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EDITOR
Paul Oh
National Center for Science Education
1904 Franklin Street, Suite 600
Oakland CA 94612-2922
phone: (510) 601-7203
e-mail: editor@ncse.ngo

BOOK REVIEW EDITOR
Glenn Branch

PUBLISHER
Ann Reid

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Dear NCSE members,

Editor's note: *This issue of* RNCSE *was conceived and executed before Covid-19 completely upended our society. Know that all of us at NCSE are caring for each other and thinking of you. Certainly, the importance of accurate science has never been greater. Thank you for your support of NCSE. And now back to our scheduled issue:*

Consider the opening lines of Charles Dickens's *Hard Times* (1854), in which school superintendent Thomas Gradgrind expounds his theory of education:

> Now, what I want, is Facts. Teach these boys and girls nothing but Facts. Facts alone are wanted in life. Plant nothing else, and root out everything else. You can only form the minds of reasoning animals upon Facts: nothing else will ever be of any service to them.

Since NCSE was founded on the principle that what students learn in science class should be consistent with the best current scientific understanding, you might think that we would reflexively agree with Gradgrind's prescription. But in fact—so to speak—the evidence shows, over and over again, that education involves many things in addition to facts: compassion, trust, and hope, to name just a few.

I was reminded of Gradgrind's theory of education by the articles in this issue of *RNCSE*, which in effect show what else is needed to be "of service" to our fellow "reasoning animals." As Kate Carter points out in her description of NCSE's Graduate Student Outreach Fellowship (p. 3), effective science outreach and communication is not simply about speaking slowly and using simple words: it's about taking the time to get to know your audience.

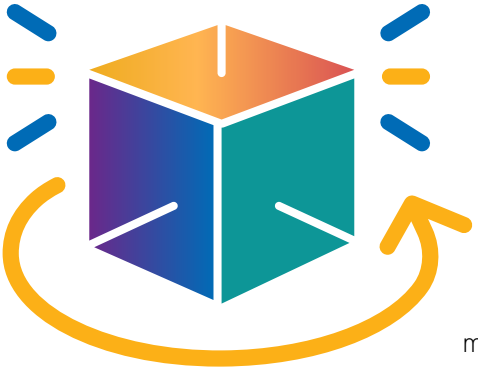
Lin Andrews (p. 10) addresses a particular challenge along these lines: "climate despair"—the anxiety that many young people feel in the face of dire predictions about the Earth's future and the current manifestations of climate instability in the form of floods, fires, and hurricanes. These students need facts, for sure; pretending the climate isn't changing does nothing to resolve their fears. But they also need hope.

I believe that one of the secrets behind NCSE's long success is this deep understanding that facts are necessary but not sufficient. Changing minds and countering misinformation requires establishing relationships and building mutual respect. And, of course, another secret of our success is a loyal group of members who understand both the importance of our mission and the uniqueness of the ways in which we strive to accomplish it. So I hope that you will find not only plenty of facts in this issue, but also plenty of inspiration.

And take care of yourselves.

Ann Reid is the executive director of NCSE. reid@ncse.ngo

NCSE's Graduate Student Outreach Fellowship: DEVELOPING A NEW MINDSET



❶ Don't use big words. ❷ Talk loudly. ❸ Don't make people feel stupid.

Those are the three most common answers we get when we ask graduate students at the beginning of the NCSE Graduate Student Outreach Fellowship: What are the most important skills for communicating science effectively?

They aren't bad answers. I imagine that most people have sat through lectures where the speaker ought to have paid these best practices more heed.

But there's more to science outreach than just giving a good TED talk. Reasons for disengagement with science are varied and nuanced, and counterbalancing them requires more than illustrative hand gestures and metaphorical language. It takes the adoption of a new mindset. The third cohort of NCSE's Graduate Student Outreach Fellows, who began in January 2020, have more than 19 years of science outreach experience among them. Through their fellowship year, NCSE will help grow their already-strong outreach skills and challenge them to become leaders in science communication, focusing on taking a community-centered approach, reaching a diverse group of participants, and collecting evidence to support their approach.

A New Mindset

In order to broaden their reach, scientists have to construct messages that resonate. They need to change their mindset from "How do I get my science in the community?" to "What does the community want to know about my science?" This altered approach creates greater resonance with audiences. It also requires forging partnerships outside academia and creating participatory experiences that empower community members.

Graduate Student Fellow Taryn Dunivant sets up shop in Lawrence, KS. Photo by Taryn Dunivant

This mindset is reflected in NCSE's entire approach to effective outreach. We mentor the fellows to use a no-conflict approach—an effort to find commonalities and create opportunities for productive communication as opposed to engaging in debate—and help them design inquiry-based science activities that create community-specific experiences for participants. We also nurture the fellows to become thought leaders through several first-semester assignments. One of the initial assignments asks each fellow to observe how participants interact with science in their community to understand who is and who isn't engaging with science, how they engage with science, and what fears and hopes they have with regard to emerging science. The fellows then build on these observations by completing a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis to map the informal science landscape in their community. Then, as the fellows start developing their own activities, we borrow from principles of user-experience design to ground our science communication with a participant-first approach. Our goal is that by the end of the year, fellows will not only recognize the importance of audience in general but also have specific experience in using multiple strategies to reach diverse audiences.

Expanding Access

Access to science is unequal in our society, and the fellows are encouraged to use evidence-based approaches to mitigate the structural barriers that create that inequity. Though every community is different, designing activities in which everyone can find success, actively listening to the experiences of diverse groups, and being present in spaces where science isn't typically found can be effective strategies for broadening participation. The fellows are also trained in specific best practices for engaging diverse communities, such as non-English-speaking populations and visually impaired participants. Our hope is that the fellows will spend a good portion of their fellowship year working with populations that would otherwise have little access to quality science outreach.

We also focus on diversity when developing activities. Many of our activities involve climate change solutions, a topic that requires a particularly nuanced approach since discussing science and solutions without including real social dynamics can lead to shifting the greatest responsibility onto the shoulders of those least able to bear it. Therefore, we design activities that empower everyone to find solutions while acknowledging real-world complications. In our Cool Cities activity, for example, participants must manage a city budget and account for gentrification and housing issues. In our long-form Climate Change Summit, we challenge communities to listen to one another as they work to find a solution to climate-change-induced problems. By combining social issues with science outreach, we can model a solution where everyone's perspective is valued and the science is not divorced from social dynamics.

The Role of Evidence

The theme of evidence permeates every aspect of the fellowship. The activities are not only intended to allow as many people as possible to engage directly with with evidence, they are also developed, conducted, and revised in light of the evidence of their effectiveness.

Supporting the professional development of academics to engage diverse audiences and to be a transformative factor in science outreach across their universities and throughout their careers is the primary goal of NCSE's Graduate Student Science Outreach Fellowship. To do this, we provide each fellow with the tools to secure funding for their outreach, opportunities to engage in dialogue with one another about pedagogy, and require them to participate in informal science research. During the second semester of the fellowship, each fellow conducts an independent research project designed to connect their understanding of science content with current research on effective science communication that will be presented in academic conferences, primarily in the

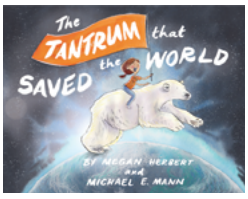
NCSE facilitates inquiry-based, hands-on activities. Photo by Kate Carter

fellow's field of study. Current projects include evaluating how different explanations for phylogeny affect participant understanding and analyzing how designing activities with a local connection can increase participant engagement with climate science. Fellows also interact with a diverse group of stakeholders, working with NCSE staff and our partners to help conduct larger research projects on such topics as creating effective academic partnerships with rural museums.

By participating in the Graduate Student Outreach Fellowship, fellows are encouraged to use evidence-based approaches to explain their science, engage diverse populations, and become thought leaders in science communication. We hope that the Graduate Student Outreach Fellows will become a bridge between local academic communities and informal science communities, creating a powerful impact that expands beyond their own careers.

Kate Carter is NCSE's Director of Community Science Education. carter@ncse.com

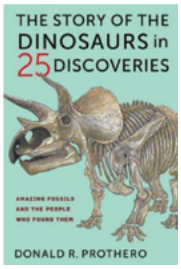
news from the **membership**



NCSE is pleased to congratulate Megan Herbert and **Michael E. Mann** (a member of NCSE's board of directors) for receiving the Louis J. Battan Author's Award (K–12) for 2020 for their book *The Tantrum that Saved the World* (2017), which (in the words of the award citation) "engages readers with empathy and compassion and empowers them to help save animals and people from the threat of climate change." The award is conferred by the American Meteorological Society "to the author(s) of outstanding learning materials or book published within the last three years that fosters the understanding of atmospheric and related sciences in K–12 audiences." *The Tantrum that Saved the World* was reviewed by Kottie Christie-Blick in the summer 2018 issue of *Reports of the NCSE*, which also featured a brief interview with Herbert and Mann.

Donald R. Prothero's new book *The Story of the Dinosaurs in 25 Discoveries: Amazing Fossils and the People who Found Them* (Columbia University Press, 2019) was published. The publisher writes:

In twenty-five vivid vignettes, he weaves together dramatic tales of dinosaur discoveries with what modern science now knows about the species to which they belong. Prothero takes us from eighteenth-century sightings of colossal bones taken for biblical giants through recent discoveries of enormous predators even larger than Tyrannosaurus. He recounts the escapades of the larger-than-life personalities who made modern paleontology, including scientific rivalries like the nineteenth-century "Bone Wars." Prothero also details



how to draw the boundaries between species and explores debates such as whether dinosaurs had feathers, explaining the findings that settled them or keep them going. Throughout, he offers a clear and rigorous look at what paleontologists consider sound interpretation of evidence. An essential read for any dinosaur lover, this book teaches us to see an ancient world ruled by giant majestic creatures anew.

Adjunct professor of geological sciences at California State Polytechnic University, Pomona, and research associate in vertebrate paleontology at the Natural History Museum of Los Angeles County, Prothero is a recipient of NCSE's Friend of Darwin award.

Glenn Branch is deputy director of NCSE. branch@ncse.ngo

Photo by Christian Bibas

Random Samples with Spencer Weart

In this issue of *RNCSE*, we introduce a new twist to a beloved feature: Place and Time (see below). This historical look at people, events, and locations that have shaped our understanding of evolution will now include similar examinations related to climate change. Spencer Weart, author of *The Discovery of Global Warming*, (2003; second edition 2008) contributed the first climate change Place and Time, about Charles David Keeling, of Keeling Curve fame. We thought you'd appreciate getting to know Weart and his work a little better; he graciously agreed to sit for a Random Samples interview.

Weart studied physics and astrophysics at Cornell University, the University of Colorado (where he received his Ph.D. in 1968), and the Mount Wilson and Palomar Observatories, publishing papers in leading scientific journals. In 1971 he went to the University of California, Berkeley, to study history of science. From 1974 until his retirement in 2009 he served as Director of the Center for History of Physics at the American Institute of Physics, while occasionally teaching at universities. His publications include children's science books as well as books on the history and imagery of nuclear energy and weapons, peace among democracies, the history of solid-state physics, and the history of climate science.

Paul Oh: You trained and worked as a physicist. What prompted you to shift fields into the history of science?

Spencer Weart: I did my doctoral thesis and postdoctoral work in solar physics. Going on eclipse expeditions was literally awesome, and I published research that was well-regarded, but I realized that progress in the field would be slow. To do something meaningful with my life, I felt I would have to become an administrator developing a solar space telescope that would not fly for many years (as it turned out, decades). On reflection I decided that with my abilities I could better contribute to science as a writer, using history to help people understand and appreciate science.

PO: Before* The Discovery of Global Warming, *your scholarly focus was more on nuclear physics. How did you become interested in the history of climate science?

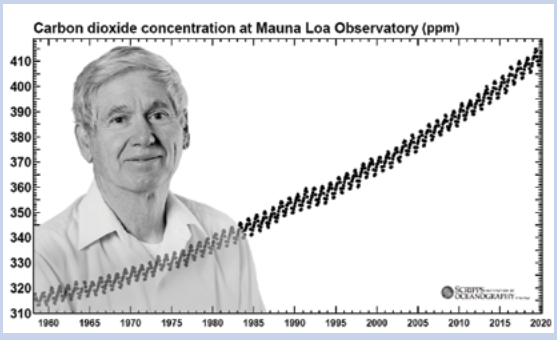
SW: When I was wrapping up my book *Nuclear Fear* (1988) and looking for a new project, I thought it would be useful to document an active research field, one with questions still unresolved: science *in vivo*. In my research on the history of nuclear controversies, I had come across claims that reactors are important because they could help solve a problem I hadn't heard of—greenhouse gas emissions. I started to look into the subject just as scientists like Jim Hansen, one of the first people I interviewed, were coming to see how serious global warming could be. So it was worth my time for the next decade.

PO: Did the book then take a decade to write?

SW: It took longer than that. Climate science involves everything from the sun to the seabed, so I had to read articles in many different research fields, each with its own story. To organize it all, I built a website with a couple dozen separate

PLACE & TIME

Charles David Keeling: Making Good Measurements



Some scientists want to develop novel theories, some want to craft ingenious experiments, some want to observe remarkable phenomena. Dave Keeling just wanted to make good measurements. "Keeling's a peculiar guy," a colleague of his once remarked. "He wants to measure carbon dioxide in his belly... And he wants to measure it with the greatest precision and the greatest accuracy he possibly can."

Charles David Keeling (1928–2005) had a second passion: mountains. Since his childhood in the flat Midwest, he had wanted nothing so much as to be in the high country. As a postdoc in geochemistry at the California Institute of Technology, he rebelled against assignments in a dim basement laboratory. A chance remark drew his attention to carbon dioxide (CO_2) in the atmosphere. Scientists had been measuring it for decades, for it carried a record of an air mass's movements. The CO_2 level was higher in air that had recently passed over a city, a forest, even a flock of sheep. With the level fluctuating so promiscuously, nobody had tried to measure it very accurately.

Keeling being Keeling, he went for precision. He took glass flasks outdoors to capture air samples and brought them back to measure the contents. There existed no instrument accurate enough to satisfy him, so he devised one based on an idea he dug up in a 1916 publication. To get samples of undisturbed atmosphere, he went, of course, into the mountains—the magnificent American ranges, from the High Sierras to the Cascades. He found that the purest air everywhere had the same CO_2 base level: 310 parts per million (ppm).

essays, connected by hundreds of hyperlinks. Only then could I collapse the history into a single book.

I thought that I was doomed to write a narrative that would have no clear endpoint, no resolution of the question whether we truly faced dangerous global warming. But as I was finishing up the book, the IPCC published its 2001 report, which marked the end of serious scientific controversy. The discovery of global warming was done, a neat conclusion. Of course the story continues; the research front has turned to studying impacts that are now visibly underway, and I keep up with that on my The Discovery of Global Warming website

PO: There's been a lot of discussion (including from people like Naomi Oreskes, Anthony Leiserowitz, and John Cook) about the scientific consensus on climate change and the importance of conveying it to the public. How can the history of science usefully inform these discussions?

SW: Leiserowitz's team found that a large majority of our citizens don't know that essentially all scientists who are currently publishing climate research agree that humans are causing dangerous climate change. When these citizens learn the truth, they become more concerned. To go deeper, history can be a big help. Into the 1990s, scientists raised credible doubts about climate change (computer models are unreliable, it's solar cycles, etc.). Each of these ideas was studied exhaustively and definitively refuted. In the 1970s, climate scientists agreed that they didn't know what was happening, whereas now they agree that they do know. It's useful to explain this, for zombie ideas killed long ago still infest the internet. It also helps to describe how some prominent doubters turned out to be taking money from fossil fuel interests, and how corporations ploughed a billion dollars into climate-denial propaganda. Understanding the controversies of the past, in both their scientific and political contexts, gives tools to understand present and future issues.

PO: Do you have any thoughts about how the history of climate science should be incorporated in K–12 education, whether in science classes or elsewhere? How can science teachers learn about the history of climate science and discover ways of enriching their classrooms?

SW: Not only climate science but all science can be enriched with history. It's more important to teach how science is done than the content of science itself! This is actually a job for all teachers. How can we understand the world rationally? When should we trust what scientists say? A great way to explain these things is by telling how past scientists argued and reached conclusions. And these are engaging stories, human stories. How about the scientists who risked their lives in the remote wastes of Antarctica, drilling a hole in the ice two miles deep, finding that the planet's greenhouse gases and temperature went up and down in tandem for the past million years, thus settling doubts about the computer models?

Good resources are Daniel P. Shepardson, et al., eds., *Teaching and Learning about Climate Change: A Framework for Educators* (Routledge, 2017), and the references for teachers and students in the links page of The Discovery of Global Warming.

Paul Oh is NCSE's Director of Communications. oh@ncse.ngo

That same year, 1956, CO_2 caught the attention of a much more senior geochemist, Roger Revelle. He calculated that humanity's emissions of the gas should be accumulating in the atmosphere. Other scientists had long since concluded that CO_2 would dissolve into the oceans as rapidly as civilization produced it. Revelle realized, first, that seawater could not take up the gas easily, and second, that our emissions from burning coal and oil were rising exponentially. If he was right, the greenhouse effect might bring global warming problems in the 21st century—for Revelle, the distant future. He looked for someone who could measure the gas; there was nobody but Keeling.

Funding was not a problem, for governments had designated 1957–1958 as the International Geophysical Year (IGY), with a pot of money for global studies. Revelle's plan was to measure the CO_2 base level in the pure air of Antarctica and atop the Mauna Loa volcano on Hawaii. Then after twenty years or so somebody could measure it again and see if it had indeed risen. Keeling had other plans. Devoted to precision, he demanded and got a costly new instrument, then relentlessly hunted down every source of noise and error. In just two years he proved that the level was climbing. By 1960 it had reached 314 ppm.

Keeling would dedicate the rest of his life to measuring CO_2 in the atmosphere. The hard part wasn't the science; it was the money. The IGY was over. Agencies saw no point in continuing "routine" measurements year after year with no "discoveries" on offer. By nature Keeling was quiet and affable, but to administrators he became a pain in the neck with his endless demands for funding. Time and again his work hung by a thread.

The program finally got a permanent institutional base in the late 1980s as most scientists came to agree that the buildup of CO_2 threatened grave climate disruption. The dwindling minority who denied the risk could find no flaw in Keeling's meticulous measurements. The inexorably climbing "Keeling Curve" began to show up everywhere. It became the icon of an ominous fact: human civilization has become a geophysical force. (The CO_2 level is now 412 ppm.)

Spencer Weart was Director of the Center for History of Physics at the American Institute of Physics from 1974 to 2009; he is the author of *The Discovery of Global Warming* (second edition, 2008) and maintains a website of the same name: https://history.aip.org/climate/index.htm. sweart1@gmail.com

UPDATES

ncse.com/updates

Are there threats to effective science education near you? Do you have a story of success or cause for celebration to share? E-mail any member of staff or info@ncse.ngo.

FLORIDA

Eleven years before becoming the chair of Florida's state board of education in July 2019, Andy Tuck, then vice chair of the Highlands County School Board, said, "[A]s a person of faith, I strongly oppose any study of evolution as fact at all. I'm purely in favor of it staying a theory and only a theory. … I won't support any evolution being taught as fact at all in any of our schools." The board is now overseeing a review of the state education standards.

ILLINOIS, DIETRICH

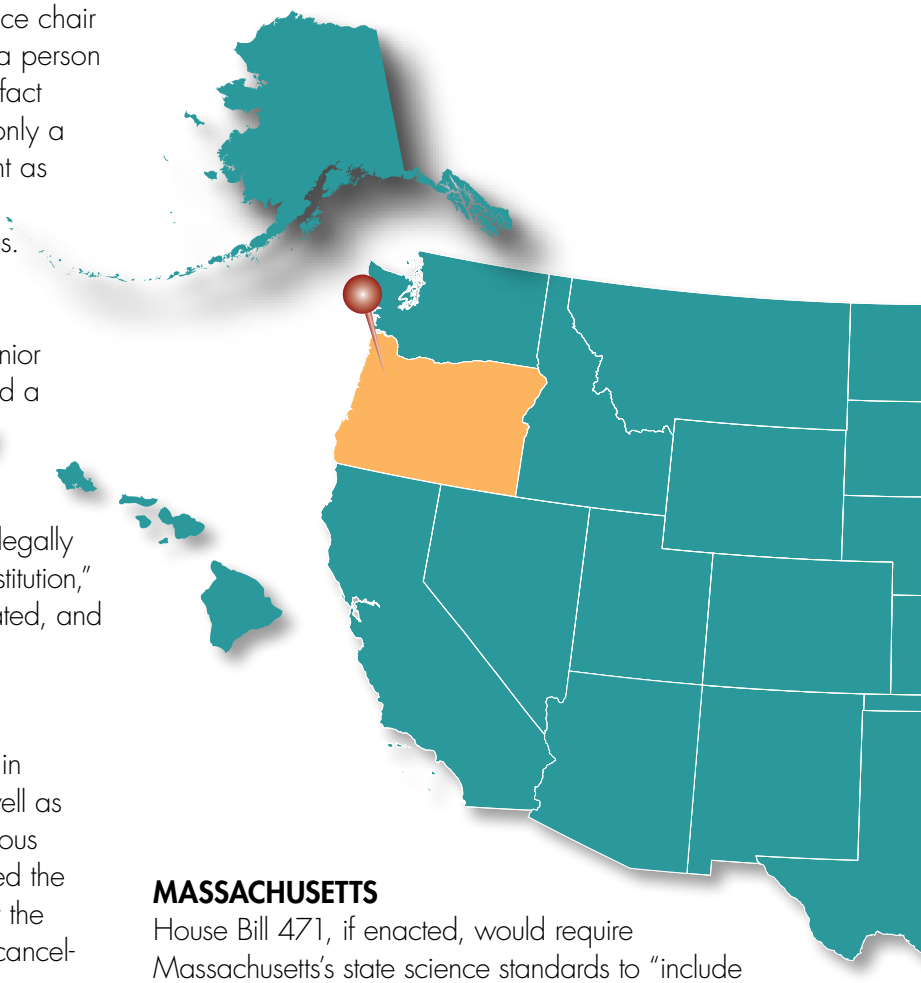
A group of high school seniors from Dietrich Junior-Senior High School were taken on a school trip that included a stop at Answers in Genesis's Ark Encounter on April 16, 2019, according to the Freedom from Religion Foundation. In a letter to the district's superintendent, the foundation warned that the trip "illegally endorses a religious message in violation of the Constitution," asked for the decision to book the trip to be investigated, and urged the discontinuation of such excursions.

ILLINOIS, FRANKFORT

After Frankfort Township advertised a trip to Answers in Genesis's Creation Museum and Ark Encounter (as well as a separate trip to a performance of "Jesus" at a religious theater), the Freedom from Religion Foundation warned the township in May 2019 that it was unconstitutional for the township to sponsor such events and called for their cancellation. The township responded by saying that the trips were already cancelled and that it would be diligent not to violate church/state separation in the future.

IOWA, IOWA CITY

At its July 23, 2019 meeting, the Iowa City Community School District Board unanimously approved a resolution on climate change. Acknowledging that "there is a broad scientific consensus among climate scientists that human activities … are the dominant cause of climate change," the resolution listed a number of ways the district would respond, including by developing "curricular and educational opportunities in areas such as climate literacy, climate change, the impact of sustainable agriculture on climate, and climate advocacy."

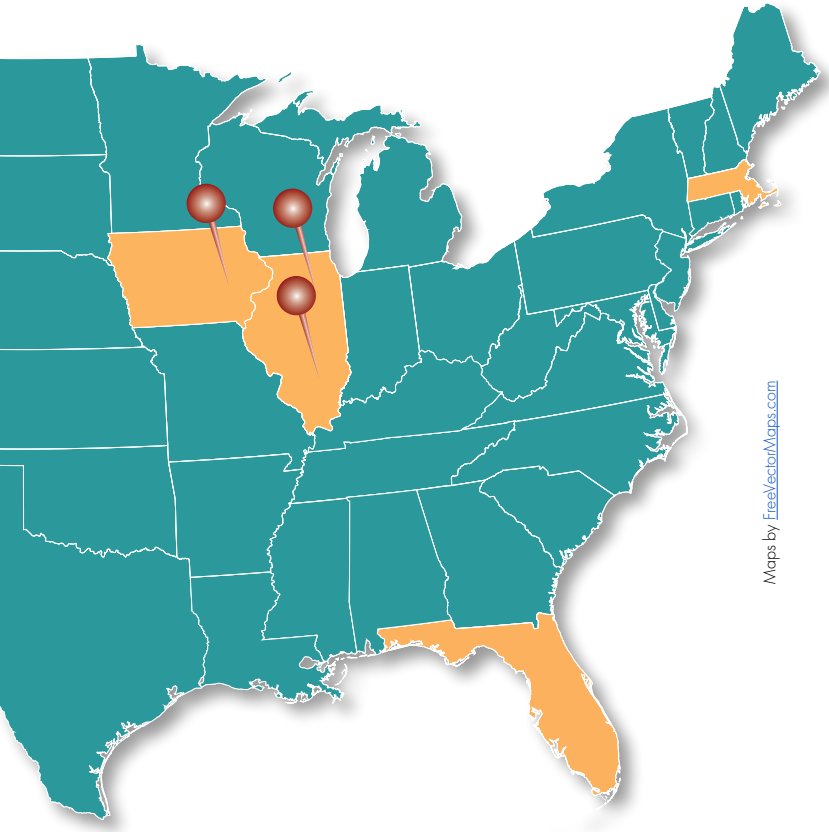


MASSACHUSETTS

House Bill 471, if enacted, would require Massachusetts's state science standards to "include only peer-reviewed and age-appropriate subject matter." Speaking to the Joint Committee on Education in July 2019, the bill's sponsor, Kenneth I. Gordon (D–District 21), explained that it would keep climate change denial out of the science classroom, and Alan MacRobert, a senior editor at *Sky & Telescope* magazine, cited other instances of "science denialism," including rejection of evolution, as evidence for the need of the bill.

OREGON, PORTLAND

Nearly fifty students attended a school board meeting in May 2019 to call for the implementation of the board's 2016 resolution to address climate change in the science and social studies curricula. According to the *Oregonian*, the superintendent "provided updates on progress the district has made in the years since the school board passed the climate resolution"; a year-long climate science and social justice course is under development but not expected to be offered before 2020–2021 at the earliest.



Maps by FreeVectorMaps.com

CANADA

A paper published in *PLoS One* "analyzed secondary science curricula in each province for their coverage of climate change according to six core topics" and found a focus on "It's climate; it's warming; it's us" but little or no emphasis on "Experts agree; it's bad; we can fix it." The researchers, Seth Wynes and Kimberly A. Nicholas, commented, "Saskatchewan and Ontario provide the most comprehensive standards for climate change education, while Nova Scotia and New Brunswick provide the least."

UNITED KINGDOM

In June 2019, the *Guardian* reported on a poll conducted by YouGov on behalf of Oxfam according to which 69 percent of teachers surveyed said that there should be more teaching in British schools about climate change, while about three in four said that they lacked adequate training to teach it properly. Neither the *Guardian*, YouGov, nor Oxfam provided details of the poll, however, such as the wording of the questions, the population surveyed, or the sample size.

UNITED KINGDOM, WALES

In September 2019, as a new national curriculum was under development in Wales, a group of the United Kingdom's leading scientists and educators called for both increasing the amount of evolution in the curriculum and explicitly banning the teaching of creationism. Their letter, organized by Humanists UK, complained that the draft curriculum "doesn't explicitly prohibit presenting creationism and other pseudoscientific theories as evidence-based, and evolution is only mentioned once (and only at secondary level at that)," unlike its counterpart in England.

HOPE IN THE FACE OF

When I first started teaching almost 20 years ago, climate change was not a primary concern for my students. In class, they tended to dismiss the data I presented as blown out of proportion or overly sensationalized, saying either that global warming will be a problem only in the distant future or that time will show that this is simply alarmist talk and not going to be an issue at all. Today a small minority of our youth is still reacting in a similar way, but the more disturbing trend, which teachers now must prepare for in today's classroom, is climate anxiety.

According to a recent article in the *Guardian*, children as young as six are starting to worry about the state of our planet, how we will overcome the damage, and whether there is even any hope for our species' future.

> CHILDREN AS YOUNG AS SIX ARE STARTING TO WORRY ABOUT THE STATE OF OUR PLANET.

Many students are suffering not only from anxiety but also full-blown depression due to having lived through climate crises such as flooding, wildfires, and drought. Additionally, many teens and young adults are considering not having children owing to such concerns.

But the present and probable future effects of anthropogenic climate change are already so disruptive, teachers can no longer bury their heads in the sand. At the same time, however, they cannot take the risk of leading their students into depression and despair. That's why an increasingly essential tool in the science teacher's toolkit is hope.

Here at NCSE, it is our goal to use the Teacher Support Program and our crew of Teacher Ambassadors to deploy effective, evidence-based tools to help students deal with the often overwhelming and depressing issues related to climate change. Our ambassadors are trained with hope in mind. Not passive hope — the kind of hope that someone else will solve the problem for them — but informed, constructive, hope based on an understanding of how to tackle these challenges and develop solutions for our planet's future.

Katharine Hayhoe, a renowned climatologist, director of Texas Tech University's Climate Center, and NCSE's 2016 Friend of the Planet awardee, recently stated that the question she is asked most often at her lectures is, "What gives you hope?" She was asked this question so often that she decided to start polling her own audiences. And the

Illustration by John Cook

CLIMATE ANXIETY

number one answer they all shared: young people. That consensus is evidence of how important reliable resources and curriculum on climate change will be moving forward.

STUDENTS REALIZE THAT ALTHOUGH THERE IS NO SILVER BULLET, ACTION-DRIVEN SOLUTIONS ARE WHAT PROVIDE HOPE FOR THE FUTURE.

According to the NCSE/Penn State survey five years ago, only 54% of teachers are currently teaching the scientific consensus on climate change; the occurrence and causes and consequences of climate change are still presented in too many classrooms as items up for debate rather than scientific conclusions based on abundant and robust evidence. NCSE's five climate change lessons developed by NCSE's Teacher Ambassadors, John Cook of George Mason University's Center for Climate Change Communication, and former Director of Teacher Support Brad Hoge make a good foundation for any secondary class's curriculum and could even be adapted for use in the humanities or history without much effort.

Most important for students experiencing anxiety about our planet's future, Lesson Five focuses completely on climate solutions. Students manipulate various factors ("wedges") in an online simulation in order to determine how best to reduce greenhouse gas emissions. The main objective of the lesson is for students to recognize that reducing such emissions is possible, though it will take multiple strategies implemented across informed nations in order for lasting change to occur. Ultimately, students realize that although there is no silver bullet, action-driven solutions are what provide hope for the future.

It will be the next generation that will have to turn the tide on the climate crisis. They are the ones who will have to live with the consequences of decisions made today. So their teachers must empower them while also addressing their fears and concerns. NCSE's Teacher Support Program will continue to provide high-quality, open-access, evidence-driven lessons and resources in order to provide future generations with the equipment needed to combat climate change misconceptions. We will continue to provide resources that not only educate, but also inspire hope.

Lin Andrews is NCSE's Director of Teacher Support.
andrews@ncse.ngo

A BEHIND-THE-SCENES LOOK AT NCSE'S

Cool Cities, which demonstrates how urban areas act as heat islands, is now one of NCSE's most popular outreach activity kits for 2019. But our first public test of the activity went disastrously wrong. For one thing, we hadn't added up the collective weight of the kit, and the 30-plus kilograms (70-plus pounds) of supplies caused the outreach table to collapse. We had also assumed that the fairgrounds where we were doing the testing would have a decent power supply, but the heater we used to warm the city caused a power outage for us and several other exhibitors. Then there was the asphalt. The asphalt instructions said that it would take 24–48 hours to dry, but after a cloudy 72 hours, kids were ending the activity with black and chalky fingertips. We had to reassure parents that it was harmless and tell the kids to wash their hands.

Not all activity tests result in this much chaos, fortunately. But prototyping and beta-testing are a crucial part of NCSE's activity development. In general, we follow the user-experience design process, where we test and revise the activity with larger and larger groups, all the while attempting to better understand audience response and design for their needs. Learning how to interpret the kit for the diverse audiences our affiliates will encounter, understanding bottlenecks in activity delivery, and developing solutions to common problems are all important reasons to go through a rigorous testing process. We also iterate kit design to help minimize initial resistance from audiences that might be hesitant about evolution or climate change. Most of our kits are tested more than nine times before they are released nationally.

In 2019, Breaking Down Barriers released more than one kit every month, spending hundreds of hours building prototypes, beta-testing in the community, and scaling up for production. NCSE's Program Coordinator, Emma Doctors, is on the front lines of this process. Her strong background in museum education and outreach means that she is able to shepherd our kit production effectively. Recently, I sat down with her and had a chat about some of our favorite activities in 2019 to give you a behind-the-scenes look at our kit-development process.

BUZZ OFF!

Kate Carter: Buzz Off! was one of the first kits that you were involved with when you started in July, right, Emma? It actually has a fun origin story. Emily Chortek, our spring 2019 intern, and I were chatting with one of the Graduate Student Outreach Fellows, who was trying to figure out how to do a mosquito activity. We ended up having a great conversation about the possible options. He successfully developed one activity, but we felt that we had generated so many ideas that we could develop a second.

Emma Doctors: I think the Buzz Off! activity of making "mosquito abatement" keychains by stringing different beads together (See image above) is a great way for people to understand how a diverse strategy is needed for dealing with mosquitos.

BIOLUMINESCENCE

ED: Making a bioluminescent organism using circuits was fun and it really gave kids the success at science we want to see. Most of the kids we work with have never built circuits, so teaching them a new skill while inspiring their creativity was great.

OUTREACH ACTIVITY KITS

KC: The activity is also an effective way to teach the distinction between proximate and ultimate causes in evolution, but it is so terrifying as an evolutionary biologist to ask someone to build a living thing.

ED: So close to "design a creature."

KC: Yes, there was a worry that we would be suggesting intelligent design. There was also the worry that we would be promoting the misconception that if a creature needs to be bioluminescent, it will evolve bioluminescence. So we had to work through the language to make sure we weren't introducing evolutionary misconceptions.

EVOLUTION OF HEARING

KC: With evolution kits in particular, it's common to find "activities" in which participants are shown something and are talked at. But NCSE is committed to inquiry-based education. So we had to figure out a way to make the evolutionary story of ears (See image below) be loud and clear.

ED: Another of our interns, Anna Ginther, did an immense amount of research and beta-testing to make it work.

KC: I also appreciate the inclusivity of the activity. While we definitely paint an evolutionary picture, we also spend a lot of time discussing human communication more broadly. And we do it in a way that challenges people to think about a definition of human communication that goes beyond speech and can be inclusive of all participants.

CLIMATE CHANGE SUMMIT

KC: Climate Change Summit was one of the more ambitious projects we took on last year.

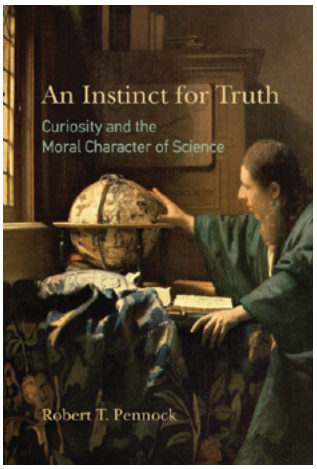
ED: I really enjoyed this activity because participants had to challenge themselves to take on the role of a different stakeholder in determining whether a dam should be built in their community, and then consider the real-world implications of their decision. I think we did a really good job of making primary source literature accessible to all the participants. My biggest takeaway: you can plan as much as possible, but you will still get some really great questions that you aren't able to answer.

KC: I eventually had to tell myself that a lot of decisions are made without complete evidence. That's something that is actually a feature, not a bug, of this game. We don't have perfect evidence when we make a decision. We have evidence that may be contradictory or incomplete or just missing, but we still have to make a decision.

ED: That's what people have to go through in real life.

KC: Right. And since this type of decision making is really important, continuing to create spaces where people can explore the science, like Climate Change Summit, is definitely a goal for 2020.

Kate Carter is NCSE's Director of Community Science Education. carter@ncse.ngo



An Instinct for Truth: Curiosity and the Moral Character of Science

author: *Robert T. Pennock*

publisher: **MIT Press**

reviewed by: **Doren Recker**

The first sentence of Robert T. Pennock's new book summarizes his thesis: "Excellence in science involves not only its methods and practices but also the character of its "practitioners (p. xi)." His chief aim is to explore and defend a set of character traits that are conducive to the *telos*—the final end, or goal—of science, discovering empirical truths. In a sense, he is proposing a version of virtue epistemology which, instead of stressing method and evidence, emphasizes the role of the knower, with knowledge regarded as a kind of *achievement* dependent upon skills that can be enhanced through practice and training. But Pennock is, in fact, more concerned with virtue *ethics* applied to science as reinforcing its vocational goals. "Scientific methods should be followed because they follow from scientific values" (p. 178).

Most interesting is the attempt to connect the realms of knowledge and values, treating them as potentially mutually supporting and overlapping rather than as, in Stephen Jay Gould's famous phrase, "non-overlapping magisteria." Yes, science stresses what is, and values stress what ought to be, but each needs to be informed by the other in order to promote human flourishing. And, Pennock insists, science is based on values that promote empirical truth-finding, such as curiosity, perseverance, honesty, and so on. Perseverance and patience were the two virtues ranked highest in the rankings in his recent survey of more than 1100 scientists (p. 150), but curiosity takes pride of place in Pennock's evaluation. "The secret to science is wondering in a special way" (p. 1). For many NCSE members, how this is applied to the relationship(s) between religion and science and science education, discussed in chapters 7 ("Creative Conflict") and 9 ("The Seeds of Science"), may be of most interest.

Pennock is well known for his cogent criticisms of "intelligent design" creationism, both as an expert witness at the *Kitzmiller v. Dover* trial in 2005 and in his many writings on this topic,

WHAT WE'RE UP AGAINST
Climate Change Denial on YouTube

In a study reported in *Frontiers in Communication* in 2019, Joachim Allgaier of RWTH Aachen University took a sample of 200 videos on YouTube provided in response to searches using terms such as "climate," "climate change," and "climate science." Analyzing the sample, he found that 89 of the videos endorsed the scientific consensus on climate change but a majority—107—disputed it, with 16 denying anthropogenic climate change and 91 promoting conspiracy theories. The videos endorsing the scientific consensus and the videos disputing it were about equally popular, receiving about 16.9 million views in aggregate in both cases. After noting the limitations of his study, Allgaier observes, "The results of this research show that there is still an unsolved problem and reason for concern: various individuals and groups that oppose mainstream scientific positions already gained a strong foothold on such channels and seem to have learnt very well how to use them to their advantage."

Joachim Allgaier Photo by Peter Winandy

—GLENN BRANCH

including *Tower of Babel: The Evidence Against the New Creationism* (1999) and his edited anthology *Intelligent Design Creationism and its Critics* (2001). Here, however, he takes a somewhat different tack. As might be expected from what was said earlier, he contrasts the leading *values* underlying (dogmatic) religious and scientific approaches. Faith, hope, and charity, for example, the traditional cardinal virtues for Christianity, have little authority in science, which is, again, based instead on virtues conducive to empirical truth-finding. Curiosity, central to the scientific vocation, is also often antithetical to the"mystery-mongering" of some religious positions and New Age fads, but rather represents "opportunities for discovery" in science (p. 199). These and other conflicting values and mindsets emotionally and psychologically fuel the many conflicts between scientists and science deniers of all stripes.

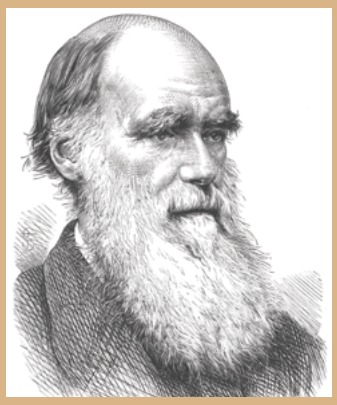
Far from eschewing a sense of wonder and excitement as detrimental to cool-headed scientific objectivity, Pennock views this as a central component of science education. The emphasis on learning facts and becoming conversant with past scientific discoveries is, while certainly important, secondary to cultivating and expanding appropriate mental habits and fostering scientific character traits in students (p. 290). Engendering curiosity and wonder at nature's puzzles, encouraging perseverance in following facts where they may lead, and so on, do more to advance scientific education than following the more authoritarian model of the "sage on the stage" dispensing wisdom to the less informed (p. 274).

Pennock defends the need for conjoining humanistic and scientific virtues throughout the book, and the last chapter, "We Are Scientists Second," is largely devoted to arguing that

"Far from eschewing a sense of wonder and excitement as detrimental to cool-headed scientific objectivity, Pennock views this as a central component of science education."

science can contribute to, without exhausting, the realm of human values. He strongly defends the need for science's emphasis on truth-finding (and defending!) in the currently dominant "post-truth" world. For this reason as well as others, science *and* the humanities "ought to figure in a democratic political vision" (p. 338). Workable values need to be informed by facts, and facts need to be organized around human flourishing if we are to be able to best visualize and achieve our hopes and dreams. Amen to that!

Doren Recker is Associate Professor of Philosophy at Oklahoma State University.
doren.recker@okstate.edu



The title of *An Instinct for Truth*

is taken from a letter written by Charles Darwin to his mentor John Stevens Henslow on April 1, 1848:

> I believe there exists, & I feel within me, an instinct for truth, or knowledge or discovery, of something same nature as the instinct of virtue, & that our having such an instinct is reason enough for scientific researches without any practical results ever ensuing from them.

Pennock comments, "More than just a personal sentiment, this is an astonishing observation with radical implications. Darwin noticed something highly significant about himself as a scientist. He recognized himself as an epistemic agent—a knowledge seeker and actor—at a very deep level" (p. 4).

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