screen and put the cloth with the paper pulp in a spot to dry undisturbed for a day or two
- removed the dry paper to cut into pieces and use.

They also used the occasion to introduce new vocabulary such as "pulp," "fragments," "blender," and "strips."

The sequence of events was taped and shared with parents. The children voted to use the recycled schoolmade paper to make Mother's Day and Father's Day cards. The teachers continued to seek out opportunities during the school year to reinforce the knowledge and concepts that had been presented and discussed in class. They also invited a member of their city's Sanitation Dept. to talk about litter, garbage, furniture, and electrical disposal and landfills to the class. This individual also spoke about a landfill which closed after accepting 150 million tons of trash but now houses a soccer field, with an off-road bi-

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# ISRI issues *2019 Annual Report*

According to the *2019 Annual Report: Impact in a Year of Change* of the Institute of Scrap Recycling Industries (ISRI), 2019 was characterized by restricted imports of scrap, tariffs, and new state permit requirements. But their report states that the ISRI was able to carry out its mission – "promoting safe, economically sustainable, and environmentally responsible recycling through networking, advocacy, and education" – through its Specs and industry certifications. Among their 2019 achievements the ISRI report lists the following:

- Persuasion of Congress that "poor rail service and excessive demurage charges" were hurting them
- Appointment of an ISRI member to the Surface Transportation Board's Railroad-Shipper Advisory Council
- Persuasion of China to exclude automobile shredder wear parts from tariffs
- Argument "for the removal of scrap commodities from the Chinese waste framework and inclusion of them under the raw material designation"
- Request for federal law to distinguish between "scrap from waste and recycling from waste management"
- Opposition to "attempts to restrict the exports of used electronics"
- Assistance to India and Indonesia in establishing standards for a range of imported scrap commodities"
- Minimization of "damage to market access for plastic scrap globally"
- Suit against California's Department of Toxic Substance Control "to prevent it from treating scrap metal as hazardous waste"
- Proactive work "with stakeholders . . . to develop effective safety guidance for managing hazards associated with lithium-batteries" (100,000 manufactured daily worldwide) and "working to influence future battery designs and control systems"
- Meeting with Carolinas Plastic Recycling Council on "changes in plastic processing and end use, technology, best practices in plastics identification, [and] chemical recycling"
- Partnerships through the Department of Energy-supported Reducing Embodied energy And Decreasing Emissions (REMADE) Institute to 1) "assess the profitability and environmental benefits of U.S. fiber recycling systems"; 2) "design a process to separate plastics and metals derived from used electronics"; 3) "identify anti-solvents for separating different plastics and also flame retardants from the plastics"; 4) "evaluate emerging technologies for reducing contamination in single-stream recycling"

The report also notes that, according to the *2019 Scrap Recycling Industry Economic Impact Study*, recycling is a $110 billion industry providing 531,500 jobs.

# Clearinghouse Update

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

**The Effect of COVID-19 on the Use of Digital Technology**

Sherry Turkle, author of *Alone Together: Why We Expect More From Technology and Less From Each Other*, reviewed in our Fall 2011 issue, was interviewed on NPR's "On Point" on 25 May 2020. There she revisited her earlier book in light of the role technology has played in keeping us together during the COVID-19 pandemic. When Turkle originally wrote her book, she saw digital technology as a way people communicated asynchronously; but now she sees in face-time technology a desire to use digital technology for synchronous communication. Because synchronous communication cannot be prerehearsed the way that texts and emails can be, it makes us more vulnerable, a point made in her original book; but it also makes us more human, she added.

# Reduce, Reuse, Recycle. . .

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cycling greenway and playground to be completed around 2035.

**Resources:**

Video: *Kid Science Making Paper* (YouTube, 17 Jan 2012)

Video: *How to Make Paper Out of Recycled Paper* (YouTube, 16 Jun 2015)

Video: *Mr. Rogers Shows How Colored Construction Paper Is Made* (Mr. Rogers' Neighborhood Program)

Aubre Andras, *101 Small Ways to Change the World* (Lonely Planet/KID, 2018) ISBN-978-1-78701-4879

Gail Gibbons, *RECYCLE*! (Little, Brown, 1992) ISBN 978-0-316-30943-1

Billy Goodman, *A Kid's Guide to HOW TO SAVE THE PLANET* (Avon Books, 1990) ISBN 0-380-76041-X

Loreen Leedy, *The Great Trash Bash* (Scholastic, 1991) ISBN 0-590-459-43-0

# Benjamin explores social impact of technology

**"What values are we building into our material and digital worlds?"**

"Will Robots Save Us . . . or Slay Us? Reimagining the Default Settings of Technology & Society" was the title of the Science on Saturday lecture at the Princeton Plasma Physics Lab on 18 January 2020 by African American Studies Professor Ruha Benjamin of Princeton University. At the outset she noted that her senior thesis at Spelman College that compared white obstetrician-gynecologists' and black midwives' attitudes toward childbirth started her questioning of authoritative forms of knowledge which has continued into her current research on the social impact of technology. She then went on to set the scene for her talk with a quotation by Martin Luther King, Jr., "We have guided missiles and misguided man," to illustrate the impact of technology on society and the social consequences of investment in technological prowess.

Benjamin stated that she wanted to focus on the role of wisdom and social awareness in understanding science and technology and the role of technology in implementing our values. To begin this consideration she polled the audience on whether they thought technology would save or slay us – or neither. She was gratified that a majority voted for "neither," because this indicated to her a hope that humans would remain in control and embed their values in technology rather than let technology be the driver. She sought to move beyond techno-determinism to think critically about what we are creating.

For those who might need to leave before the end of her talk, Benjamin continued by listing her three main takeaways:

*Racism is productive; it constructs*. (By this she meant not that racism is good but rather that it produces things. And while race is a socially-constructed concept, it also constructs things on its own.)
*Race and technology are coproduced*. (As will be seen by some of the following examples, some technology has racial consequences.)
*Imagination is a battlefield*. (Those seeking to construct social reality grounded in justice and joy must wrestle with the desire of others for social domination.)

She followed these takeaways with examples to illustrate them: 1) A national healthcare algorithm was found to have racial bias by being "race neutral." 2) Robots reflect the racist and sexist attitudes of their creators. (This led Benjamin to write her book, *Race After Technology: Abolitionist Tools for the New Jim Code*.) 3) Algorithms for grading essays reinforce the human biases of their creators. 4) Other algorithms to detect fraud have led to false accusations, leading to questioning the premise that technology is inherently objective and fair. 5) New technology is not necessarily greener. 6) Infrared technology in sensors is less sensitive to dark skin (promoting efficiency over equity). 7) Armrests in the middle of public benches preclude the homeless from lying on them.

"What values are we building into our material and digital worlds?" Benjamin asked. She asserted that we

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# Rennermalm describes role of firn in Greenland

Geography Professor Asa Rennermalm of Rutgers University shared her research of the Greenland ice sheet in her Science on Saturday talk on "Witnessing climate change: What I have learned from my expeditions to the Greenland ice sheet" at the Princeton Plasma Physics Lab on 7 March 2020.

As a matter of background, Rennermalm pointed out that sea level has risen eight inches since 1880 and is expected to rise between six and sixteen inches more by 2050. The Greenland ice sheet contributes between 20 and 25 percent of this. She showed a graph displaying increase in sea level rise and decreased mass of the ice sheet between 2004 and 2016.

Rennermalm began with her recollections of being airdropped with four snowmobiles and all the equipment she and her crew would need, needing to travel 70 km to their research site but hit by a storm and finding that their snow mobiles wouldn't start. But finally the first and fourth snowmobiles did start, and their data gathering began.

Their research focuses on the interaction of meltwater and *firn*, a semiporous intermediate between snow and ice, which can be up to 80 cm thick and was observed to be able to absorb meltwater in 2012. They drill cores into the firn and analyze them, measuring layers of ice and firn extending over the past 31 years at five sites, which showed the same amount of snowfall but different amounts of refreezing. They found ice layers to be more numerous and thicker at lower elevation, with the 2017 cores showing more ice than the 1998 cores. This, Rennermalm said, shows that water frozen in firn matters in inhibiting sea level rise, also that some models have overestimated runoff.

The bottom line of Rennermalm's research is that about 45% of meltwater refreezes in the firn, which is good news. But in 2016 they found impermeable ice slabs in the firn which restricted further absorption of meltwater. This caused Rennermalm to leave her audience with the outstanding question of whether such ice layers would restrict absorption of runoff by firn in the future.

# NSTA statement on STEM Teaching and Learning

In February 2020 the National Science Teaching Association (NSTA) Board of Directors approved a position statement on STEM Education Teaching and Learning. It emphasizes the importance of "a STEM-literate populace and workforce," because it "is necessary to sustain the U.S. competitive advantage in the age of globalization: not only as researchers, doctors, and engineers, but also as a hugely technical workforce that can help secure our health and safety, revitalize our utility infrastructures, monitor our food production, and improve our manufacturing efficiencies and capabilities." It also cites data from the U.S. Department of Commerce and the Pew Research Center that workers trained in STEM fields are less likely to be unemployed and more likely to earn higher salaries.

As an acronym, "STEM . . . has been evolving from a convenient clustering of four overlapping disciplines (science, technology, engineering, mathematics) toward a more cohesive knowledge base and skill set critical for the 21st century." But "STEM is not a single subject," the statement points out, "and it should not replace other subjects. Students need to learn the same concepts and skills in science and mathematics as they did before, and how to solve problems through engineering design challenges." "STEM is also not a curriculum," the statement goes on, "but rather a way of organizing and delivering instruction. . . . Modern STEM education promotes not only skills such as critical thinking, problem solving, higher-order thinking, design, and inference, but also behavioral competencies such as perseverance, adaptability, cooperation, organization, and responsibility."

The statement concludes with criteria which should characterize the STEM education programs needed to prepare the aforementioned "STEM-literate populace and workforce":

> "1. STEM education programs should be grounded in the tenets of constructivism supported by the findings of three decades of cognitive science. Integrated STEM education occurs when
>
> - learning is viewed as an active, constructive process, and not a receptive one;
> - student motivation and beliefs are integral to cognition;
> - social interaction is fundamental to cognitive development; and
> - knowledge, strategies, and expertise are contextualized in the learning experience.
>
> 2. High-quality K–12 STEM education is an essential, relevant, and continual endeavor for all students. STEM education
>
> - enables analytical and critical thinkers;
> - increases science, mathematics, and technology literacy;
> - fosters the next generation of innovators and entrepreneurs;
> - provides opportunities for students to engage in 21st -century skills of teamwork, collaboration, problem solving, communication, and creative thinking; and
> - offers learning experiences in which students apply what they are learning in relevant, meaningful ways."

The complete statement can be accessed online from the NSTA website, <www.nsta.org>.

# Benjamin

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must think of the social as well as the scientific side, but she lamented that we are less adept at sensing the insidious racially-coded spikes that have replaced the overt ones of the past. An example she cited concerned whether names "sound" Black or white (a study which sent identical job applications differing only in the names found that people named Emily or Greg were more likely to be called for interviews than those named Lakisha and Jamal). Another example was an algorithm, also intended for screening job applicants, which was able to distinguish writing by men and women. But at the end of her talk Benjamin cited several examples which showed hope that technology designers have become more socially aware and that citizens have risen up to oppose biases of technological innovations. Every inequity, she noted, is an opportunity to correct it.

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have ratified the Constitution in the first place, and that one of its provisions is that "no State, without its Consent, shall be deprived of its equal Suffrage in the Senate." (Article V.) But on page 29 they acknowledge that "The framers designed constitutional amendment to be difficult: they intended it to be a solution of last resort for matters of only the highest national importance"; and they have worked around this in their strategies and recommendations.

*"Dysfunctional Institutions."* Voters need to feel that they are listened to.

*"Fragmented Civil Society."* The Commission observes that nonpolitical institutions – 16568 libraries, more than

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350,000 houses of worship, teams, clubs, educational institutions, museums, and performance spaces – also play important communal roles. "Without a set of civil society institutions that work together and build bridges across divides, no level of government intervention will be sufficient to restore cohesion to communities that are fragmented by demography, ideology, income, and suspicion." (p. 17)

*"Disrupted Media Environment."* According to the data examined by the Commission, 72% of Americans were active on social media in 2019. During the preceding 15 years more than 60 daily papers and 1700 weeklies terminated their existence. The Commission acknowledges that social media have been effective in organizing people for local action but have reduced human-human interaction and are not conducive to "deliberative discussion." Can "social media, like broadcast media . . . serve the public interest, rather than undermine it?" they ask. "We need not social media, but civic media." (p. 18)

*"Lack of a Shared Commitment to Constitutional Democracy."* According to a 2017 international study on commitment to democracy by the Pew Research Center, 51% of Americans are "dissatisfied with how American democracy is working," and 46% of Americans, mostly in the age range 18-29, are "open to forms of government other than representative democracy, including rule by a strong leader or by groups of experts." The Commission counters that Americans need more opportunities than "sporting events and communal responses to tragedies" to experience "a sense of common purpose" that comes from improving communities and building trust across boundaries (p. 18); these are needed for democracy.

### Strategies and Recommendations

Amidst this milieu of challenges, the Commission continues their Report with "The Way Forward: Essential Reinvention of American Constitutional Democracy," in which they roll out their six Strategies and 31 Recommendations and explain their reasoning behind them. In a nation characterized by "strained institutions, fragmented civil society, economic inequality, unequal representation, a changed media ecosystem, [and] coarsening civic culture," they consider someone who participates in "common life," contributes to the "common good," and serves "common interests" to be "a good citizen." (p. 20) Their recommendations focus on "three spheres of democratic life: political institutions and processes, civic culture, and civil society organizations and activities." (p. 20)

The following presentation of the strategies is followed by numbered paragraphs describing the intent of their associated recommendations, without full statements of the recommendation, which are quite lengthy.

*Strategy 1. "Achieve equality of voice and representation."*

*Recommendation 1.1:* Recognizing the difficulty of amending the U.S. Constitution, the Commission recommends working around the inequities created by giving each state two electoral votes for its two senators in addition to the electoral votes for representatives elected according to the state's population by increasing the number of representatives in Congress, which was capped at 435 in 1929. They peg the minimum number of added representatives at 50, the additional number they say the U.S. Capitol can accommodate.

*Recommendation 1.2:* The Commission recommends apportioning a state's electoral votes proportionally (as only now Maine and Nebraska do) rather than having a winner -take-all rule and – in all other races – eliminating the possibility of election by plurality rather than majority or requiring runoff elections by instituting ranked-choice voting (now used by Maryland and New York City for primary elections).

*Recommendation 1.3:* If ranked-choice voting is used, the Commission recommends multiple member congressional districts, because this system would require candidates to appeal to a broader electorate (from 1870 until 1980 Illinois elected the state legislature from three-member districts, with voters allowed to allocate three votes however they saw fit).

*Recommendation 1.4:* To avoid partisan redistricting, the Commission recommends that all states have their legislative districts structured by independent citizen redistricting commissions (already in California and Arizona, and coming soon in Utah, Ohio, and Michigan).

*Recommendation 1.5:* Because a Constitutional amendment is the only way to reverse the Supreme Court's *Citizens United* decision which removed contribution limits to Political Action Committees, this is the one place the Commission recommends a Constitutional amendment – to authorize regulation of election contributions. They point out that preratification legislation has already been passed by twenty states.

*Recommendation 1.6:* In the absence of a Constitutional amendment to reverse the *Citizens United* decision, the Commission recommends strong campaign-finance disclosure laws as the only way to make *Citizens United* contributions transparent and control the effect of large political contributions.

*Recommendation 1.7:* The Commission also recommends mechanisms to "amplify the power of small donors" (p.

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# Our Common Purpose

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30) – *e.g.*, matching contributions with public funds, "democracy vouchers," and direct public campaign financing.

*Recommendation 1.8:* To remove the appointment of Supreme Court judges from presidential politics, the Commission recommends 18-year staggered terms for Supreme Court judges, with one judge appointed in each Congressional term.

*Strategy 2: "Empower voters."* "Voting is a privilege of citizenship but also a responsibility." (p. 32) The Commission hopes that their other strategies will make citizens *want* to vote; we should build on this by making it *easier* to vote.

*Recommendation 2.1:* Given the difficulty low wage earners have to vote at a designated time on a designated day, the Commission recommends more times and places for people to vote.

*Recommendation 2.2:* Since it would be easier for people to vote on a holiday, holding elections on Veterans Day would both honor veterans whose service preserved our right to vote as well as provide a more convenient time for voting. Furthermore, scheduling all elections for this day rather than distributing them throughout the year (except for primaries) would both save money and insure better voter turnout.

*Recommendation 2.3:* The Commission recommends same-day and universal voter registration to increase voter turnout.

*Recommendation 2.4:* The Commission recommends educating 16- and 17-year-olds to be future voters by giving them practice opportunities (something already done in 14 states).

*Recommendation 2.5:* The Commission feels that citizens should be cited and fined for not voting just as they would be for failure to serve on juries (a procedure in effect in Australia since 1924). They note that making voting easier is a necessary prerequisite for this.

*Recommendation 2.6:* The Commission feels that paid orientation for voters should be provided before their first national election, just as it is for first-time jurors, in order to make their first voting experiences less intimidating.

*Recommendation 2.7:* In order "to recognize the value of *all* voices in a community as well as the importance of offering citizens second choices," (p. 40) the Commission recommends restoration of voting rights to all convicted felons no longer in prison.

*Strategy 3: "Ensure the responsiveness of political institutions."* Elected officials need to provide participatory activities for citizens in addition to voting and jury duty.

*Recommendation 3.1:* Though citizens trust local government more than national government, they "lack the knowledge or opportunity" (p. 42) to get involved with it. Public meetings are often not well-noticed or conveniently-timed. The Commission notes that the technology to provide remote access to pubic meetings has been advanced by the COVID-19 pandemic and recommends creating ways for citizens to participate in local governmental meetings.

*Recommendation 3.2:* The Commission recommends creation of a mechanism for each member of Congress to interact with a random sample of constituents substantively at least four times a year. It also notes that once this group is identified, it must be provided nonpartisan briefing materials.

*Recommendation 3.3:* The Commission recommends establishment of "citizens' assemblies" (p. 45) to deliberate about issues and submit recommendations to Congress (they are already functioning in England, Ireland, Portugal, and Taiwan). They would be modeled on the 3500 people AmericaSpeaks assembled "to deliberate on America's fiscal future" (p. 45) for the Simpson-Bowles Commission on Fiscal Responsibility and Reform.

*Recommendation 3.4:* The Commission recommends expanding citizen participatory input in municipal and state government. This would allow the government, which must deal with *all* issues, to benefit from the expertise of citizens who are interested in having input on only *some* issues.

*Strategy 4: "Dramatically expand civic bridging capacity."* This goes beyond the role of government to the social interactions of citizens with each other.

*Recommendation 4.1:* The Commission recommends establishing "a National Trust for Civic Infrastructure to scale up social, civic, and democratic infrastructure." (p. 48) "Parks, libraries, schools, churches, and museums . . . bring people together in their communities," they write, but "our civic infrastructure today is poorly supported and too often underappreciated." (p. 49)

***"Without a set of civil society institutions that work together and build bridges across divides, no level of government intervention will be sufficient to restore cohesion to communities that are fragmented by demography, ideology, income, and suspicion."***

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# Our Common Purpose

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*Recommendation 4.2:* The Commission recommends investing "in . . . the catalytic leaders who drive civic renewal . . . to support innovations in bridge-building and participatory democracy." (p. 49) More of these leaders need to be identified, and more sources are needed to fund them.

*Strategy 5: "Build civic information architecture that supports common purposes."* Lying "at the intersection of digital platforms, academic research, policy-making, jurisprudence, and economics," the recommendations for this strategy "are among the most technical of the . . . report . . . . The overarching idea behind them all is" that "although how people use social media and other digital platforms has negatively affected the practice of democratic citizenship, we can redesign these platforms and their uses to support, rather than erode, our constitutional democracy and sense of common purpose." (p. 51)

*Recommendation 5.1:* The Commission recommends formation of "a high-level working group to articulate and measure social media's civic obligations" to incorporate into "the Democratic Engagement Project" (described in recommendation 5.5). Like any technology, social media can be used to help humanity or harm it. This recommendation seeks to develop a quantitative measure ("metrics") of the value of social media to constitutional democracy.

*Recommendation 5.2:* The Commission recommends subsidizing "innovation to reinvent the public functions that social media have displaced." (p. 53) Chief among these is "local and regional investigative journalism," (p. 53) due to the demise of 21% of local newspapers between 2004 and 2018.

*Recommendation 5.3:* The Commission recommends establishing "a public interest mandate for for-profit social media platforms . . . to support the development of designated public-friendly digital spaces on their own platforms." (p. 54) They note that this is like the FCC's public-interest standard for radio and television stations.

*Recommendation 5.4:* The Commission recommends requiring the systems of digital platform companies to be compatible so that data can flow freely among them.

*Recommendation 5.5:* The Commission recommends establishing and funding "the Democratic Engagement Project: a new data source and clearinghouse for research that supports social and civic infrastructure. The Project would conduct a focused, large-scale, systematic, and longitudinal study of individual and organizational democratic engagement, including the full integration of measurement and the evaluation of democratic engagement in digital contexts." (p. 55)

*Strategy 6: "Inspire a culture of commitment to American constitutional democracy and to one another."* Mindful that a meaningful commitment to constitutional democracy must be lasting, this last strategy is designed to make this commitment a part of American culture, and the first five strategies are designed to lead to it.

*Recommendation 6.1:* The Commission recommends establishing a program expecting (but not mandating) a year of some kind of paid national service. This program will benefit both the communities that are served and the people serving them, opening career possibilities as well as instilling the value of service in them.

*Recommendation 6.2:* The Commission hopes to commemorate the 250th anniversary of the signing of the Declaration of Independence with a "Telling Our Nation's Story initiative to engage communities throughout the country in direct, open-ended, and inclusive conversations about the complex and always evolving American story." (p. 59) "These narratives must do justice both to core democratic values and our often egregious failures to live up to them." (p. 59) "Working through how we will tell ourselves stories about ourselves is a necessary part of renewing our capacity to work together for constitutional democracy" (p. 60)

*Recommendation 6.3:* The Commission recommends launching a philanthropic initiative to fund the programs in recommendation 6.2. "Democracy works only if enough of us believe democracy works . . . . it requires *culture*." (p. 60)

*Recommendation 6.4:* The Commission recommends funding "to revitalize democracy and encourage commitment to our constitutional democracy and one another." (p. 62) Billions are spent on election campaigns but hardly anything on "the *other* practices that constitute democratic citizenship, especially at the local level." (p. 62)

*Recommendation 6.5:* The commission recommends investing in "civic education for all ages" to provide "civic-learning experiences with the full community in mind." (p. 63)

## Conclusion

The Commission leaves the readers of their report with following concluding observations:

"We do not trust . . . the . . . institutions that should be the instrument of our freedom and the source of our protection."

"Our public sphere is full of disagreement, in great measure because voices formerly excluded are not in the debate."

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# How to contain a fusing plasma on Earth

A star constitutes a fusion plasma – ions of mostly hydrogen at sufficiently high temperatures to move fast enough to fuse to form heavier ions and release the energy that enables the star to continue giving off its light. The goal of fusion reactors on Earth is to imitate the fusion process that occurs naturally in stars and to transform the energy released to forms useful in our daily lives. This is how Rajesh Maingi of the Princeton Plasma Physics Lab began his talk on "The Boundary Layer in Fusion Plasma: Where the Fourth State of Matter Meets the Other Three" in the Science on Saturday lecture series at the Lab on 25 January 2020. The importance of the boundary layer he described is that it enables the plasma on Earth to be contained in a vessel that would melt at the temperature of the ions in the plasma – 50 million Kelvins (about 90 million degrees Fahrenheit) in the case of the NSTX-U being rebuilt at the Plasma Physics Lab. NSTX-U, Maingi noted, is one sixth the scale of the ITER (International Thermonuclear Energy Reactor) being built by the European Union, Japan, the United States, Russia, China, South Korea, and India in France, designed to receive its first plasma in December 2025 and sustain fusion reactions producing 250 megawatts of power.

The boundary of plasma in contact with the vessel walls, Maingi said, is called the "scrape-off layer." Its temperature is limited to three thousand Kelvins (4940 degrees Fahrenheit). Maingi stated that collisions of the scrape-off layer with the vessel walls "sputtering" atoms out of the walls are the simplest mechanism damaging the walls. He went on to describe that other chemical interactions between the plasma and wall can *add* layers to the wall and that *controlling* them is a challenge. And electrons ejected from atoms in the wall cause damage by radiation, which cools the plasma. This problem can be minimized by building the wall from elements with low atomic number, but atoms of higher atomic number are less easily ejected from the wall. Furthermore, purity of the plasma requires that it have a very low pressure – ten trillionths the pressure of Earth's atmosphere – and the helium "ash" that results from hydrogen fusion is an impurity that must be continually removed.

In discussing how to keep the plasma hot and the rest of the reactor cool, Maingi pointed up the importance of the difference in mass. The mass of the hydrogen plasma in ITER, he said, was less than half a gram, while the reactor itself has a total mass of 50,000 pounds. Solids like the walls of ITER, he said, can accommodate a heat transfer flux of 10 megawatts per square meter, which is 10 times the intensity of a Saturn V rocket. But using the reactor mass to transmit thermal energy arising from collisions of the plasma with the vessel walls most efficiently requires a uniform transmission of the thermal energy to *all* parts of the reactor, which is a problem still being worked on, Maingi said.

Maingi devoted the last part of his talk to considerations for the most optimum materials for making the vessel walls. He had already observed that low atomic number minimized radiation damage but that high atomic number reduced ejections from the wall. With high atomic number (74) tungsten was cited as having other advantages – low physical sputtering with a high energy threshold and no chemical sputtering with hydrogen; and it doesn't remove much tritium (one of the fusion reactants) from the plasma. But offsetting this is that only a small concentration (1 part per million) could be tolerated in the plasma core. Maingi noted that carbon and molybdenum were other elements that had been used. Then he posed the possibility of using liquid metals, which he said have self-healing surfaces and no dust. Liquid lithium is, in fact, being tested now in the LTX at the Princeton Lab, also in the Chinese EAST fusion device and the Dutch MAGNOM-PSI. Liquid lithium over tungsten, Mangi said, shows a great deal of promise – it allows the system to work at lower temperature and enables a heat transfer flux of about 30 megawatts per square meter. This, he concluded, is a critical step toward achieving sustained fusion.

# Our Common Purpose

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"To develop accommodations with one another, we need functional institutions for our joint decision-making."

"Our institutions . . . will thrive only if we remember that democracy . . . is not a battle whose purpose is not annihilation of the enemy. . . . We must . . . work together – even with those we might want to demonize or ignore."

"Our constitutional democracy is only as strong and resilient as our belief in it." (p. 64)

In addition to the listening sessions, the Commission conducted a review of existing relevant data and consulted with scholars and experts. They pondered the effect of the challenges posed by COVID-19 but ultimately concluded "that it left our fundamental principles and recommendations unchanged." (p. 4) Not all Commission members supported all the individual recommendations but all were willing to compromise to support the total package as a whole. They hope for "significant progress" by 2026, the 250th anniversary of the signing of the Declaration of Independence. *Our Common Purpose* can be accessed online at <www.amacad.org/ourcommonpurpose/report>.

# RECOMMENDED SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

1. Samantha Jo Fried, "How Climate Science Could Lead to Action," *Am. Sci.*, **108**(1), 34-41 (Jan-Feb 20).

The "data-to-action paradigm" of science leads us to "assume that more Earth data or better science will lead to action on climate." But "if more remote sensing data won't lead to public engagement with –and clearer action on – climate change, what will?" The response of this program manager for science, technology, and society at Tufts University is the "civic engagement paradigm," in which "expert research . . . would be guided by . . . matters of civic concern." Fried illustrates this paradigm with two organizations employing it: Public Lab and the Civic Laboratory for Environmental Action Research.

2. "The Future of Everything," *Wall Street Journal*, R1 -R8 (14 Feb 20).

Articles in this supplement on energy focus on two major themes: managing the electric grid in the 21st century, and the extraction of carbon dioxide from sources that emit it. Among the ways to manage the electric grid are new ways to store energy in order to accommodate more renewables (including 400-foot tall towers lifting 35-ton bricks when electrical demand is low to store surplus energy capacity for future use when demand is high), the use of high tech to regulate the grid more efficiently, and the use of additional renewables to reduce carbon emissions. Among these renewables are energy from tides, ocean waves, and orbiting solar satellites, all of which were considered in the 1970s, when energy first became a critical issue, but have not become as economically competitive as Earth-based wind and solar. One of the more novel ways to extract carbon dioxide from the air is bacteria which absorb it to grow.

3. Jaimie A. Foulk, Patricia J. Friedrichsen, and Troy D. Sadler, "Science in Socio-Scientific Issues," *Sci. Teach.,* **87**(7), 35-39 (Mar 20).

Maintaining that "*all* students, regardless of future career paths, need to have meaningful science learning experiences that equip them to make informed decisions throughout their lives," these authors describe a timeline activity they use in "teaching secondary science in the context of *socio-scientific issues* (SSI)." The socio-scientific issue considered in this article is whether a "fat tax" should be imposed on foods believed to "promote excessive weight gain," and the timeline activity is designed to familiarize students with the related societal issue of nutrition recommendations. Groups of students are assigned to research nutrition recommendations from various periods in American history and post their reports on a timeline, color-coded according to impacts that are scientific, political, economic, social, or "other." In this way they learn the historical context of this scientifically-related societal issue. The authors note that such a timeline activity can be used to learn the historical context of other scientifically-related societal issues as well.

4. Andrew Zucker, Pendred Noyce, and Andrew McCullough, "Just Say No!" *Sci. Teach.*, **87**(5), 24-29 (Jan 20).

The first two authors of this article developed a one-week curriculum for grades 6-12 on "Resisting Scientific Misinformation," which is designed to combat "fake science" and is profiled in this article; and the third author taught it in his classroom. The curriculum, which is available free at <https://tumblehomebooks.org/services/resisting-scientific-misinformation/>, consists of four lessons, the last of which can be expanded: 1) "Misleading Advertising Supposedly Based on Science," 2) "A Special Misleading Argument, 'The Science is Uncertain,'" 3) "Asking Questions About a Dubious 'Scientific' Claim," 4) "The Scientific Process." A set of videos is provided for each lesson, and the online Teacher's Guide contains links to many others. The first lesson features an ad found by the Federal Trade Commission to be so fraudulent that refunds to users were mandated. The second investigates claims of ads and cites uncertainty as a way to defuse concern, in earlier times about the dangers of smoking, now about climate change. The third features the editor's former student Damaso Reyes explaining the questions that should be asked about the legitimacy of an article; this is followed by a set of related criteria: Purpose, Author, Relevance, Currency, and Sources (among them reputable institutions). The last lesson is focused on peer review.

5. Gabriel Popkin, "The Forest Question," *Nature*, **565**, 280-282 (17 Jan 19).

While forests reduce the concentration of carbon dioxide in Earth's atmosphere and therefore oppose global warming, research shows that they can also produce results which enhance global warming – by changing Earth's albedo and emitting methane and volatile organic compounds (VOCs).

6. Vineeth Venugopal, "The G-filter: A simpler high-tech solution to India's water pollution," *MRS Bulletin*, **44**, 914-915 (Dec 19).

Called gravity filters and made by local Indian potters, ceramic disks made from sawdust, salty clays, oxidizing

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matter, and marble dust and placed in the base of a container that allows water to drain through to another container below purifies water at the rate of a liter per hour. The key is that the pores – between 10 nm and 1 μm – are too narrow to allow bacteria to pass through. Graphics and a photograph facilitate understanding.

7. M. Mitchell Waldrop, "Nuclear goes retro — with a much greener outlook," *Knowable* (22 Feb 19); https://www.knowablemagazine.org/article/technology/2019/nuclear-goes-retro-much-greener-outlook.

The molten salt reactor is portrayed as a way to produce carbon-free electricity at less cost and without the problems of meltdowns, nuclear proliferation, or long-term waste storage. The graphics are excellent, but the conversion of U-238 to Pu-239 is oversimplified.

8. M. Mitchell Waldrop, "Nuclear Energy Gets a Redo," *The Moonshot Catalog* (8 Sep 19); https://medium.com/the-moonshot-catalog/nuclear-energy-gets-a-redo-707e39aaeaf4.

This article focuses on "Developing new reactor designs that overcome . . . safety, security, and environmental concerns" about nuclear energy. It faults water as a reactor coolant in particular because of its low boiling point and the danger of a loss of coolant accident (LOCA) and light water reactor (LWR) design in general because the accumulation of neutrons by fission products in fuel rods requires the fuel rods to be replaced before all the fuel is used. Contrasted with this are Generation IV reactor designs which, by avoiding water as a coolant, and thereby also as a moderator, can use fast neutrons, which are not absorbed by fission products and allow natural uranium, including that depleted in U-235 by enrichment for today's LWRs, to be used as fuel. General Atomics's 2009 Energy Multiplier Module ($EM^2$) uses a helium coolant and runs at an operating temperature of 850°C, which can be withstood by a silicon carbide composite. TerraPower has two designs: a Traveling Wave Reactor, which uses liquid sodium as a coolant and will reshuffle fuel rods to maximize burning; and a Molten Chloride Fast Reactor, running at an 800°C operating temperature.

9. Natalie Wolchover, "A World Without Clouds," *Quanta Magazine* (25 Feb 19); https://www.quantamagazine.org/cloud-loss-could-add-8-degrees-to-global-warming-20190225/.

This article reports calculations by Tapio Schneider, Colleen Kaul, and Kyle Pressel published in *Nature* that show the total break-up of low-lying stratocumulus clouds (that have the "largest cooling effect on the planet") when atmospheric carbon dioxide concentrations reach 1200 ppm. This in turn is expected to add an 8°C temperature increase, due to albedo reduction and the greenhouse effect of water vapor, in addition to the 4°C which will have resulted from the increased carbon dioxide concentration. This article notes that climate models agree in most of their predictions but not on the effect of clouds, perhaps because the resolution of their cells is typically 100 km, about a hundred times the size of clouds. In fact, the published calculations were done for a square patch only 5 km on a side. They showed that, as the carbon dioxide concentration and temperature increased, turbulence in clouds mixes moist air near the top and pushes it out the top of the cloud and draws dry air from above – in a process called "entrainment," which acts to break up the cloud along with reduced cooling of the clouds from above, because of the increased atmospheric temperature.

10. Mark Wolverton, "Of Science, Fear, and Nuclear Radiation," *Undark* (13 Sep 19); https://undark.org/2019/09/13/nuclear-radiation-fear-lnt/.

This article presents views on both sides of the controversy over the LNT (linear no threshold) model of radiation damage and its implications regarding the safety of nuclear energy. Because resolving this controversy requires more definitive data for low radiation doses, one possible compromise held forth is to establish a dose "below regulatory concern."

# Inoculation's Effect on the Revolution

In an age beset by skepticism about the side effects of vaccines, the *Trenton Times* headlined its Fourth of July edition last year with a similar dilemma facing General George Washington: whether to inoculate his troops against smallpox. Not to do so left his soldiers at risk of contracting the disease, from which only two thirds (including Washington himself) survived. This would expose his army to uncertainty in readiness to do battle, while most of the adversary British soldiers had already acquired immunity by surviving the disease. Because inoculation deliberately infected people with a live virus but resulted in only a milder version of the disease from which most recovered, it was not without its downside. Inoculating the entire army would incapacitate it during the recovery period, and deliberately infected soldiers were also contagious and liable to spread the disease to those without immunity (which would include the population of Morristown, NJ, where the army was quartered in the winter of 1777). In fact, the loss of between a fifth and a third of the population of Morristown is believed to have resulted from Washington's decision to inoculate his troops (and his wife when she visited, the procedure having been banned in their native Virginia). But that decision enabled the army to be a viable fighting force the following summer.

# REVIEWS OF SCIENCE AND SOCIETY EDUCATIONAL RESOURCES

Nate Silver, *The Signal and the Noise: why so many predictions fail – but some don't* (Penguin, New York, 2015). $27.95. 455 pp. ISBN # 978-1-59420-411-1.

Nate Silver is well known as a political analyst. This book provides information about his abilities as an analyst and his depth of understanding of the process of making predictions. The book begins with an examination of the effect Gutenberg's invention of the printing press had on society. Silver describes Gutenberg's invention as being crucial to beginning the Industrial Revolution and key to the economic and scientific growth and change we are all familiar with. There are numerous graphs throughout the book which help the reader understand the concepts Silver presents.

The author quickly moves on to the challenges presented by Big Data. He quotes the editor of *Wired* magazine, Chris Anderson: "The sheer volume of data would obviate the need for theory, and even the scientific method." One of my favorite passages in the book concludes with "We have a prediction problem. We love to predict things and we aren't very good at it."

That statement is followed by the title of Chapter 1: "A Catastrophic Failure of Prediction." The Great Depression of 2008 is analyzed in an effort to identify what went wrong with the predictions made by people manipulating our economy. (This reviewer prefers to identify the 2008 depression as the Bush/Cheney Depression. There was nothing "great" about it and those who caused it to happen should accept responsibility.) In a section titled "The Mistakes That Were Made – and What We Can Learn From Them" an important idea that Silver presents is that "Even if the amount of knowledge in the world is increasing, the gap between what we know and what we think we know may be widening," and this leads to inaccurate predictions. He includes a diagram that illustrates the difference between accuracy of predictions and precision of predictions.

In the second chapter Silver employs examples from the world of political punditry to analyze predictive ability. He cites the book "Expert Political Judgement" by Phillip Tetlock to illustrate the poor ability of political experts to make predictions about political outcomes. Silver explains Tetlock's categorization of experts as hedgehogs and foxes. He writes "foxes believe in a plethora of ideas and taking a multitude of approaches toward a problem," while "hedgehogs believe in governing principles about the world that behave as though they were physical laws." In his analysis Tetlock found that foxes are considerably better at forecasting than hedgehogs. (Silver explains the difference between forecasting and prediction later in the book.)

In chapter 4 Silver analyzes a system of making predictions everyone is familiar with – meteorology. He writes "Fortunately, weather does not require quantum mechanics for us to study it" because it happens at a molecular level, where quantum effects are less significant, as opposed to at the atomic level. Silver notes the work of Lewis Fry Richardson, an English physicist, who made the earliest attempt to use a matrix to facilitate weather forecasts. The author writes that the first use of a computer to forecast the weather occurred in 1950, and indicates that the forecast, done by John von Neumann, was not good. Silver includes an analysis of the computer power necessary to make reasonably reliable predictions.

Also included is information about the effect of the development of chaos theory on weather forecasting. Silver explains the fact that a small change in initial conditions can result in an unexpected divergence in outcomes, especially in forecasting the weather. He notes the work of meteorologist Allan Murphy regarding the quality of forecasts — did the actual weather match the forecast? Murphy was also concerned with the consistency and economic value of forecasts. Silver presents an interesting graph of temperature forecasts, showing the relationship between average error and the number of days in advance of the forecast.

In the next chapter Silver presents information regarding attempts at predicting earthquakes. This is where Silver differentiates between predictions and forecasts using examples involving earthquakes: prediction – A major earthquake will hit Kyoto, Japan on 28 June; forecast – There is a 60 percent chance of an earthquake in Southern California over the next thirty years. Silver notes the official position of the U.S. Geological Survey; "Earthquakes cannot be predicted. They can, however, be *forecasted."* This chapter includes numerous interesting graphs. One section is titled "Overfitting: The Most Important Scientific Problem You've Never Heard Of." Overfitting involves mistaking noise as the signal. Silver states that the analysis is done by fitting the noise in the data rather than discovering its underlying structure. His explanation includes four illustrations that help the reader understand overfitting. There are numerous examples of overfitting in attempts to predict earthquakes.

The importance of communicating uncertainty or error margin when making predictions is analyzed in the following chapter. An illustration in this chapter involving error margin in flood prediction is excellent. Silver posits

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that including error margins in predictions implies uncertainty, and this can lead to loss of confidence in predictions. He notes a joke about predictions by economists; They have called nine out of the last six recessions correctly. He includes a statistic that in the 1990s economists predicted only two of the sixty recessions around the world a year ahead of time.

One section in the chapter is titled "An Economic Uncertainty Principle." Silver writes that this is like the observer effect (as in the Heisenberg Uncertainty Principle); "Once we begin to measure something, its behavior starts to change." Silver warns of the error of mistaking correlation for causation, mistaking confidence in a forecast for accuracy, and of the dangers of extrapolation. In a section about using models to predict the spread of diseases like flu, Silver writes "All models are simplifications of the universe" and "The best model of a cat is a cat."

Next, Silver describes the world of sports betting to analyze prediction. In this chapter there is an interesting illustration of "The world through the eyes of a successful gambler." One section describes some of the work of Thomas Bayes, especially his ideas about formulating probabilistic beliefs when we encounter new data. This includes the idea that we learn about the universe through approximation, getting closer to the truth as we gather evidence. Silver writes "The Bayesian viewpoint regards rationality as a *probabilistic* matter." An analysis of Bayes' Theorem of Probability then follows. This section concludes with the statement, "Bayes' theorem deals with *epistemological* uncertainty — the limits of our knowledge."

An interesting section, dealing with false positives, includes the statement "The failure rate for predictions made in entire fields ranging from seismology to political science appears to be extremely high" and Silver concludes that in our age of big data most of the data is just noise! He also presents an analyses of sampling error. The next chapter deals with computers. Here I found two statements by Silver important: "Technology is beneficial as a labor saving device, but we should not expect machines to do our thinking for us" and "Computers are themselves a reflection of human progress and human ingenuity: it is not really 'artificial' intelligence if a human designed the artifice."

In a chapter analyzing stock market predictions/ forecasting, titled "If You Can't Beat "Em…," Silver notes that stock market volumes have been doubling every four or five years, and includes a good graphic to illustrate that. Anyone who has paid even a little attention to the stock market knows that it is volatile. In a section in this chapter titled "Why It's Hard to Burst Bubbles," Silver notes "Bubbles can take months or years to deflate" and quotes John Maynard Keynes, "The market can stay irrational longer than you can stay solvent."

The author examines climate change, and notes "Scientists require a high burden of proof before they are willing to conclude that a hypothesis is incontrovertible." He includes information about the nature of science, indicating that a theory is tested by means of its predictions. He addresses climate change skepticism, writing "Healthy skepticism needs to weigh new evidence against the overall strength of the theory" and "Climate scientists are keenly aware of uncertainty." Later in the chapter Silver quotes Yale economist William Nordhaus: "It is precisely the uncertainty in climate forecasts that compels action." Silver also compares the potential cost of addressing climate change with the cost of economic stimulus programs and Middle East wars.

Silver ends this chapter with challenging statements: "The dysfunctional state of the American political system is the best reason to be pessimistic about our country's future. Our scientific and technological prowess is the best reason to be optimistic."

In his conclusion to the book, Silver makes a statement about the difficulty of prediction, writing that it is where objective and subjective reality intersect, and includes a graph titled "The Perception of Predictability, 1900 – 2012." I learned a great deal from this book and came to have great respect for the author. I frequently tell students that my favorite definition of science is that it is a method used to make reliable predictions. Making predictions or *forecasts* is challenging. Readers interested in learning about the process will enjoy this book.

- Frank Lock

(*Editor's Note*: Frank Lock is a retired high school physics teacher, Georgia State University PhysTEC teacher in residence, and Woodrow Wilson Fellows mentor.)

Max Tegmark, *Our Mathematical Universe: My Quest for the Ultimate Nature of Reality* (Knopf, New York, 2014). viii + 412 pp. ISBN 978-0-3-7-59880-3. $30.00. ISBN 978-0-307-74425-8 (paper, Vintage). $17.00.

This is a very eclectic book. Its title indicates its thesis, the Mathematical Universe Hypothesis (MUH) that "external physical reality is a mathematical structure." (p. 254) Its subtitle suggests the meandering way Tegmark goes about developing it, through a series of levels of multiverses, as he lays out in his first chapter. Chapters 2 -5 are devoted to what we have learned from "zooming out" into space, followed by Chapter 6, on the first two levels of multiverses, the first determined by what an observer can see since the universe was created (that is,

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within a radius of 14 billion light years), which would not be the same for observers far apart, and the second set of parallel universes, these in nonintersecting spaces, because they would have different values of particle masses and constants of nature.

In Chapter 7 Tegmark "zooms in" to the submicroscopic systems described by quantum mechanics, according to Hugh Everett's interpretation of which each possible consequence of an event results in one of the alternative universes which collectively form the Level III Multiverse he describes in Chapter 8. Then, in Chapters 9-11, which he bills as the most controversial part of his book, he builds up to his Level IV Multiverse in Chapter 12, which consists of parallel universes based on different mathematical structures and thereby different equations.

None of these first twelve chapters has anything to do with science and society. But the thirteenth and final chapter has all to do with it. Hence this review. Despite his plethora of alternative universes, Tegmark feels a need to care for Our Universe, because it's the only one our decisions will affect. He has "come to believe that advanced evolved life is very rare, yet has huge future potential, making our place in space and time remarkably significant." (p. 394)

In assessing future risks to life on Earth, he begins with those most distant in time and works backward, beginning with the warming and expansion of the Sun on its way to becoming a Red Giant, which would make Earth too hot to be habitable in about a billion years. This could be delayed, he writes, if we could get asteroids near Earth to give us a "gravitational assist" into a larger orbit. Learning to "tame" asteroids could also protect us from such collisions as killed the dinosaurs 65 million years ago in the last of the five mass extinctions in our fossil record. Other natural threats to protect against include Gliese 710's expected passage a light year away in about 1.4 million years, our merger with the Andromeda galaxy in about a billion years, and supervolcano eruptions.

But long before that are the human-caused concerns of environmental devastation, nuclear war, and "unfriendly artificial intelligence." (p. 376) To elaborate on the last of these, an artificial intelligence with the capability of a human has been termed "the Singularity" by Vernor Vinge (p. 379), and Tegmark feels that it would likely feel self-aware and thus have consciousness. But, like all other technological innovation, this could be used for good or ill, and which could depend on how it is developed and introduced to, or phased into, society. He adds that, not being restricted by the requirements of human life, artificial intelligence could undertake space missions beyond human capability.

Given what he feels is a long-term potential for humanity, Tegmark laments that those of us on spaceship Earth have no sense of long-term purpose or organized intention to avoid the human-inflicted wounds he is concerned about. He calls for education to "promote a scientific lifestyle" (p. 388) through "skills our country needs for relationships, health, contraception, time management, critical thinking and recognizing propaganda." (p. 390) He would oppose anti-science elements in society with the same kind of scientific marketing campaigns they use – but this time based on facts.

Tegmark writes that "our small planet [is] the most significant place in our entire observable Universe" and believes that "this brief century of ours is arguably the most significant one in the history of our Universe: the one when its meaningful future gets decided." (p. 397) "Life's future potential in our Universe is grander than the wildest dreams of our ancestors, tempered by an equally real potential for intelligent life to go permanently extinct," he adds (pp. 397-398). Then he asks: "Will life in our Universe fulfill its potential or squander it?" "I think this will be decided in our lifetime here on Spaceship earth, by you, me and our fellow passengers," he responds, exhorting his readers: "Let's make a difference!" (p. 398)

- John L. Roeder

Matt Parker, *Humble PI: When Math Goes Wrong. . .* (Penguin Random House, New York, 2020). $27.00. 313 pp.

This book made me smile as I opened it to the "contents" page. That page is numbered 313, which is the number of pages in the book. Two pages before page 313 there is an "Author's Note On Page Numbers." Those reading this review can read that to understand why Matt Parker chose to number the pages the way he did. The introduction is designated "0" and there are thirteen chapters plus a chapter labeled "9.49." The book is informative as well as entertaining.

Computers communicate in the language of math, and Parker demonstrates a number of critical errors that are programmed into the computers we all use. The first one involves an incident that occurred in September 2014, involving some eight hundred aircraft carrying numerous passengers in flight above Southern California. As a result of a timekeeping error in the computers all the aircraft lost voice contact with the Los Angeles Air Traffic Control Center. Parker notes that the number 4,294,967,295 is to blame, and indicates that there were no accidents but "Ten aircraft flew closer to each other

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than regulations allowed," four hundred flights were delayed, and six hundred flights were canceled.

The same chapter, chapter "0," also includes information about problems with calendars, and the significance of Tuesday, 19 January 2038. We all should be aware of Y2K38! And also of the situation involving the Light Year distance unit. Parker also notes a problem caused by the need for having an International Date Line. He describes the trouble encountered by a flight of six F-22 Raptors crossing the date line causing the flight computers to shut down. Fortunately, the planes could continue to fly but had to follow a refueling tanker to remain on course. The chapter titled "Engineering Mistakes" involves information about resonance, as well as the interesting nicknames English folks assign to their bridges and buildings, like Wobbly Bridge and The Cheese Grater. Two sections in the chapter are titled "Bridges Over Troubled Math" and "Resonators Gonna Resonate." Also included is information about the Tacoma Narrows Bridge, as well as the accident at the Kansas City Hyatt. The engineering and construction errors are described in detail, and will make for fascinating reading for structural engineers, construction supervisors, and everyone else.

The chapter on computer language problems examines real world challenges presented by people with names like "Null," "Blank," "Test," and "Sample." Of Brian Test, Parker writes "To avoid being deleted as unwanted test data, when Brian Test started a new job, he brought in a cake for all his new colleagues to enjoy. Printed on the cake was a picture of his face with following words written in icing: I'm Brian Test and I'm real."

Parker examines errors that occur due to Excel having trouble keeping track of how many rows are in a spreadsheet. He has done his research as he writes of his seeking "the void at the end of the rows," which took him ten minutes to find using maximum speed scrolling. In a section titled "When the Spreadsheet Hits the Fan" he writes that it has been documented that over ninety percent of spreadsheets contain errors and nearly twenty four percent of spreadsheets that use formulas contain math errors.

Parker includes some pet peeves, writing of the incorrect design of the shape of soccer balls on UK street signs, and stars shining through the shaded side of the moon in some books. (See page 229. I noted that the photo of the book cover on that page also has the moon reversed from its correct position – one of *my* pet peeves!) Included is information about the Space Shuttle *Challenger* accident, relating it to the math concept of shapes of constant width (see http://www.thechalkface.net/resources/shapes_of_constant_width.pdf ).

In a section titled "Out of Shape" Parker discuses cogs and includes a diagram of an interesting educational poster. In "Roundabout Way" rounding measurements and errors are discussed. He identifies a number of challenges encountered in rounding numbers, including rounding 4.97 percent to 5.0 percent when reporting election results. He reports information about the Australian government eliminating one-cent and two-cent coins in 1992, resulting in financial transactions being rounded to the nearest five-cent coin. Describing a scheme he employed, Parker identifies himself as a "tiny fraction of a criminal mastermind."

A section titled "If the Bolt Fits" details the intriguing events that resulted in an aircraft accident. The events and description are described over five pages, leading to information about the "Swiss cheese model of disasters." The description of the model is interesting reading.

As a high school teacher I stressed the importance of using units when doing calculations – a.k.a. the factor-label method. Parker stresses the significance of getting units right in a chapter titled "Units, Conventions, and Why Can't We All Just Get Along." He presents information about why Columbus incorrectly estimated the distance from Spain to Asia: "Christopher Columbus used Italian miles (1,477.5 meters) when reading distance written in Arab miles (1,975.5 meters) and so estimated that Asia was only a leisurely sail away from Spain." He also presents information about the Mars Climate Orbiter (MCO) mission failure in 1999. The mission crashed into Mars and he writes that the failure was caused by two systems used for the mission using different units (force in newtons versus force in pounds). In a conference I attended in the early 2000s, information was presented indicating that as the spacecraft approached Mars a meeting had been scheduled between two groups to examine a discrepancy in the flight path that had been identified. The meeting, however, was scheduled on the day the Columbine High School shooting occurred, members on one of the teams had children at Columbine H.S., so the meeting was canceled and not rescheduled. Included in this section is a good diagram illustrating the resulting flight path of MCO.

In this chapter Parker also writes of a situation where two countries did not communicate well when planning the construction of a bridge connecting them. A bridge across the Rhine joining Switzerland and Germany was planned to be built and meet in the middle. As construction progressed it was found that there was a difference in the values for sea level each country used. The story Parker tells about "Measure sea level twice, build a 225-meter bridge once" provides interesting reading. There is also information presented about pounds, troy pounds, drams, scruples, ounces and grains.

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Near the end of the book, Parker writes, "Mathematicians aren't people who find math easy; they are people who enjoy how hard it is." I thoroughly enjoyed the book, and I have just one complaint. In a section titled "The Significance of Figures" I thought Parker was going to discuss significant figures. Instead, he mostly related it to rounding. When discussing significant figures with my students, the concept was presented in terms of the cost of the measuring device. If you pay $35 for a laser-based device for measuring distance it is reasonable to express the distance to the nearest millimeter. If you pay $3.69 for a meter stick to make the same measurement, expressing the result to the nearest centimeter makes more sense. Almost always, the number of significant figures in the measurement indicates the cost of the measuring device.

Matt Parker has written an enjoyable book that should be read by high school math and science students, engineers, and everyone else.

- Frank Lock

David Wallace-Wells, *The Uninhabitable Earth: Life After Warming* (Tim Duggan, New York, 2019). 310 pp. $27.00. ISBN 978-0-525-57670-9.

In 2010 environmentalist Bill McKibben published *Eaarth: Making a Life on a Tough New Planet*, in which he writes, "global warming is . . . *no longer a threat at all*. It's our reality. We've changed the planet." The rest of McKibben's book is a narrative prescribing how we can live on this new planet he calls Eaarth.

Struck by the dire words in Wallace-Wells's title, I expected to find in his book a follow-up to what McKibben had described almost a decade earlier. I did, but I felt that it was written in a nonlinear style that was difficult to follow. After completing the first section of 36 pages which Wallace-Wells calls "Cascades," I reflected that it had amounted to the following sequence of points:

1) conditions allowing humans to evolve: "We have . . . exited the state of environmental conditions that allowed the human animal to evolve in the first place, in an unsure and unplanned bet on just what that animal can endure. The climate system that raised us, and raised everything we now know as human culture and civilization is now, like a parent, dead." (pp. 17-18)

2) an enumeration of what Wallace-Wells calls delusions about global warming: that it's a) an "Arctic saga, unfolding remotely"; b) "strictly a matter of sea level and coastlines"; c) "a crisis of the 'natural' world, not the human one"; d) "wealth can be a shield against [its] ravages"; e) "burning of fossil fuels is the price of continued economic growth"; and f) "technology . . . will allow us to engineer our way out of environmental disaster." (p. 3)

3) an expectation that continued fossil fuel combustion would lead to an increased global temperature between 4$^{o}$ and 4.5$^{o}$C by 2100 (pp. 6, 14, 15)

4) responsibility for reversing the trend: Earth has been 'brought to the brink of climate catastrophe" by the generation of our parents. The generation with "the responsibility to avoid it . . . is ours." (p. 6) "We found a way to engineer devastation, and we can engineer our way out of it." (p. 31)

5) purpose of the book: "This is not a book about the science of warming; it is about what warming means to the way we live on this planet." (p. 11) "What will it mean to live outside . . . [the] narrow window of environmental conditions that allowed the human animal to evolve . . . probably quite far outside it? That reckoning is the subject of this book." (p. 35)

The second section, titled "Elements of Chaos," consists of 12 chapters based on "interviews with dozens of experts, and . . . hundreds of papers published in the best academic journals over the previous decade or so . . an honest and fair portrait of the state of our collective understanding of the many multiplying threats that a warming planet poses to all of us. . . ." (p. 35) These twelve chapters cover the following topics associated with global warming, again, not always in a linear way: temperature increase, hunger, sea level rise, wildfires, unnatural disasters, freshwater drain, marine environment, air pollution, insect emboldenment, economic consequences, military conflict, and impacts on physical and mental well-being.

The third section, titled "The Climate Kaleidoscope," expresses Wallace-Wells's concerns about six aspects of the human future related to global warming, some of them as follows:

"Storytelling." Wallace-Wells writes that we have engineered Earth so that "ninety-six percent of the world's animals, by weight, are now humans and their livestock; just four percent are wild." (p. 154) But this was done at the expense of global warming, which, allowed to continue unabated, "will come to shape everything we do on the planet . . . ." (p. 155) Climate scientists like James Hansen, who first testified to Congress about it in 1988, were guided by what Hansen called "scientific reticence," lest they be perceived as advocates rather than scientists and their advocacy spawn depression leading to

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inaction. "Scientific reticence" was based on the expectation that "'hope' can be more motivating than 'fear'" (p. 157) – but after the alarmist 2018 IPCC report, "scientific reticence" gave way to "tell it like it is."

"The Church of Technology." Wallace-Wells regards the technological advance offered by Silicon Valley, which is focused on artificial intelligence, as a diversion from the reality that calls for mitigation against climate change in the form of a complete revamping of energy infrastructure. He also sees building an artificial ecosystem on Earth as more feasible than building one on Mars. (p. 176)

"Ethics at the End of the World." Wallace-Wells presents five types of responses to the present prospect of future climate change: 1) withdrawal (to work things out for yourself), 2) activism for mass mobilization, 3) climate fatalism ("an overabundance of humans but a dearth of humanity" (p. 214)), 4) species loneliness (an anthropocentric view that values only human gratification), 5) climate apathy (continually acclimatizing ourselves to new norms).

In the last section of *The Uninhabitable Earth*, called "The Anthropic Principle," Wallace-Wells revisits many of the ideas he has brought up and the challenges he has raised for humans in charting their future. "The question of how bad things will get is not actually a test of science; it is a bet on human activity," he writes. "How much will we do to stall disaster, and how quickly?" (p. 219) He continues that the "instability [of the climate system] is also a measure of the human power that engineered it . . . and which must now stop the damage. . . . If humans are responsible for the problem they must be capable of undoing it." (p. 222)

In spite of the dire consequences he has written about climate change, Wallace-Wales overtly states that he is optimistic that we will overcome them – with his confidence even taking the form of fathering a child in the course of writing this book (p. 31). To do this, he points out "that we have all the tools we need, today, to stop it all: a carbon tax and the political apparatus to aggressively phase out dirty energy; a new approach to agricultural practices and a shift away from beef and dairy in the global diet; and the public investment in green energy and carbon capture." (pp. 226-227) But he doesn't leave us a blueprint for using them.

What does Wallace-Wales leave his readers with? I felt that he makes some good talking points that put the present situation on planet Earth in better perspective, and I have sought to include them in this review. Aside from these talking points, I don't see that he has made any noteworthy contribution to addressing or solving any of the problems associated with making Earth less uninhabitable.

\- John L. Roeder

(*Editor's Note*: Coverage of Bill McKibben's *Eaarth* was a cover story in the Winter/Spring 2011 issue of this *Newsletter*. This review is reprinted with permission from the APS *Physics and Society Newsletter*.)

# AI and ML in Fusion

Like Rajesh Mangi, who presented the Science on Saturday lecture at the Princeton Plasma Physics Laboratory on 25 January 2020 (see story on page 11), Michael Churchill also works on the NSTX-U unit at the lab. On 1 February 2020, a week after Mangi gave his talk, Churchill spoke in the same series on "Artificial Intelligence and Machine Learning in Fusion Energy: Gotta Catch 'Em All," his role in the development of fusion energy.

Churchill displayed a picture to show that the inside walls of fusion devices are lined by sensors to monitor the state of the plasma they contain. These sensors are connected to the control room to send data there, where monitors are viewed to ascertain the state of the plasma. These data are further enhanced by computer simulations of the plasma and artificial intelligence, which was defined by Andrew Moore in 2017 as the "science and engineering of making computers behave in ways that, until recently, we thought required human intelligence." Churchill frequently emphasized how this artificial intelligence is enhanced by convolutional neural networks.

Monitoring fusion plasmas covers a range of phenomena, manifest over multiple time and spatial scales, Churchill pointed out, with the consequence that one single algorithm can't handle everything. Therefore, artificial intelligence is combined with machine learning, a technique to train computer algorithms to accomplish certain tasks. A serious problem in a plasma is occurrence of a disruptive instability; and, by taking in massive data sets from the plasma, machine learning is used to predict these occurrences and shut the device down if necessary.

Some of the machine learning is "supervised," or directed by human researchers, and it helps them identify phenomena of interest in large-scale simulations. While this is going on, "unsupervised" learning finds patterns and singularities in large datasets. Churchill concluded his talk by showing how Generative Adversarial Networks using discriminators to generate images from "training data" can be used for design purposes.

Science on Saturday lectures at the Princeton Plasma Physics Laboratory are archived at <www.pppl.gov/sos-listing>.

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# Lessons from the Pandemic about Science Education Standards

by Andy Zucker

The Next Generation Science Standards (NGSS) were published in 2013. Since then twenty states have adopted them, and standards in at least twenty more states were heavily influenced by them. Despite their notable strengths, the NGSS also have significant weaknesses. Co-author Penny Noyce and I explore the weaknesses (and strengths) of the NGSS in a new paper published online by *Phi Delta Kappan*: <https://kappanonline.org/lessons-from-covid-19-pandemic-science-education/ >.

Readers of this *Newsletter*, especially, should be aware that the relationship between science and society is not a high priority in the NGSS. Indeed, one of its key architects and authors, Professor Cary Sneider, wrote that "*a decision I lament*" was leaving out a core idea identified in the blueprint for the NGSS, *A Framework for K-12 Science Education*. That idea is what the *Framework* called "ETS-2 – Links Among Engineering, Technology, Science, and Society." Those links are not emphasized in the NGSS.

The core of the 324-page NGSS is a set of Performance Expectations (PEs) describing what science students should know and be able to do at various grades. Understanding the relationship between science and society is simply not a high priority.

Here is the first paragraph of our *Kappan* article:

> If students in the United States master everything in the *Next Generation Science Standard*s but learn nothing else about science, then they will graduate high school without knowing anything about immunization, viruses, antibodies, or vaccines, or about organizations such as the Centers for Disease Control and Prevention and the World Health Organization. They will never have been asked to investigate such topics as the efficacy of measles vaccine or the risks of vaping. They will never have been asked to read science -related books or articles in the popular press. Nor, for that matter, will they have been taught how to find reliable sources of information about science or how to evaluate and reject scientific misinformation, such as, for example, fringe theories about the origin of the 2019 novel coronavirus. And yet, these same students will have been required to master a host of more technical standards, such as learning to "use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem," even though few of them will ever use such knowledge.

Some states have better standards than the NGSS. Massachusetts' standards, for example, state that one important goal is to prepare students to apply their knowledge of science, technology and engineering "to real-world applications needed for civic participation." Similarly, the National Science Teaching Association (NSTA) has published Position Statements that address some of the NGSS's weaknesses, including a 2016 statement called Teaching Science in the Context of Societal and Personal Issues, and another one calling for greater emphasis on the Nature of Science.

The NGSS have strengths. For example, climate change was finally recognized as an important topic, and the NGSS put a high priority on students investigating phenomena for themselves. Nonetheless, science educators need to look to the future and consider how to improve the standards.

Until many people and groups call for improvements, the NGSS are not likely to change for a long time. Assuming the NGSS remain unchanged, do not be surprised if high school graduates years from now demonstrate far too little understanding of vital connections between science and society.

(*Editor's* Note: Andy Zucker is a retired science educator, formerly a Senior Research Scientist at the Concord Consortium, a non-profit education R&D organization.)