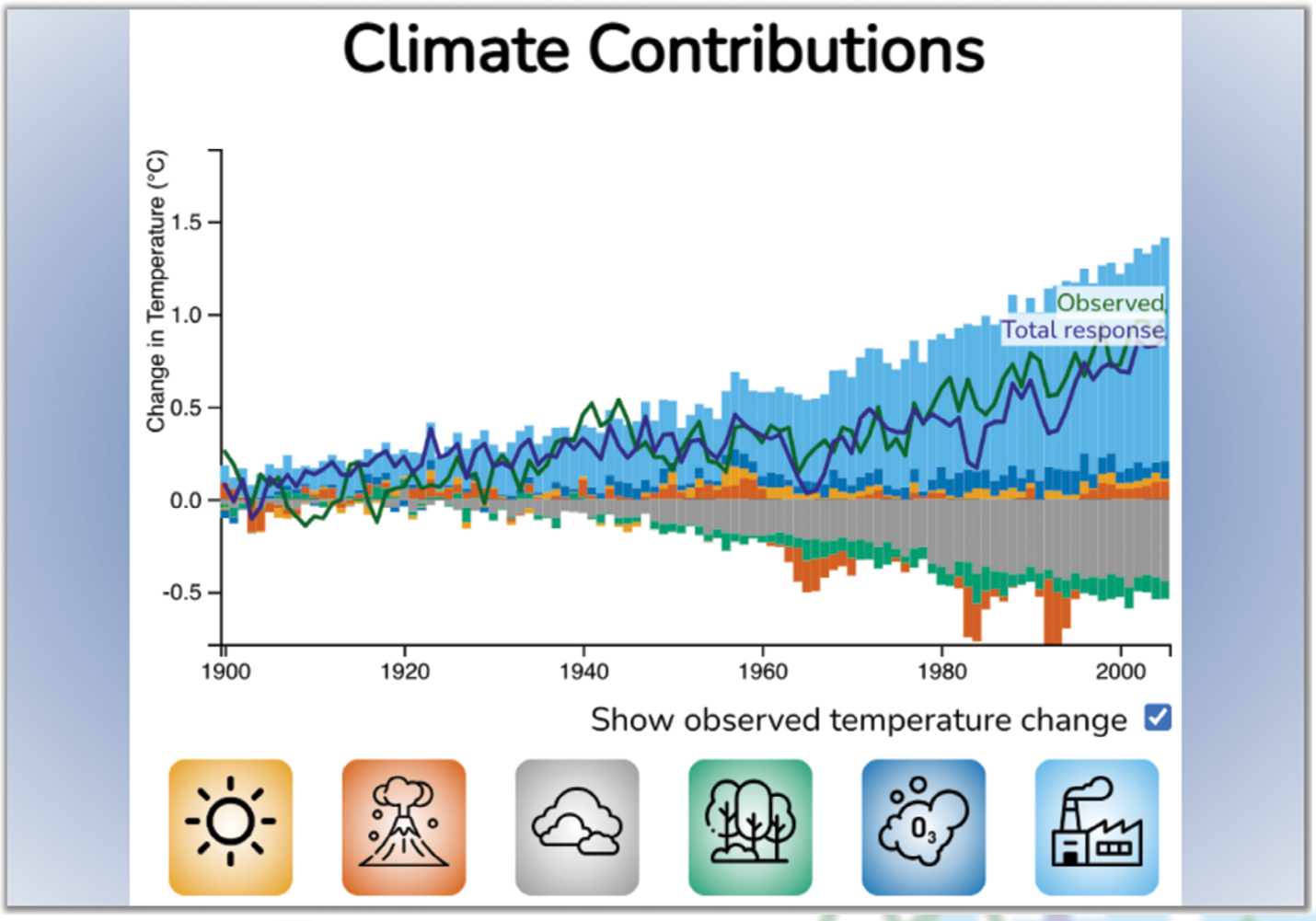
reports

OF THE NATIONAL CENTER FOR SCIENCE EDUCATION | FALL 2021 | VOLUME 41 | NO 4

MAKING THE BIG—AND LITTLE—OF SCIENCE VISIBLE

p. 3



EDITOR
Paul Oh
National Center for Science Education
230 Grand Avenue, Suite 101
Oakland, CA 94610
phone: (510) 601-7203
e-mail: editor@ncse.ngo

BOOK REVIEW EDITOR
Glenn Branch

PUBLISHER
Ann Reid

VOL 41, NO 4, FALL 2021

ISSN 1064-2358 ©2021 by the National Center for Science Education, Inc, a not-for-profit 501(c)(3) organization under US law. *Reports of the National Center for Science Education (RNCSE)* is a quarterly publication for NCSE's members, providing the latest on our work supporting accurate and effective climate change and evolution education.

NCSE is a nonprofit, tax-exempt corporation affiliated with the American Association for the Advancement of Science and an Associated Group of the National Science Teachers Association.

OFFICERS & DIRECTORS
Kenneth R. Miller, President
Benjamin D. Santer, Secretary
Michael Haas, Treasurer
Vicki Chandler, Director
Sarah B. George, Director
Joseph L. Graves Jr., Director
Michael B. Lubic, Director
Michael E. Mann, Director
Naomi Oreskes, Director
Barry Polisky, Director

Views expressed are those of the authors and do not necessarily reflect the views of NCSE. *RNCSE* is published 4 times a year.

Address editorial correspondence to editor@ncse.ngo

Write to the publisher regarding address changes, missing issues, purchases of back issues, reprint rights, and related issues.publisher@ncse.ngo

ERRATUM
The Y axis in figure 3 of Glenn Branch's "The Foundering of Creation Science's Flagship" (*RNCSE* 2021; 41:3, p. 7) was mislabeled. The corrected figure appears in the online version of the issue. https://ncse.ngo/foundering-creation-sciences-flagship.

Dear NCSE Members,

When I tell people what NCSE does, I often get the following response: "Oh thank goodness you're doing that!" And about half the time, that's followed by, "But how do you convince people that climate change is real?"

My go-to answer to the second question is to tell them about ice core data. But before their eyes glaze over in anticipation of a nerdy lecture, I whip out my secret weapon: The King's Centre for Visualization in Science website and its dozens of science simulations. In particular I point to the interactive graph that shows the correlation between CO_2 levels and temperature rise over the last 400,000 years based on ice cores taken from Vostok Research Station in Antarctica. (Spencer Weart wrote about these cores in RNCSE 41:2, by the way.) I tell my audience that playing with this graph quickly dispels the misconception that because climate has changed in the past, current climate change is nothing to worry about. Go ahead and try it; you'll see.

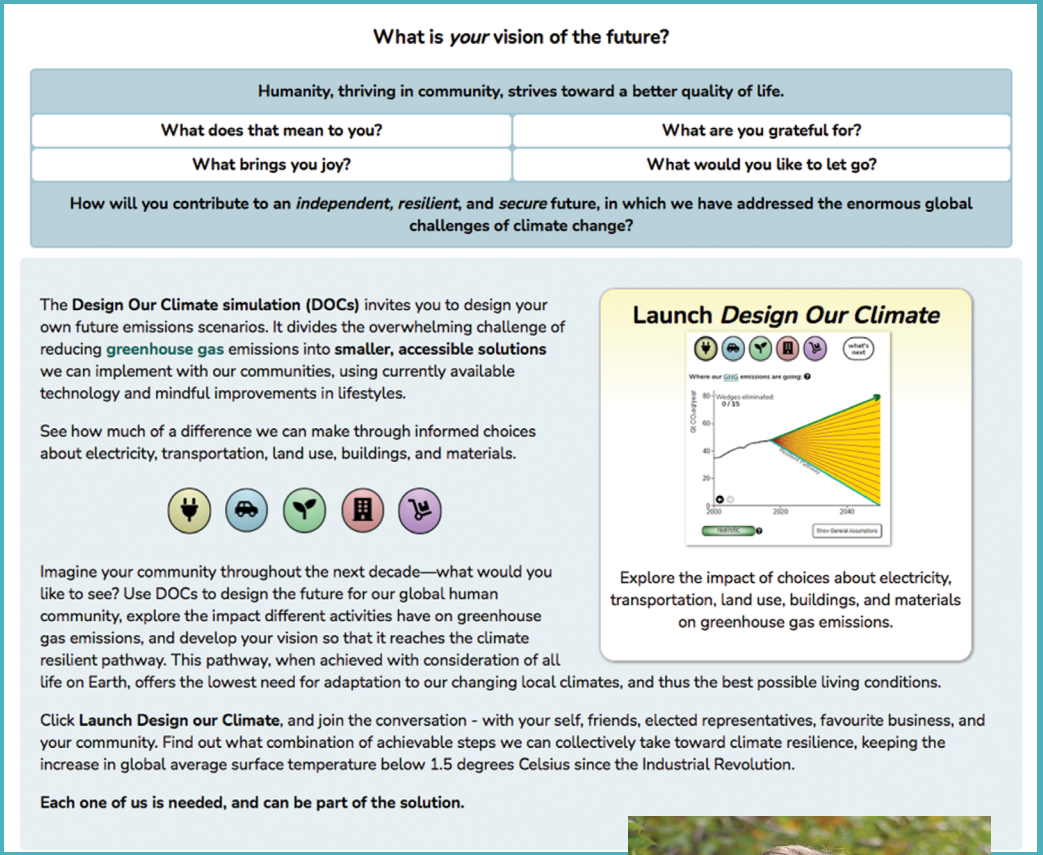
But I could just as easily cite any of the dozens of other KCVS simulations focused on making the science of climate change more visible and therefore more concrete. And they work. They truly do help people who are not scientists better understand the scientific data.

In fact, the KCVS simulations work so well, we at NCSE have teamed up with the wonderful folks at KCVS to develop two new interactives for teachers and students that we've included in our climate change lessons. One, which debuted in late August 2021 just in time for back to school, is a hindcasting simulation that shows the accuracy of past climate change models—how they got it right for the most part, and how we know that. The other interactive shows all the various reasons why Earth's temperature is rising—and makes clear that humans are the cause of the climate change we are currently experiencing. Both of them help to debunk the kinds of spurious claims that models don't work and that Earth is simply experiencing a "natural" warming cycle.

For this issue of *RNCSE*, Paul Oh spoke with Rob MacDonald at KCVS to delve deeper into the work of the center and its myriad science simulations. My hope is that after reading the article, you'll find yourself better prepared to communicate the science behind climate change in a way that gets the people you speak with to say, "I see."

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

MAKING THE BIG —AND LITTLE— OF SCIENCE VISIBLE



Science involves phenomena both unimaginably large and unbelievably small. Yet teachers are tasked with helping students understand such objects and processes. How can they get their students to wrap their minds around these often hard-to-fathom concepts?

One answer, according to The King's Centre for Visualization in Science (KCVS), is to give them—teachers and students alike—interactive digital tools that make some of the abstractions of science more concrete.

"Humans on average are very visually oriented," explains Rob MacDonald of KCVS, a research center of The King's University, Edmonton, Alberta, Canada. "We tend to think visually. It's right in our language—'Do you see what I'm talking about?'—these sorts of things. So having information presented in a visual way often makes it easier to absorb and easier to make sense of and engage with."

As examples, MacDonald points to specific KCVS tools: "There are a lot of simulations of chemistry ideas, like molecular fractions, that are too small to see. There are quantum mechanics visualizations." On the other hand, he adds, "There are astronomy applets—the scale of astronomy is too large to work with directly. And, of course, climate change. Earth is a huge and complex system that's difficult to directly connect with."

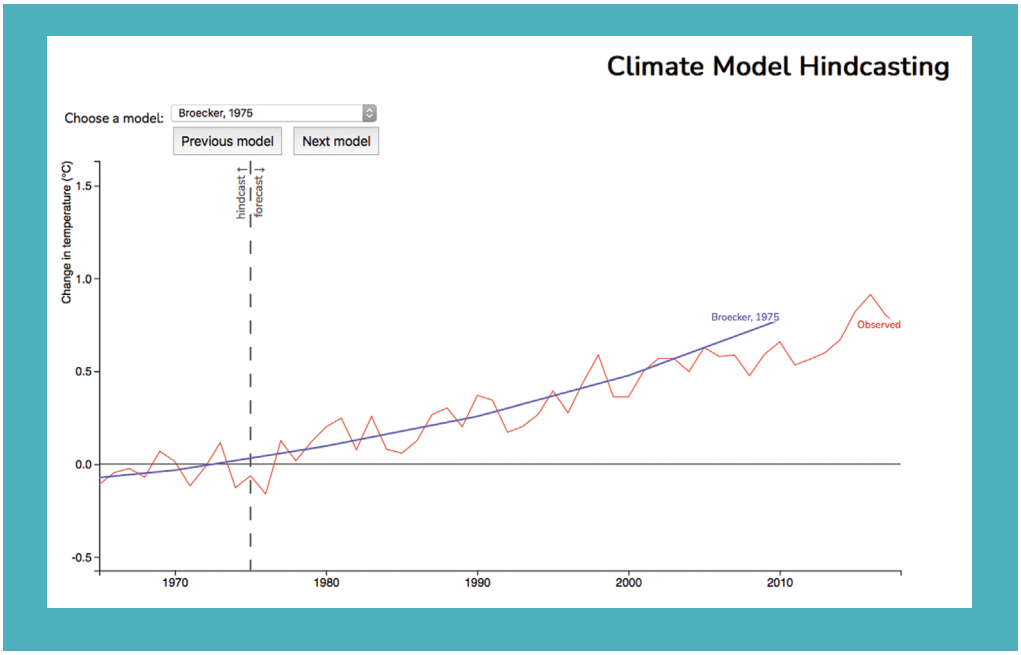
Photo courtesy The King's University

Rob MacDonald

With that in mind, NCSE decided to partner with KCVS to develop specific visualizations that support our climate change lessons. So far the center has developed two applets in collaboration with NCSE Director of Teacher Support Lin Andrews. The first, released in 2020, is called Climate Contributions and depicts many of the different possible reasons why the global temperature is rising. The interactive graph allows a student—or anyone, for that matter—to see how much warming might be attributable to particular factors, such as volcanic activity and fluctuations in solar radiation.

"A lot of people have said, 'Well, [volcanic activity and solar radiation] contribute to the changes in our climate.' So the idea with this applet is to try to show they do affect the climate. But they don't come anywhere close to creating the large increase in temperature that we actually see until you incorporate things in the simulation like

greenhouse gases—the human contributions to the climate," MacDonald says. "The simulation demonstrates that we really do know with a great deal of confidence that humans are causing the change in climate."



In 1975, Wally Broecker's model—one of eight included in a new hindcasting interactive—predicted that the CO_2 effect would overwhelm Earth's natural climate cycles. For more on Broecker, see "Place and Time" on p. 12.

The second applet, called Climate Model Hindcasting, which was released just as school was starting across the country in late August 2021, looks at the accuracy of climate models. And, no surprise, those models turn out to have been very accurate in predicting the warming experienced over the past 50 years. Students are able to test out these models by altering parameters to see for themselves what might make a model more or less accurate. The applet also helps students see how the models became more accurate over time—what parameters were added to increase reliability. In addition, students can access information to help them understand what's meant by "accurate" in models, why some short-term fluctuations are ignored, how to know which fluctuations to ignore, and other aspects of climate modeling that might otherwise be hidden to them.

> teachers are able to put real climatological evidence into the hands of their students

With both simulations, the visualizations not only provide students with a more concrete understanding of climate science, they also address two important misconceptions— "Climate change has always been happening" and "You can't trust models"—that NCSE's climate lesson plans are specifically aimed to help students overcome.

"By using visualization tools like those generated by KCVS, teachers are able to put real climatological evidence into the hands of their students," explains Lin Andrews, NCSE's Director of Teacher Support. "These tools condense large amounts of data and provide strong visual support for understanding previously hard-to-grasp concepts—all with the click of a button. This is what gives these manipulatives such power in the classroom."

KCVS works with local, national, and international partners to develop the many dozens of visualizations at its website. Co-founded in 2005 by current director and chemist Peter Mahaffy and astrophysicist Brian Martin, its goal has always been to help students better "see" science. MacDonald says, "I basically stuck my nose in and took a look around to see where I could help" several years ago once he learned what the center was up to. Since then, he's been working with KCVS to provide technical support overall and as design lead on specific projects such as the NCSE visualizations.

"I'm very interested in visualization in general," explains MacDonald, who along with his work at KCVS also teaches physics, statistics, computing science, and mathematics at The King's University. But addressing climate change misconceptions is of particular interest. "It's one of the things that comes up a lot when I'm teaching—addressing misconceptions and trying to help people to see that this idea that they had that's actually often interfering with their further learning is wrong or oversimplified."

One of the simulations MacDonald is most proud of working on is Design Our Climate, which is incorporated in KCVS's Climate Solutions resource. Design Our Climate

> If we make changes—and these are all realistic changes—we can solve this problem. It's addressing the misconception in a very positive way.

lets you make decisions about the planet's future climate, addressing the misconception that there's no hope and therefore no point in doing anything about climate change. By manipulating various interventions in the simulation, you realize that it is in fact possible to have a significant impact, though it will take many interventions rather than any single one to reach a comprehensive, lasting solution. The simulation shows that "if we make changes—and these are all realistic changes—we can solve this problem. It's addressing the misconception in a very positive way," MacDonald says. This KCVS visualization tool is also included in another of the NCSE lesson sets, Climate Super Solutions.

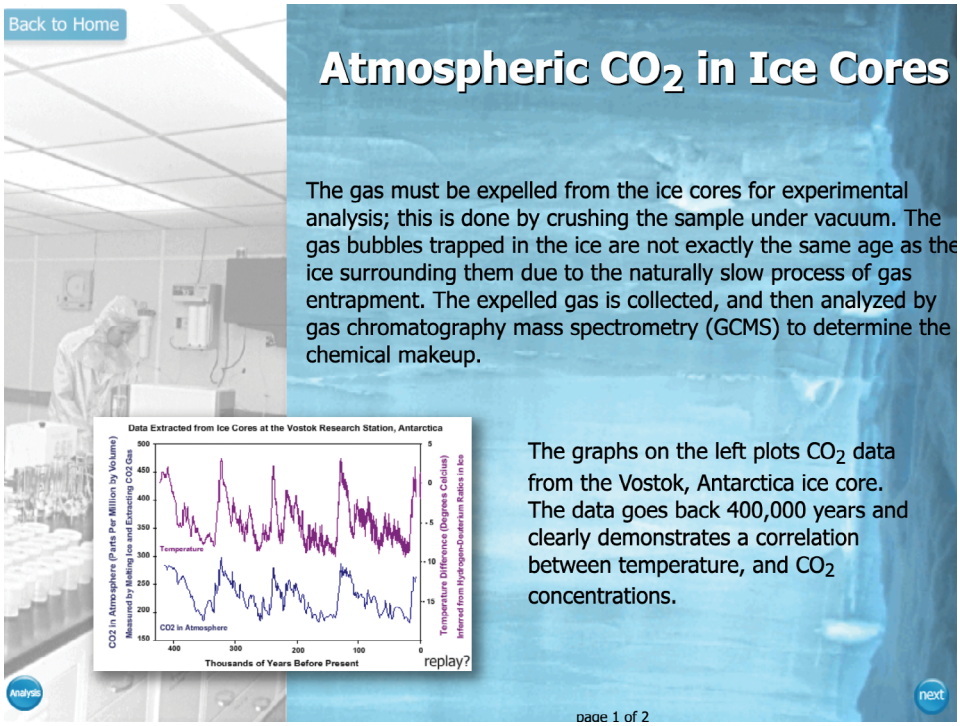
MacDonald is quick to share the credit with the many people whose efforts are involved in creating the KCVS simulations. The Climate Solutions website development, in particular, was an all-hands-on-deck moment for KCVS. MacDonald is especially appreciative of the work of the university's undergraduates, who do everything from revisiting different tools ensuring that they incorporate the latest data to coding to engaging with the primary scientific literature. "We've consistently had really good students, and they've really made KCVS and its resources what they are," MacDonald says.

KCVS works with local Canadian school districts, organizations like NCSE, and groups like the Climate Literacy and Energy Awareness Network to ensure that its visualizations get into the hands, or rather onto the screens, of students all over North America. Thousands of visitors each month flock to the KCVS site. Soon they will include the students of all the teachers who use NCSE's resources.

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

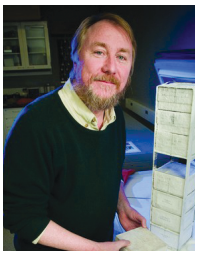
Putting 400,000 Years of Ice Core Data in Students' (Virtual) Hands

As part of an upcoming refresh of our climate change lessons, in particular Lesson 3—Back to the Future: Climate Edition, we'll be asking students to examine for themselves the evidence of carbon emissions in the Earth's atmosphere over time. To do that, we ask them to engage with The King's Centre for Visualizing Science interactive Atmospheric CO_2 in Ice Cores. To set the stage, the interactive provides information about ice cores: what they are, how they're analyzed, why they're important, and what they tell us. Students are then given an opportunity to view a graph that plots CO_2 data from the Vostok, Antarctica, ice core alongside temperature fluctuations. The data, which stretch back 400,000 years, show a clear correlation between carbon dioxide emissions and temperature. Further analysis of the source of the carbon dioxide emissions also demonstrates to students that human activity is responsible for the increase in concentration of carbon dioxide in the atmosphere over the last 150 years.



Members in the SPOTLIGHT

Among the new Fellows of the American Association for the Advancement of Science for 2020 were **Renny Theodore Franceschi** of the University of Michigan, **Kenneth D. Irvine** of Rutgers, The State University of New Jersey, and **Dennis F. Mangan** of the Chalk Talk Science Project. Congratulations to all three! (Let the NCSE office know if we overlooked your name on the list of new Fellows.)



NCSE is pleased to congratulate **Richard E. Lenski** of Michigan State University on receiving the Lifetime Achievement Award from the Society for the Study of Evolution in 2021. The award, according to SSE, "was created to recognize individuals who have made substantial contributions to the study of evolution, who have demonstrated outstanding mentorship of trainees, and/or who have provided noteworthy service to the evolution community." Lenski was previously the recipient of NCSE's Friend of Darwin award in 2017. Alluding to his famous *E. coli* Long-Term Experimental Evolution Project—which, started in 1988, is the longest continuous experiment on evolution—NCSE's executive director **Ann Reid** remarked, "it would be hard to think of anybody who has done as much to show that evolution is among the experimental sciences as Rich Lenski."

Laurie Luckritz, one of NCSE's first Graduate Student Outreach Fellows, received her M.S. in biological sciences from the University of Central Missouri in May 2021—and she proudly declared her affiliation with NCSE in her graduation regalia with a custom sash!

Clyde Peeling defended evolution in a pair of letters to the editor published in the *Williamsport* (Pennsylvania) *Sun-Gazette*. On February 12, 2021—Darwin Day—he took a topical approach, arguing, "For evolution deniers, what we've learned about new strains of coronavirus should be all the evidence they need." Then, on March 10, 2021, he deftly rebutted a rambling creationist response to his previous letter, noting that the views of "intelligent design" advocates Michael Behe and William Dembski, cited in the response, were not representative of the scientific community. A week later, a letter from NCSE's **Glenn Branch** discussed Behe and Dembski in the context of *Kitzmiller v. Dover*.) Peeling is the director of Clyde Peeling's Reptiland in Allentown, Pennsylvania, an AZA-accredited zoo specializing in reptiles and amphibians.

New Legacy Society Member Passionate About Science and NCSE

At 46, Jeremy Taylor may very well be NCSE's youngest Legacy Society member. He is inspired by NCSE's mission and work. So, while recently doing some long-term life planning, he decided it made sense to make an enduring pledge of support to NCSE.

"I have always cared deeply about the natural world and environmental issues. I think that science, especially in regard to renewable energy, sustainability, and developing science-based climate mitigation strategies, is going to be critical as we move forward," Taylor explained. "By leaving a gift in my will to NCSE, I am hoping that in some small way, I will be able to continue to act on behalf of science and the environment after I am gone."

Science in some form has been central to Taylor's life, from being a state wildlife biologist in the Everglades (yes, he was hanging out with alligators) to his current position as editor of *Conservationist for Kids*, a magazine published by the state of New York and distributed to fourth graders. "Every job I've had since college has had some sort of a science and biology focus," he said. Even his past volunteer work had a science connection—he served as an education assistant at a local environmental education center.

Taylor notes that science affects our lives in fundamental ways, whether people realize it or not. That's why he thinks it's imperative young people understand how science works.

"Science is part of pretty much everything we do, and there has never been a greater need for a strong science presence in our educational systems as there is right now. From preparing students for careers in science fields to renewable energy and sustainability, our future depends on science," he commented.

And that's where NCSE comes in, according to Taylor. "The work of NCSE, from supporting teachers in the classroom to defending the need for science education and researching ways to make it better, are of great importance to me personally, and of critical importance to the future of our planet," he said. "I can't think of a better reason than that for including NCSE in my will."

We greatly appreciate the support of Jeremy Taylor and of all our Legacy Society members. Their desire to ensure NCSE has the resources far into the future to continue promoting and defending accurate evolution and climate education inspires us as we support today's science teachers in myriad ways. To learn more about the Legacy Society, visit ncse.ngo/legacy-society or contact Director of Development Deb Janes at janes@ncse.ngo or 510-601-7203.

Wally Broecker's Intuition

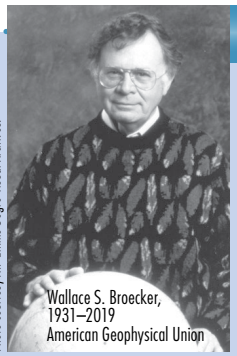


Photo courtesy AIP Emilio Segrè Visual Archives.

Wallace S. Broecker, 1931–2019 American Geophysical Union

"Are we on the brink of a pronounced global warming?" Yes, warned a now famous 1975 paper in *Science* magazine. It was the first time a scientist, or almost anyone, had published the term "global warming." The paper's argument was in fact wrong, based on a false hypothesis and misunderstood data. Yet the author was right. This wasn't the first time nor the last that Wally Broecker was both embarrassingly mistaken and profoundly correct.

Back in 1957 when he was a graduate student, Broecker had heard that Roger Revelle, the dean of the world's oceanographers—a title Broecker would eventually win for himself—claimed that carbon dioxide (CO_2) accumulating in the atmosphere would raise the sea level and devastate California and Texas with droughts. The untested "greenhouse" theory meant little to the young oceanography student. He was busy trudging around some of the driest places in America.

The bleak hardpan of Nevada's Great Basin had been wet with lakes back in the ice ages, and for his doctoral research Broecker was applying the new technique of radiocarbon dating to find how the lakes came and went. Comparing his dates with layers of clay in cores extracted from the seabed and other data, he found a correspondence. Just when his lakes had dried up, other things had changed around the world. He postulated that at the end of the last ice age the entire global system of weather and ocean currents had lurched from one state to a different state in the span of a few centuries.

Few read the thesis and most of them dismissed it. Everyone knew that ice ages came and went over many thousands of years; the global system was sluggish. And indeed Broecker was wrong. He had not cleaned his samples correctly and got false dates. Yet ... Broecker was right. His intuition was better than his measurements. Decades later, layers of ancient ice in cores drilled from deep in the Greenland ice cap and other data showed that around the end of the last ice age there was indeed a global climate lurch, startling jumps of temperature and sea level within the timespan of a single human lifetime.

Meanwhile Broecker had left behind his doctoral work and gone on to dig up data in other wild and lonely places, from the coral reefs of New Guinea to the high seas. He made important discoveries about the geochemistry of seawater, the progression of ice age cycles, the slow circulation of the world-ocean, and more. In the 1970s global warming caught his attention. Scientists were perplexed: the atmosphere's CO_2 level was steadily climbing, but temperatures had been level since the 1940s. Was Revelle's prediction wrong? Broecker saw an answer when a Danish team reported a roughly 80-year cycle of variations in a Greenland ice core. Similar cycles were found in records of sunspots and weather over past centuries, presumably reflecting a periodic change in the Sun's energy. Broecker wrote in his *Science* paper that the solar energy was currently in a downswing, counteracting the temperature rise expected from CO_2. The cycle was due to reverse, and then global temperatures would soar dangerously.

Wrong. There is no 80-year solar cycle, and the ice and weather data turned out to be only local North Atlantic effects, not global at all. And yet ... right. Broecker's intuition told him that something was holding back the greenhouse temperature rise. As we now know, the *something* was not a change in sunlight itself but an increase of industrial smog blocking the sunlight. When the something halted—and regulations did halt the increase of smog—Broecker's "pronounced global warming" would indeed appear.

In the 1980s a Swiss team reported something even more disturbing in a Greenland ice core: radical shifts of CO_2 within a single decade. Only a radical transformation in the oceans, Broecker said, could have changed the atmosphere so fast. Returning to a speculation in his doctoral thesis, he declared that the global system of ocean circulation (which he had done more than anyone to reveal) could grind to a halt. The idea was popularized, to his dismay, in science-fiction disaster epics that went far beyond his warnings of rapidly shifting weather systems.

Anyway Broecker was wrong again. The Swiss measurements did not in fact reflect CO_2 levels; what had changed was the ice's acidity. And ... right again. The chemical changes reflected shifts in the amount of dust in the ice, due to abrupt reorganizations of wind patterns that swept minerals from deserts across the entire Northern Hemisphere. Global weather could indeed change radically within a decade, at least around the end of an ice age. As for ocean circulation, evidence is accumulating that it has recently begun to slow down.

"The climate is an angry beast," Broecker liked to say, "and we are poking it with a sharp stick." He meant that lurches like those seen in ice age times might happen today. Wrong, according to computer model teams. They see nothing in the current climate system susceptible to a catastrophic shift. Broecker pointed out, however, that the models are *designed* to be stable. Models are adjusted to represent the climate we have known over the past few millennia—an unusually stable period. And now we are shoving the temperature up at an unprecedented rate. If we keep pushing into unknown territory, we could find that Broecker was right again.

For more information search "Broecker" at *https://history.aip.org/climate/k2searchClimate.html*.

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. sweart1@gmail.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.

CONNECTICUT

House Bill 5619 would have required "that the climate change curriculum in the Next Generation Science Standards be taught as part of the state-wide science curriculum for public schools and that such teaching begin in elementary school." The bill, introduced by Christine Palm (D–District 36) in January 2021 and referred to the Joint Committee on Education, was similar to her House Bill 5011 from 2019. House Bill 5619 died in committee in April 2021.

MASSACHUSETTS, CAMBRIDGE

In May 2021, a parent of a Cambridge elementary school student expressed concern at the dissemination of two activity booklets, one entitled "Natural Gas: Your Invisible Friend," by the school. The booklets were provided by a local utility, Eversource. In a written statement, the superintendent of the school system apologized, writing that Cambridge Public Schools "cares deeply about climate change and energy efficiency." A spokesperson for Eversource agreed that climate change information would be included in future educational activities.

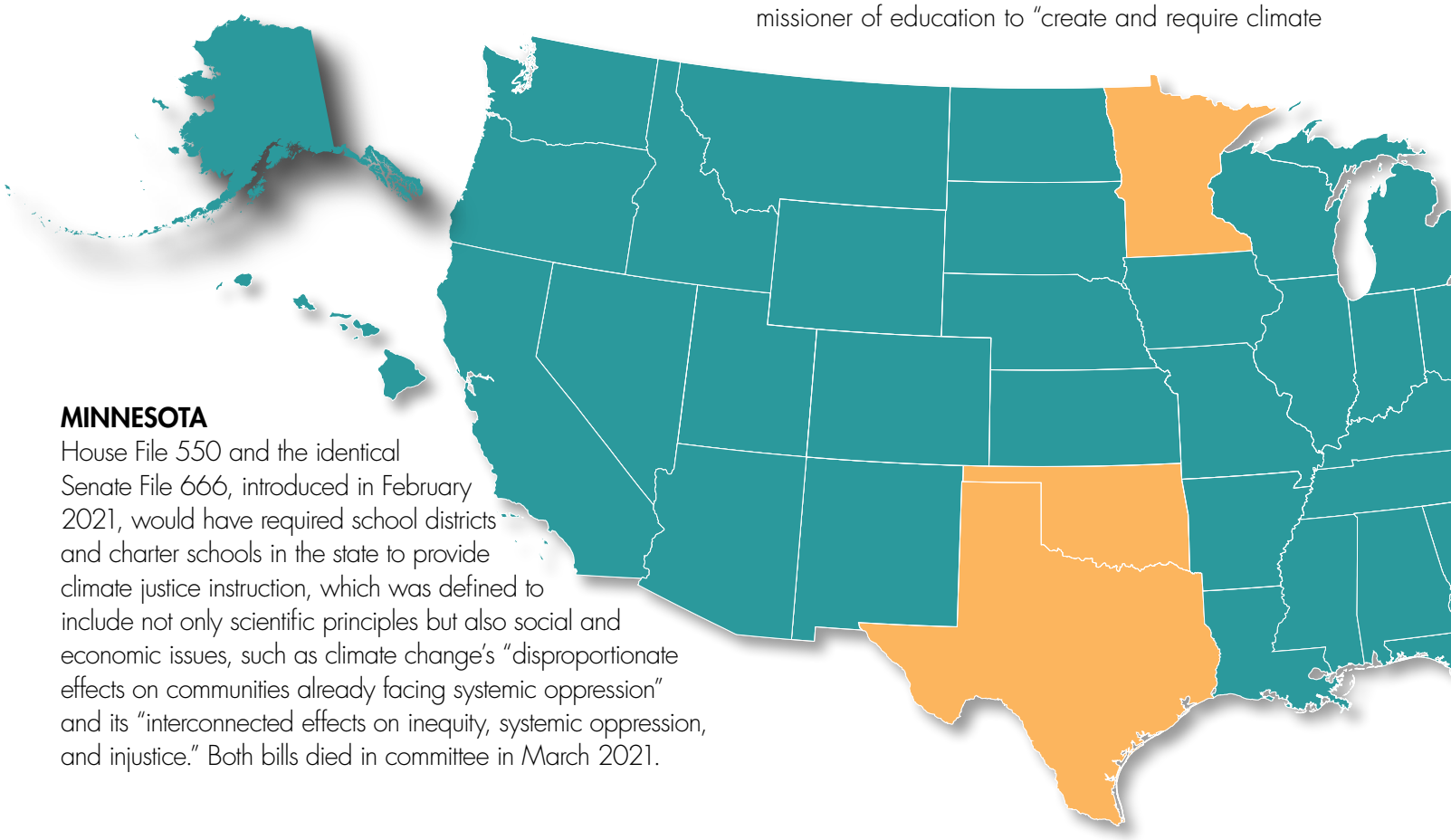
NEW YORK

When the New York legislature adjourned on June 10, 2021, no fewer than eight climate change education bills died in committee.

- Assembly Bill 617 and Senate Bill 4683 would have established a climate change education grant program "to award grants to eligible applicants to support climate change education grant programs for young people or to provide optional teacher training or professional development programs relevant to the advance of climate change literacy in young people."

- Senate Bill 596 would have required the state commissioner of education to offer "recommendations to the board of regents relating to the adoption of instruction in climate science in senior high schools," including "the effect and impact of greenhouse gasses" and New York's commitment to reducing greenhouse gas emissions.

- Senate Bill 654 would have required the state commissioner of education to "create and require climate



MINNESOTA

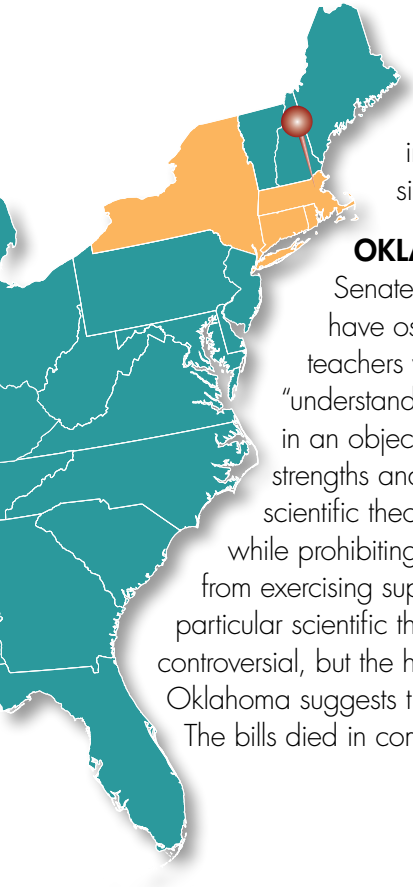
House File 550 and the identical Senate File 666, introduced in February 2021, would have required school districts and charter schools in the state to provide climate justice instruction, which was defined to include not only scientific principles but also social and economic issues, such as climate change's "disproportionate effects on communities already facing systemic oppression" and its "interconnected effects on inequity, systemic oppression, and injustice." Both bills died in committee in March 2021.

change instruction within the current established science curriculum" for grades one through twelve of New York's public schools. Correspondingly, school authorities would have been required to support the instruction.

• Assembly Bill 2325 and Senate Bill 1081 would have required the state commissioner of education to "establish a model environmental curriculum on climate change to be taught in all public elementary and secondary schools," included in the standards of instruction for not only science but also history, social studies, health, and mathematics.

• Assembly Bill 3468 would have required the state commissioner of education to "create and establish a comprehensive and accurate climate change and sustainability curriculum which shall be taught in grades kindergarten through twelve in all public and charter schools." Local districts would have been expected to use the curriculum or a substantially similar curriculum.

• Senate Bill 4781 would have required the state commissioner of education to "make recommendations to the board of regents relating to adjusting curricula for social studies, economics, geography, and government classes in New York schools to include requirements for climate change education."



In the 2020 legislative session, five climate change education bills introduced in the New York legislature similarly died in committee.

OKLAHOMA

Senate Bills 613 and 662 would have ostensibly provided Oklahoma's teachers with the right to help students "understand, analyze, critique and review in an objective manner the scientific strengths and scientific weaknesses" of scientific theories discussed in their courses, while prohibiting state and local administrators from exercising supervisory responsibility. No particular scientific theories were identified as controversial, but the history of such legislation in Oklahoma suggests that evolution was the target. The bills died in committee in February 2021.

UNITED KINGDOM

Concerned about language in a high-school-level geography textbook published by Pearson Education that seemed to imply that anthropogenic climate change is currently under scientific debate, a British educator alerted the climate scientist Michael E. Mann, a member of NCSE's board of directors, who in turn alerted NCSE staff. After a brief e-mail discussion with NCSE's deputy director Glenn Branch, Pearson Education committed to revising the textbook and to reviewing its other textbooks that discuss climate change for similar problems.

RHODE ISLAND

House Bill 5625 and the identical Senate Bill 464 would have required the state department of education "to develop a set of key environmental, climate, and sustainability principles and concepts" and to ensure that they are reflected in Rhode Island's public schools. The bills called for the revision of the state science standards for science and social studies, guidance about incorporating climate change into math and English language arts, and teacher professional development. Both bills died in committee in April 2021.

TEXAS

House Bill 4157 would have, if enacted, amended state law governing education by adding "the long-term problem of human-caused climate change and its effects" as well as "bioregionalism" to the topics to be covered in each school district's required science curriculum. The treatment of climate change in Texas's state science standards is presently subpar. The bill was introduced by James Talarico (D–District 52)—a former public school teacher—but died in committee in May 2021.

NATIONAL

House Resolution 29, introduced in the House of Representatives on January 11, 2021, would, if adopted, express the House's support for "teaching climate change in public and private schools at all grade levels." The resolution observes that "there is a broad consensus among climate scientists that the human activities contributing to increases in greenhouse gas emissions are the dominant cause of climate change." The resolution is identical to H. Res. 574 from the previous legislative session, which died in committee.

Meet Katherine Jenkins—An NCSE Curriculum Study Field Tester

Thirty middle and high school teachers in diverse communities around the country have begun the task of testing, assessing, and reporting on NCSE's climate change, evolution, and nature of science lessons as part of a curriculum study field test during the current and next school years. (For more on the curriculum study field test, see *RNCSE* 41:3.) During July 2021, NCSE staff conducted a two-week virtual professional development session to prepare these educators to teach the NCSE lessons. I recently spoke with one of those teachers, Katherine Jenkins, who teaches at an independent Quaker school in Baltimore, about her experience with the session. The interview has been edited for clarity and brevity.

LIN ANDREWS: So why did you decide to sign up to be a curriculum study field tester?

KATHERINE JENKINS: Simple—the state of the nation. I've been apprehensive about how divided our country seems to be about all things science lately. The pandemic only added to a sense of isolation and division, and I was excited about the idea of working with a national cohort of teachers to help bridge these divides. Scientific knowledge and research are being questioned constantly by a segment of the media. I was helping my students break down the rampant science misconceptions spreading during these trying times. It is much easier to make changes and improve curriculum in a cohort than all on your own, so it is a win-win for teachers.

LA: We recently finished our two-week online professional learning summer session, where NCSE staff explained best practices on approaching the nature of science, evolution, and climate change in the classroom. Compared to other professional learning you have taken part in, how do you feel NCSE's approach was different?

KJ: First, we were given a huge palette of lesson plans to pick from when implementing the misconception-based curriculum in our classrooms. There were so many activities to choose from, it almost felt overwhelming at first. But my favorite part of that is that it gave me more freedom to implement the lessons in a tailor-made fashion for my course. I will teach them in a tenth-grade-class called Life and Physical Science, designed to help students better understand scientific concepts and attain scientific literacy. These lessons were a perfect match for a course of this nature.

Second, NCSE staff and teacher ambassadors provided multiple strategies for tackling each misconception by creating several entry points into the concepts whenever possible. During the two weeks, you also allowed teachers to participate in ongoing conversations, guide the direction of the discussion, and even change the schedule daily based on our feedback. It was a very positive experience.

LA: Have you ever taught a nature of science unit before?

KJ: In the past, I've only ever spent a day or two on the scientific process. I would incorporate other aspects of the nature of science throughout my entire year, but having a complete unit at the beginning of my course will be entirely new for me. I'm dividing the Nature of Science unit into two pieces in my classroom because I plan to have an entire section dedicated to the COVID-19 pandemic. [NCSE's nature of science unit uses the current pandemic and the science behind the SARS-CoV-2 virus as a central example throughout.] I'm allowed a little more freedom to do this since I teach in an independent school.

LA: How do you see your part in this study playing out over the next two years? How will you make this work in your classroom?

KJ: One of the things I love about teaching is how it always involves trying new things. What I look forward to most is providing my students more and different opportunities to work with and collect authentic data. I love giving my students puzzles and watching them figure out how all the pieces work together. I feel confident students will figure out how science works. This method, in turn, will help inoculate them against new misinformation when they encounter it in the future.

LA: A distinctive feature of the new evolution curriculum is a focus on human origins. Have you ever approached this topic in the classroom before? What are you most excited about with this opportunity?

KJ: I've told the story of Piltdown Man in my environmental science class when discussing the possibility of bias affecting the conduct of science. My students and I have also included humans in discussions of biodiversity, as well as how our species is much less genetically diverse than other species. I'm very excited to use 3-D skulls and structures to help my students see the differences

between different hominids and assist students in seeing that there is a treasure trove of evidence supporting human evolution. I only wish I could place physical skull models in all my students' hands! But I am grateful for the opportunity to incorporate even computer-rendered images into my course. I think it will significantly reduce misconceptions that surround human origins and defuse the controversy surrounding the subject.

Katherine Jenkins's enthusiasm for NCSE's lesson plans is representative of the many teachers serving as curriculum study field testers. We at NCSE are very excited about this initiative and will continue to report how the curriculum study is progressing. Stay tuned for more!

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

NCSE Names 2021 Friend of Darwin and Friend of the Planet Awardees

Save the Date: We'll be celebrating the 2021 recipients at an online event on December 9, 2021. Follow us on social media for more information as we get closer to the date.

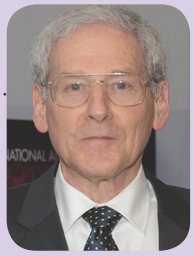
NCSE is pleased to announce the winners of the Friend of Darwin award for 2021: Mohamed Noor, Professor of Biology and Dean of the Natural Sciences at Duke University and author of *Live Long and Evolve* (2018); Briana Pobiner, a paleoanthropologist who leads the Smithsonian National Museum of Natural History's Human Origins Program's public programs, website content, social media, and exhibition volunteer training; and Jason R. Wiles, Associate Professor of Biology at Syracuse University, a specialist in evolution education.

"The Friends of Darwin for 2021 have tirelessly promoted the cause of evolution education," commented NCSE's executive director Ann Reid. "For Mohamed Noor, through his use of *Star Trek* to teach evolution concepts as well as through his popular open online course. For Briana Pobiner, through her profound commitment to bringing human evolution to formal and informal educational settings alike. And for Jason Wiles, through his innovative research on teaching and learning about biological evolution as well as his advocacy in his native Arkansas."

NCSE is also pleased to announce the winners of the Friend of the Planet award for 2021: Ayana Elizabeth Johnson, a marine biologist specializing in ocean conservation and climate policy and the co-editor of *All We Can Save* (2020); Marshall Shepherd, the Georgia Athletic Association Distinguished Professor of Geography and Atmospheric Sciences at the University of Georgia; and Climate Generation, a Minneapolis-based non-profit organization that seeks to build climate literacy and action among educators, youth, and the broader public.

Reid extolled the Friends of the Planet for 2021 as well, explaining, "When it comes to climate change, Ayana Elizabeth Johnson is at the vital nexus of science, policy, and communication, while Marshall Shepherd is not only a distinguished scientist but also a highly successful communicator on issues related to weather and climate." She added, "And I can't praise Climate Generation highly enough for its work on climate literacy and action, especially for its extensive and effective outreach to educators."

The Friend of Darwin and Friend of the Planet awards are presented annually to a select few whose efforts to support NCSE and advance its goal of defending and supporting the teaching of evolution and climate science have been truly outstanding. Previous recipients of the Friend of Darwin award include Brian Alters, Susan Epperson, Brandon Haught, Lawrence S. Lerner, and Patricia Princehouse. Previous recipients of the Friend of the Planet Award include Katharine Hayhoe, Frank Niepold, and the Climate Literacy and Energy Awareness Network (CLEAN).



RanDom Samples with Jeremy Thorner

Jeremy Thorner, a long-time member of NCSE, is Professor Emeritus of Biochemistry, Biophysics, and Structural Biology at the University of California, Berkeley, where his research focused on the biochemistry of yeast. A member of the National Academy of Sciences and the American Academy of Arts and Sciences, he will receive the Centenary Award for 2022 from the Biochemical Society in the UK. The interview has been edited for length and clarity.

Glenn Branch: First of all, congratulations on the Centenary Award, presented in recognition of your contributions to our understanding of biological signal transduction mechanisms! Can you give a brief explanation of your work?

Jeremy Thorner: Thank you. To survive, all living things need to be able to sense changes in their surroundings and respond accordingly. To avoid danger and noxious conditions, it has been to our very great advantage that we have evolved our senses of sight, taste, smell, touch, and hearing. Likewise, individual cells inside our bodies need to orchestrate and coordinate their behavior by responding to signals emitted by other cells. For example, the insulin released from the pancreas into our bloodstream after we eat a meal instructs our muscle, liver, and fat cells how to deal with the rising level of glucose absorbed into our bloodstream from our intestines. Quite similarly, even unicellular organisms, like the yeast cells we have studied, need to recognize and adapt properly to physical cues (like changing temperature) or chemical stimuli (like nutrient availability) to survive.

GB: Would it be fair to say that nothing in your research makes sense except in the light of evolution?

JT: Absolutely. Despite its deceptively simple existence, every yeast packages its genome in separate linear chromosomes within a nucleus inside a cell that contains mitochondria and all the other organelles that are hallmarks shared with every other eukaryotic cell type, including human cells. For that reason, the features of cellular signal transduction mechanisms—the molecules, processes, and principles—that we have uncovered in our research are conserved and thus central to the existence and operation of even human cells. Fundamental discoveries made first in yeast have provided seminal understanding of biological processes that are broadly applicable to humans. In fact, several of the Nobel Prizes awarded in Physiology or Medicine over the last two decades have been awarded to yeast researchers who have conducted studies that have elucidated the genes and gene products that drive the cell division cycle (2001), that mediate secretory transport (2013), and that carry out the cellular recycling system known as autophagy (2016). What could be a more telling affirmation of Theodosius Dobzhansky's aphorism that "Nothing in biology makes sense except in the light of evolution"?

GB: Creationists—and not only creationists—often think that evolution isn't practically important. But your own work has proven to have important medical applications, right?

JT: Yes. I am very proud of the fact that the cellular "machinery" we discovered by which yeast cells produce and secrete a peptide hormone, called alpha-factor, was re-engineered by a Bay Area biotechnology company (Chiron Corporation), establishing yeast as a "factory" from which to generate copious amounts of very pure, authentic human insulin. This process has been used ever since by a Danish company (Novo Nordisk) to provide this essential hormone to diabetics worldwide.

GB: Since 2005, you've been regularly teaching a seminar for first-year students, "Evolution: Creatures, not Creation." Why did you decide to start teaching the seminar, and why have you kept doing it for so long?


Climate change: fake news or global threat? These are the facts

By Sarah Knapton, SCIENCE EDITOR
23 March 2019 • 4:02pm

WHAT WE'RE UP AGAINST

Warmed-Over Global Warming Denial

"Climate Change: Fake News or Global Threat? These Are the Facts," a March 23, 2021, column in *The Telegraph,* the British daily broadsheet, by the newspaper's science editor Sarah Knapton, looked all too familiar. *The Telegraph* published a similar column by Knapton, entitled "Climate Change: Fake News or Global Threat? This Is the Science," on October 15, 2019.

JT: I was first motivated to offer this freshman seminar in early August 2005, after I heard about a remark of then-US President George W. Bush during a press conference with a group of Texas journalists. One reporter asked Bush about whether he supported teaching "intelligent design" in the public schools. Bush replied, "both sides ought to be properly taught ... so people can understand what the debate is about." I said to myself, "Oh, my goodness, there is no debate between the fact of evolution and the parables of religion, no matter how meaningful the latter may be to any individual of faith."

I was also aghast because, even though Bush never went to law school, he should have been aware of two landmark Supreme Court decisions bearing on this very issue. First, in *Epperson v. Arkansas* (1968), the Supreme Court invalidated an Arkansas law prohibiting (in fact, criminalizing) the teaching of human evolution in public schools because the law violated the First Amendment of the Constitution. Second, in *Edwards v. Aguillard* (1987), the Supreme Court invalidated a Louisiana law requiring that creationism be taught in public schools whenever evolution is presented, again because the law violated the First Amendment of the Constitution.

GB: How has "Evolution: Creatures, not Creation" developed over the years? And what have you learned about the creationism/evolution controversy from teaching it?

JT: First, and quite remarkably, in late December 2005, after I had received approval to teach "Evolution: Creatures, not Creation") here at UC Berkeley, and just before I was to commence teaching the course for the first time, Judge John E. Jones III of the US District Court for the Middle District of Pennsylvania (who was, ironically enough, an appointee of former President George W. Bush) handed down his ruling in *Kitzmiller v. Dover*. Tammy Kitzmiller and other parents sued the Dover, Pennsylvania, school board, which had decided that "Darwin's theory of evolution" was "not a fact" and required that students be exposed to the alternative of "intelligent design." Judge Jones flatly rejected the school board's position, noting that evolution is one of the most strongly supported theories in all of science, backed by broad evidence from across the field. Moreover, in his lengthy decision, Judge Jones concluded that "the overwhelming evidence at trial established that ID ("intelligent design") is a religious view, a mere re-labeling of creationism, and not a scientific theory."

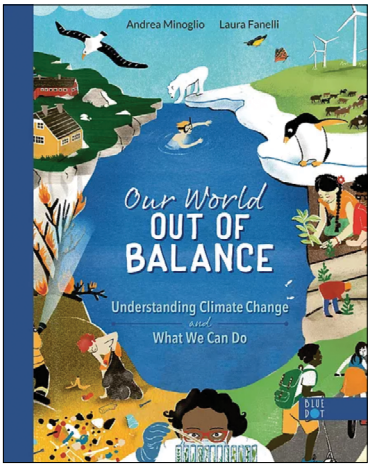
Second, the advent of molecular biology, recombinant DNA methodology, and the capacity to obtain the complete nucleotide sequence of any genome has confirmed the close relationships among all organisms. In fact, in the 16 years since I began teaching the course, the number of both existing and extinct eukaryote species whose genome sequences have been determined has gone from literally a handful (including the yeast and human genomes) to many thousands, including non-human primates, ancient hominids (Neanderthals, Denisovans, etc.), and current-day humans from a wide variety of ethnic groups and geographical locations around the globe. Comparisons among these genomes has amply confirmed the major tenets of the theory of evolution that were based (before DNA) on the fossil record and other more circumstantial and empirical evidence derived from field observations of extant organisms.

The third lesson I have learned from teaching the course is that the wonderful thing about scientific principles are that they are a true description of our natural world, regardless of whether anybody chooses to disbelieve or deny them. Earth is not flat; a stork is not responsible for the production of human offspring; and bloodletting to balance the humors is not an effective way to cure disease. Incorrect assumptions about the nature of our world pass away all the time; but the truth stands the tests of both time and continued rigorous investigation.

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

The earlier column was assessed by six scientists for Climate Feedback, who estimated its overall scientific credibility as "very low": -1.7 on a scale of -2 (very low) to 2 (very high). The later column, unfortunately, was no improvement. On the contrary, Dana Nuccitelli (a recipient of NCSE's Friend of the Planet Award) commented on Twitter that by his count Knapton "made 30 errors in 2019 and, despite copying and pasting most of that piece, made *38 errors* in 2021" (emphasis in original), adding a "facepalming" emoji to indicate his exasperation.

—*GLENN BRANCH*



Our World Out of Balance: Understanding Climate Change and What We Can Do

author: **Andrea Minoglio**

publisher: **Blue Dot Kids Press**

reviewed by: **Jason Carter**

Finding nonfiction books to help children understand the science of climate change is difficult, so I was excited to dig into Our World Out of Balance, written by Andrea Minoglio and illustrated by Laura Fanelli. Minoglio specializes in translating big science issues into language kids will understand, and he succeeds in doing so throughout the entire book.

This volume, aimed at children ages 8–12, is structured more like a reference book than a narrative with an overarching storyline. The book is divided into very concise sections each of which explains a specific facet of climate change, such as rising sea levels, melting ice, and plastics in the ocean. So it is not a book a child would want to read from beginning to end. Instead, teachers or parents can consult the book on specific topics to help explain a relevant issue and use the information as a jumping-off point for further exploration.

Trying to discuss climate change with children can be a depressing endeavor, but Minoglio makes the wise decision to supplement each topic with information not only about what is being done to mitigate various problems caused by climate change but also about what children can do now to help. For example, the section on shrinking forests encourages students to plant trees, become "guerrilla" gardeners, and reuse paper. Though these actions seem simple to adults, they help kids feel like part of the solution. Instilling hope with a call to action is so important for this age group.

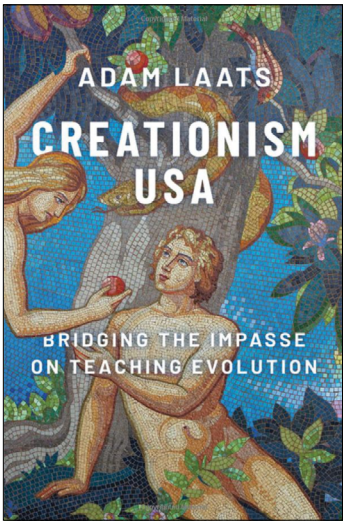
The writing itself is simple, straightforward, and easy to understand. Minoglio does not sugarcoat the information. For example, when explaining loss of rainforests, he writes "Farming is the biggest cause of deforestation. The more people there are in the world, the more food we need. The more food we need, the more farmland we need. To make space for more crops or animals grazing, people are cutting down large numbers of trees" (p. 15). This directness does not patronize children but instead clearly identifies causes and effects related to climate change using language they can understand.

Other features of the book that make it a strong learning tool include the use of boldface to emphasize unfamiliar words, like *cryosphere* and *permafrost*. Each of these words receives succinct definitions that flow nicely with the rest of the text. Another stand-out feature is the way the book points out the before and after of many of the phenomena. When describing melting ice, for instance, Minoglio contrasts what ice cover used to be like on the planet with what ice cover will be like in the near future if changes are not made. These concrete details really help children visualize how the planet is changing.

The book is beautifully illustrated by graphic designer Laura Fanelli. The images feel like folk art paintings. with bright and inviting colors and busy scenes. While the illustrations enhance the text, I wonder whether the choice of illustrations over compelling photographs will limit its appeal to all elementary students. The work looks and feels more like a picture book and less like the reference book it actually is. Students in upper elementary grades are usually more attracted to realistic imagery in their nonfiction.

Overall, *Our World Out of Balance* is an excellent reference book for helping children better understand specific aspects of climate change. I can easily see teachers using sections of the book to begin class discussions on the importance of recycling plastics, the reasons for the increase in wildfires, and the price of feeding a growing population. The book not only explains the issues but also offers concrete steps students can take to help improve the world around them. How often does a reference book also serve as an inspirational call to action?

Jason Carter is the Assistant Director, Mountain Office, of the Science House of North Carolina State University.
jmcart25@ncsu.edu



Creationism USA: Bridging the Impasse on Teaching Evolution

author: **Adam Laats**

publisher: **Oxford University Press**

reviewed by: **Andrew J. Petto**

In *Creationism USA*, the historian of education Adam Laats surveys the history of the creationism/evolution controversy in the United States with an eye toward drawing a moral for alleviating the controversy in the future.

To begin, Laats reminds us that support for creationism in public opinion polls shows barely any movement since Gallup's first poll in the early 1980s. Newer polls asking better questions show stronger evolution acceptance than Gallup's, but after all the effort that evolution's supporters have put into improving evolution education (and science education in general), the scant change in the public's position suggests that those of us who support and promote evolution education are doing something wrong.

What are we doing wrong? In effect, Laats suggests that we are failing to understand what creationists want from science education. It is easy to be distracted by the culture-wars battles that surround big court cases or legislative and school board actions. These are problematic, but Laats argues that they are fomented by representatives of a minority position that he labels "radical" creationism. Yes, these folks really do want to remove evolution from the schools, from the culture, and from the face of the Earth if possible. They are, however, only a small proportion of people who acknowledge a deity in charge of the universe when they answer public opinion polls. Readers may be surprised to learn Laats's conclusion that these creationists do want their children to learn evolution, and to learn it well and correctly.

To be sure, not all of Laats's non-radical creationists wholeheartedly accept evolution, but as a rule, their objections are not to the science proper but to what they regard as its consequences. Laats uncovers this same theme repeatedly. In the chapter entitled "Evolution and All That," he writes, "[F]or a lot of Christian creationists, it is not evolution they hate, but rather the theological implications that they associate with it" (p. 47). They like, or at least tolerate, evolutionary science, but they hate the "all that"—that there is no purpose in evolution (and therefore that humans are not its pinnacle), that modern evolutionary science is more about process than progress, that evolutionary science might be used in making decisions about life and society that they disagree with.

If you are interested in promoting the acceptance of evolution among the general public, you should read this book!

This latter "all that" is at the basis of some of radical creationism's strategies to win over the non-radical majority. The radical creationists argue that science—particularly evolutionary science—is atheistic, and they blame many of the trends toward secularization and cultural diversity in the post-World-War-II U.S. on "belief in" evolution. So what will people of faith (who accept a Creator God if not necessarily the historicity of Genesis) choose when presented with the choice that radical creationists force on them: creationism/salvation or evolution/damnation?

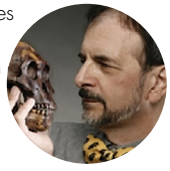
Yes, it is a false dichotomy. But it is an effective one. One of the best features of this book is Laats's chronicle of the events that fueled the emergence of this radical creationist strategy during what he calls the times when the "world broke apart." These were watershed events that changed the role of religion in public life: some court cases, some changes in curriculum in the schools, and some demographic shifts. Prior to these events, Laats points out, public institutions (such as schools and governments) reflected the religious beliefs and practices of a theologically conservative Protestant majority, at least in a generic way. Teachers and public officials led prayers or Bible readings in classrooms and at government functions.

These apparently slight changes marked a momentous shift to a public view of religion that offered to *respect* different religious views, but not to *reflect* any one of them as an "official" (or quasi-official) position for public institutions. This trend accelerated in the late 1950s and early 1960s, coinciding with an emphasis on more, and more modern, science instruction, and so radical creationists found evolutionary science—now forming an integral part of the increased emphasis on science education—to be a handy foil for their resistance to the trend away from a public religiosity.

Radical creationists framed their argument by focusing on the "science" (for example, "evidence[s] against" or "strengths and weaknesses of" evolution), and we took the bait; we argued about the science. But science is not the issue. The main battleground is for the control of the institutions responsible for teaching our children American civic values. This is where the common ground is to be found: making our children (and ourselves) decent, responsible, and honorable citizens. And that is where we can win over people who love God and also love science and even evolution, and maybe even move the needle on those opinion polls.

If we take no other message from this book, it should be this: we need to make it clear to the non-radical contingent of creationists that evolution education does not threaten their values. But the starting point of this process is to listen to what creationists really are saying about their concerns about the place of evolution in public life. If you are interested in promoting the acceptance of evolution among the general public, you should read this book!

A former member of NCSE's board of directors and a former editor of *RNCSE*, **Andrew J. Petto** is a Distinguished Lecturer Emeritus at the University of Wisconsin, Milwaukee, where he taught human anatomy and physiology. He currently teaches human anatomy and physiology short courses at Alverno College. He is co-author with Alice B. Kehoe of a new edition of the introductory anthropology textbook *Humans* (Routledge, forthcoming). ajpetto51@gmail.com



NATIONAL CENTER FOR SCIENCE EDUCATION
230 GRAND AVENUE, SUITE 101
OAKLAND, CA 94610-4587

CHANGE SERVICE REQUESTED

Non-Profit Org.
U.S. Postage
PAID
Oakland CA
Permit 686

JOIN NCSE'S LEGACY SOCIETY

Science students of the future need your help

To learn how to make an enduring impact on science education through NCSE's Legacy Society, visit ncse.ngo/legacy-society or call 510-601-7203 or email janes@ncse.ngo.

NCSE.ngo/legacy-society

Photo by Barry Polisky