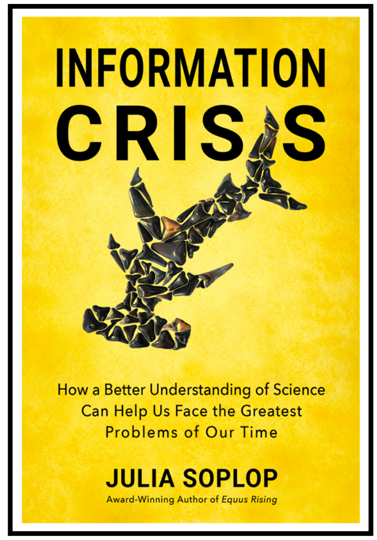
INFORMATION CRISIS

How a Better Understanding of Science Can Help Us Face the Greatest Problems of Our Time



Book Description

The rapid and ubiquitous spread of information has failed to remedy one of humanity's most enduring challenges: making accurate sense of the world. Instead, a constellation of factors influencing how we interact with information—and, in particular, scientific information—has prevented us from digesting and adequately confronting many of the greatest problems of our time, from climate change to pandemics.

The book, an essential read for non-scientists and scientists alike, offers both an analysis of this burgeoning crisis of (mis)information overload and a practical guide for navigating it. Soplop argues that becoming a more discerning and less vulnerable consumer, or producer, of health and science information is critical.

Soplop has created an indispensable primer for reimagining how we think about and communicate what science really entails, including its profound social value and its many limitations. She also presents a series of engaging case studies—the decades-long disinformation campaign to sow doubt in climate change, the schemes in the wellness industry, the push for pseudoscience in the science classroom, the century-old rhetoric of the anti-vaccination movement, and the nation's unfathomable COVID-19 response—demonstrating how players across society employ common, and therefore easily identifiable, tactics of distorting scientific information to manipulate us for power and profit. In vivid prose, Soplop crafts a compelling and hopeful case that building a stronger foundation of science and media literacy can empower us to improve our lives both personally and collectively.

"This is a book every citizen should read."

SY MONTGOMERY, *NEW YORK TIMES* BESTSELLING AUTHOR OF *THE SOUL OF AN OCTOPUS* AND EDITOR OF *THE BEST AMERICAN SCIENCE AND NATURE WRITING 2019*

"A brilliantly told, eye-opening read."
***BOOKVIEW REVIEW* (gold badge review)**

About Julia Soplop

Julia Soplop is a science writer and the author of *Equus Rising: How the Horse Shaped U.S. History*, winner of an Independent Book Publisher (IPPY) Award and a Feathered Quill Book Award. Her work has appeared in numerous publications, including *National Geographic*, *Summit Daily News*, and *Skiing*. She also develops thought leadership for organizations that address issues of scientific or social concern. She holds a bachelor's from Duke University and a master's from the medical journalism program at UNC-Chapel Hill. She lives with her family outside of Chapel Hill, NC.

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Transforming Our Anxiety into Purposeful Action

New Book Explores How Improving Our Science and Media Literacy Can Slice a Path Through the Exploding (Mis)information Crisis

Pittsboro, NC, April 16—In this moment of profound unease, it feels as if our very democracy could be smothered by an impermeable blanket of misinformation and manipulation. But it's important to recognize that we do have agency to transform our anxiety into action to safeguard our individual wellbeing and foster a more capable, evidence-based society.

A book released today, *Information Crisis: How a Better Understanding of Science Can Help Us Face the Greatest Problems of Our Time* (Hill Press), by Pittsboro author Julia Soplop, analyzes the burgeoning crisis of (mis)information overload and offers a practical guide for navigating it. In this essential read for non-scientists and scientists alike, Soplop crafts a compelling and hopeful case that building a stronger foundation of science and media literacy can empower us to improve our lives both personally and collectively.

"We aren't helpless against the societal dysfunction in which we find ourselves living," Soplop said. "We can staunchly reject it. We can choose a different path. *Information Crisis* illustrates how we can each contribute to a more functional future—and why we have to."

"This is a book every citizen should read."
—SY MONTGOMERY, *New York Times* bestselling author of *The Soul of an Octopus*
and editor of *The Best American Science and Nature Writing 2019*

"Weaving technological insights, neuropsychology, and fascinating case studies, *Information Crisis* hands us an urgently needed blueprint for science literacy in the digital age and beyond."
—WALLACE J NICHOLS, PhD, marine biologist and bestselling author of *Blue Mind*

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"A journalistic triumph…This book belongs in every institute of higher education, health care office, statehouse, newsroom, and living room in America."
—HEIDI SCHUMACHER, MD, assistant professor of pediatrics,
University of Vermont Larner College of Medicine

"Soplop balances her convincing research (which is backed by over 900 endnotes) with an accessible writing style geared toward readers unfamiliar with scientific scholarship."
—*KIRKUS REVIEWS*

Julia Soplop is a science writer and the author of *Equus Rising: How the Horse Shaped U.S. History*, winner of an Independent Book Publisher (IPPY) Award and a Feathered Quill Book Award. Her work has appeared in numerous publications, including *National Geographic*, *Summit Daily News*, and *Skiing*. She also develops thought leadership for organizations that address issues of scientific or social concern. She holds a bachelor's from Duke University and a master's from the medical journalism program at UNC-Chapel Hill.

The book launch will take place at Pittsboro's storied McIntyre's Books in Fearrington Village on Saturday, April 20 at 2 p.m. The event is free and open to the public. All are welcome!

A digital press kit with additional reviews, a chapter excerpt, and high-resolution images is available: https://www.juliasoplop.com/press

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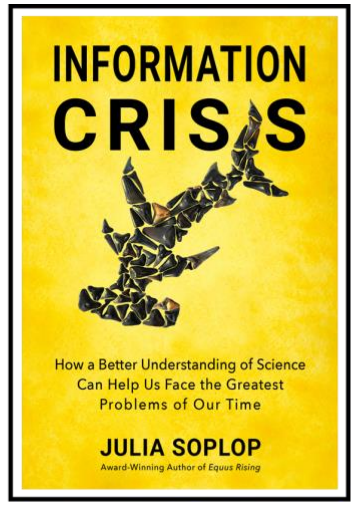
Advance Praise for

INFORMATION CRISIS

How a Better Understanding of Science Can Help Us Face the Greatest Problems of Our Time



"Amid a tsunami of shrill voices, deep fakes, and paid disinformation campaigns, it's more important than ever that Americans learn to recognize and understand science and how to weigh the evidence. Soplop's research is wide and deep. *Information Crisis* is chock full of vivid examples, surprising case studies, and fascinating data on everything from how American leaders bungled the COVID and climate crises, to how industry manipulates the way we think and remember. This is a book every citizen should read."
—SY MONTGOMERY, *New York Times* bestselling author of *The Soul of an Octopus* and editor of *The Best American Science and Nature Writing 2019*

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"A journalistic triumph. In a world in which truth is subjective and distrust of experts is rampant, Soplop provides a compelling primer on the fundamentals of science literacy and their relationship to a strong and healthy society. With meticulous research and engrossing case studies, she paints a comprehensive picture of the crisis and opportunity before us to save science—and democracy as a whole...This book belongs in every institute of higher education, health care office, statehouse, newsroom, and living room in America."
—HEIDI SCHUMACHER, MD, assistant professor of pediatrics, University of Vermont Larner College of Medicine

“A well-documented and frightening assessment of America’s fraught relationship with science…Soplop balances her convincing research (which is backed by over 900 endnotes) with an accessible writing style geared toward readers unfamiliar with scientific scholarship.”
—KIRKUS REVIEWS

“Amidst the chaos and uncertainty that surround us, *Information Crisis* is a book that can help us right now. By illustrating how to effectively distill and evaluate a deluge of science and media information, Soplop mitigates our vulnerability and anxiety, while underscoring our ability to harness this evidence-based knowledge for positive change. Her masterpiece exemplifies a familiar adage of Maya Angelou—this book empowers us to know better, so that we can do better.”
—LISA BERGHORST, PhD, clinical psychologist, lecturer at Northwestern University Feinberg School of Medicine, and co-author of *Exposure Therapy for Treating Anxiety in Children and Adolescents*

"Meticulously researched, comprehensive, and accessible, this is a must-read for anyone seeking to understand the complexities of our current information landscape. A triumph.”
—THE PRAIRIES BOOK REVIEW

“If you want to understand how distortion of scientific information is threatening your democracy and your world, then read this book. In plain English, Soplop explains how messengers of fake science manipulate public perceptions to the detriment of all of us.”
—TOM LINDEN, MD, professor of medical journalism, University of North Carolina at Chapel Hill, and author of *The New York Times Reader: Health & Medicine*

“Thought-provoking, timely, and important. Blending absorbing narratives with extensive research, Soplop persuasively argues that bolstering science literacy is vital to creating a more functional society...She writes for a general audience, but her work will resonate just as much with scientists, physicians, journalists, and educators, as it illustrates the necessity of more effectively articulating science to the public—and the high stakes of neglecting to do so.”
—REMY SCALZA, freelance journalist

“[*Information Crisis*] is a book about solutions to problems and how they are found as well as how they are resisted or rejected...This is much needed even among those who study and practice in public health.”
—THOMAS RICKETTS, PhD, senior policy fellow and adjunct professor of health policy and management, University of North Carolina at Chapel Hill, and editor of *Rural Health in the United States*

INFORMATION CRISIS

How a Better Understanding of Science Can Help Us Face the Greatest Problems of Our Time

JULIA SOPLOP

Award-Winning Author of *Equus Rising*

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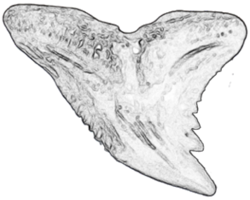

How a Better Understanding of Science
Can Help Us Face the Greatest
Problems of Our Time

Julia Soplop

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Citizen Science and More

"It's a hammerhead!" someone shouted.

The boat erupted into cheers. What luck! Great hammerheads are critically endangered, which meant that for many of us on board, this could be a once-in-a-lifetime chance to see one in the wild.

Suddenly, the boat was buzzing with activity. The research team began to reel in the shark and prepare their gear to quickly collect data. The photographer grabbed an underwater camera and donned flippers. And the rest of us headed up to the second level for a clear vantage point.

We often see images and videos of sharks breeching dramatically out of the water or swimming with sharp, jerking movements as they pursue prey. But what immediately struck me was the extraordinary grace of this animal. It glided through the water with eyes set wide on its enormous cephalofoil head, its tall, sleek, narrow dorsal fin gently breaking the surface. It didn't fight the line; it *soared* through the water. Finding myself in the presence of such a rare and magnificent creature felt unexpectedly overwhelming. I realized tears were streaming down my cheeks.

At the invitation of my cousin, Lacey Williams, who was at the time a graduate student in the University of Miami's Shark Research and Conservation program, I had flown down to Florida the previous day to join this shark tagging excursion as a citizen scientist. As my plane landed over Biscayne Bay, I peered out the window and wondered what was swimming in the water below that I might have the good fortune to examine up close the next day.

There are many ways for non-scientists to become more intimately familiar with science and its value to society. Citizen science is one of the most invigorating. (We'll discuss some other practical actions to engage in and advocate for science later.) It benefits researchers by providing more hands for data collection. But it also benefits the public.

"One of the big values of citizen science is that it lets people understand the scientific process. They get to see it first hand and experience it directly," Keene Haywood told me.[891] Haywood is a geographer, documentary filmmaker, and senior lecturer at the University of Miami's Rosenstiel School of Marine, Atmospheric, and Earth Sciences, where he teaches a graduate course on designing and implementing citizen science projects. "For a long time, science has lived in an ivory tower or behind a lab door."

Citizen science breaks down that barrier and allows adults and kids alike to take "an active role in discovery," he said. "You don't need a PhD to do that." Participation can help to "dispel some of the mystery around science" and make the process more transparent.

Experiencing science may help non-scientists feel less "like they're walled off from it, or that it's happening in some secret lab somewhere and they're being manipulated or lied to," Haywood said.

It can also illustrate the realistic limitations of science. Science "is messy," he said. "There are problems. There are issues. There are all kinds of challenges with it. It's not a clean process, so you see that, too."

The Shark Research and Conservation program regularly takes kids and non-scientist adults on citizen science excursions to teach them about sharks, conservation, and how science unfolds by allowing them to participate in the data collection process.

Once or twice a year, the lab hosts a similar trip for the research team's friends and family, which is how I scored a sought-after spot.

We arrived at the marina early on the morning of our trip. Given my lifelong propensity for motion sickness during just about any type of movement aside from walking, I was loaded to the gills with anti-nausea medication.

As the all-female research team scurried around stowing gear, one of the researchers and the captain, a woman named Mo, gave us a brief orientation to the basics of the operation and also told us what to do in case of emergency. The safety instructions boiled down to this: If the crew becomes incapacitated, radio the Coast Guard. And if the boat goes down, do *not* climb inside the life raft, but instead float in the water and hold onto the outside of the raft. (I found this second point humorous given that, in such a disaster scenario, we would be floating around in the waters we had just baited to attract sharks.)

We pushed off and headed about 30 minutes offshore, zipping up Miami's building-clad coast to waters with depths around 100 feet, where some of the most exciting predators hunt.

My motion sickness medication was holding up surprisingly well.

As we motored toward deep water, the research crew gave us more detailed instructions on how we were going to, hopefully, catch some sharks.

"The most dangerous things on this boat are the lines," Lacey, who has since graduated and become the head field specialist at Oceans Research in South Africa, told the group. In no uncertain terms were we to straddle the lines as we walked to the back of the boat to set them. Getting pulled overboard and tangled in a weighted, shark-baited line would be very, very, bad.

The team then showed us the process of deploying a line. At the captain's signal, we'd first throw in a thick, clear line with a circle hook that held a large hunk of barracuda. A circle hook is more likely than a traditional hook to set properly in a shark's mouth rather than somewhere else on its head or body. It also corrodes and falls out easily if it can't be entirely removed and, if swallowed, it won't tear up a shark's insides. We'd let that line uncoil all the way. A hook timer was attached to the end of the line, which, if a shark nabbed the hook, was supposed to pop open and start a timer to let us know how long the shark had been on the line. Next we'd toss in a weight tied to the line, which would sink to the bottom to hold the line in place. Then we'd throw in yet another rope, tied to that weight, which was attached to two large orange buoys. The buoys would show us where the line was when it was time to reel it back in.

As we arrived at the fishing area, the boat slowed. The team sets up to 10 lines at a time depending on the conditions. That day, we were going to set seven. Anyone working at the back of the open-ended boat had to strap a personal floatation device (PFD) around their waist in case they fell overboard.

We citizen scientists lined up and strapped on our PFDs. The crew helped us each to deploy a line. Once we had set all seven, we idled for a bit to let them "soak," or sit long enough for a shark to find that barracuda and chomp it—which is to say, not long.

As we waited, we checked and recorded the water salinity. Lacey and her undergraduate mentee brought out a shark stuffed animal and demonstrated how we would work up a real shark if we caught one. There are extremely strict research protocols when working with vulnerable species, and little room for error.

If we citizen scientists dragged in a line and saw the hook timer had popped, indicating a shark could be on the hook, the crew would take the line and gently guide the shark toward the boat. They would then attach a modified jet ski platform to the back of the boat. The platform had a groove in the middle, onto which they would position the shark.

They told us to stay back until they had pulled the shark onto the platform and stabilized it by putting a pipe of running water into its mouth. Then it would be our turn to help. They divided us into groups of four or five, and each group would take one shark, if we were lucky to get that many. I was placed in the first group, which meant my chance of being able to work up a shark was high. Within each group, we would split the following jobs: shower the shark to help it maintain body temperature and reduce its stress out of the water (and, for some species, to help it breathe); clip a fin for a tissue sample, tag the shark with a satellite and/or other type of identification tag; and measure the shark's length and width.

Once the lines had soaked, we circled the boat back to the buoys and began to check them, beginning with the first we had set.

Line 1: The hook timer was intact. No shark. We reset the line.

Line 2: The hook timer had been pulled! Was there a shark? The crew began to draw in the line. This was our great hammerhead.

Great hammerheads are so sensitive to human interaction that they are the one exception to the standard research protocol in which the citizen scientists were allowed to participate. Only the research team was permitted to work up this species, and they would only collect data if the hammerhead had been on the line for fewer than about 40-45 minutes and looked healthy as they brought it toward the boat. Unlike other, less sensitive species, hammerheads couldn't be hauled onto the platform, so the team would have to collect the data while hanging off the back of the boat. And they had to get the job done in under six minutes to try to prevent stressing the animal.

This hammerhead hadn't been on the line long, and it had swum in beautifully, so they decided it was safe to work up. Once the animal was secured against the back of the boat, the researchers descended like a pit crew. The six-minute timer was ticking.

The first mate and photographer jumped into the water near the shark. The first mate began to guard the photographer with a stick in case the animal suddenly swung back at her when it was released. The stick also came in handy to gently push aside the school of moon jellyfish that happened to float by, surrounding them as the photographer worked to capture the hammerhead with an underwater camera.

From above, we could see that tall dorsal fin cutting high above the water as Lacey and her team lay on their bellies, dangling off the boat with their arms around the animal. They measured it and snipped a fin sample to collect DNA in a spot with no nerve endings, so it likely feels like clipping a fingernail. They determined the shark was female. She was between nine and 10 feet long, which sounded like an impressive size—until we learned great hammerheads can grow to double that length.

Satellite tags that can remotely track a shark's movement cost $3,000 a pop, so the team uses them discerningly. They decided to place a satellite tag on this hammerhead, which Lacey secured to its dorsal fin. She also used a rubber mallet to tap a spaghetti tag, labeled with a unique identification number, into the fin.

As the minutes sped by, the citizen scientists grew silent, knowing the time limit was approaching. The researchers would need to release the shark soon to ensure her health.

I held my breath as they worked to cut the hook out of her mouth using an enormous pair of bolt cutters. She swam away looking strong, as we serenaded her with more cheers and well wishes.

Lacey emerged from the encounter with fresh "shark burn" on her forearms, caused by friction against the sandpaper-like shark skin. Shark skin feels smooth when rubbed in one direction, but rough when rubbed in the other due to v-shaped scales called dermal denticles.

With the shark on her way, we resumed pulling in lines.

Line 3: No shark. We reset the line.

Line 4 (which I had deployed): No shark. Darn. We reset the line.

Here's where my memory grows hazy. The air temperature had warmed, the sun was shining intensely, there was little breeze, and we were slowly circling the boat to work the lines. As the adrenaline from the hammerhead encounter wore off, a switch seemed to suddenly flip; I went from feeling okay-ish to horrible. Really, the only thing that was surprising was how long I'd lasted. I spent a good amount of time vomiting over the side (the captain had directed us to go to a VIP—vomiting in progress—section where there was a gap in the railing if the need arose) while other people continued to haul in and reset the empty lines.

Then someone yelled again: "The timer's popped!" And: "We've got a nurse shark on the line!"

I scrambled to right myself. This was the ultimate boot-and-rally moment. My group was on deck, making it my one shot to work up a shark. My adrenaline kicked in. I buckled the PFD around my waist and inched my way toward the back of the boat, joking with my compatriots to leave a path open for me to the VIP area.

The researchers quickly tossed the platform into the water and bolted it to the back of the boat. They climbed on and hoisted the nurse shark onto the platform. (Nurse sharks are the one species that doesn't receive the pipe of running water in their mouths, because they'll crush it.) One person in my group stepped forward and began to shower the shark to make sure it had enough oxygen while we worked it up. Next, my partner and I scooted forward to collect three length measurements. I was so excited I could barely read the measuring tape. I shouted out the measurements to the data recorder, as we'd been instructed to do. She shouted them back to me to confirm. I was, in fact, so excited that I can't remember how long the shark was, though it was certainly smaller than the hammerhead, probably six to seven feet.

As I pressed the measuring tape to the shark's skin, I was surprised by its texture. Lacey had told me that nurse sharks have the largest dermal denticles. What I was not expecting, however, was that its skin felt almost reptilian. Between the denticles and the wrinkles caused by its wriggling, I felt as though I were touching an iguana; its skin was bumpy but also soft and pliable.

The team determined this shark was also female. Another volunteer stepped forward to take the fin clip, and another hammered a tag into her dorsal fin. This tag didn't include a satellite tracker, but it would allow researchers to identify the individual animal if they caught her again later.

With that, our citizen science jobs were complete. The researchers had a few more things to do, though. They had to take measurements closer to the mouth, which are considered more dangerous.

Lacey had also been assigned to physiology duty, which meant she was in charge of taking a blood sample from underneath the tail while one of her colleagues tried to hold the shark steady. Nurse sharks thrash around quite a bit out of water, unlike the larger sharks, so it took a few attempts before Lacey had enough time to inject the needle and draw the sample of blood. (It's not unheard of for a researcher to sustain an injury from a powerfully thrashing shark tail.)

With the workup finished, the team released the shark. We waved her off.

Lacey took the sample to the front of the boat, where she used two types of centrifuges to "spin down" the blood into its components: red blood cells, white blood cells, and plasma. These components would be sent to scientists at the Shark Research and Conservation program and other collaborating labs within the university, as well as to institutions around the country to study all sorts of things, such as shark immunology, stress responses, accumulation of heavy metals or toxins, and reproduction.

I couldn't watch Lacey do this task; as soon my adrenaline had dissipated, intense nausea had crept back in. I had to resume my position in the VIP area. A few others had begun to suffer from motion sickness by this point, too.

Those still standing returned to the task of pulling in lines and resetting them. Eventually, we had another popped hook. Unbelievably, as the shark neared the boat, we could see that telltale profile of another great hammerhead. We had caught two critically endangered sharks in one day.

This animal swam elegantly, but it had been on the line for just over 40 minutes—in that questionable range of whether it was safe to work it up. The team erred on the side of caution and decided to release it immediately to ensure its safety. They carefully guided the shark to the edge of the boat, determined it was yet another female, and cut out her hook. She seemed slightly smaller than the first, though they didn't measure her.

It turned out I had the perfect perspective from the VIP area to see her off (though I had to will myself not to vomit on her as she glided away from my side of the boat). The way the afternoon sun hit her skin transformed her into a glowing aqua silhouette set against the steely blue sea—nothing short of ethereal.

After she swam off, I sunk back into a post-adrenaline state and curled up on a bench. The team deployed and pulled in four more empty lines before it was time to return to the marina. We had set a total of 16 lines and caught three sharks, two of them endangered, which seemed like pretty good odds to me. The team's re-catch rate is only about 5 percent, which means there are a lot of sharks in Biscayne Bay.

Docked at the marina in the later afternoon, we took a celebratory photo to commemorate the adventure. Together, we had collected several forms of data that would contribute to numerous studies at the university and other research institutions. Not bad for a day-long excursion.

The crew set to work breaking down the equipment and stowing some of it in various onsite buildings. We lugged the rest back to the marine lab before our well-earned dinner.

Citizen science can be personally exhilarating and edifying. It can also offer important lessons in how science actually transpires. One of those lessons is that data collection is always grueling in some way, regardless of the field of study. On dry land, I began to revive from my sea sickness. Marine biology research is not for the faint of heart or the weak of stomach. The experience reminded me why one queasy summer spent at a marine lab in college promptly quashed my early aspirations of a career in marine biology. Thank goodness for stronger-stomached researchers who help us to better understand the role of sharks in our world.

Leveraging the public to collect data can be useful in scientific fields in which there aren't enough trained scientists on the ground—or in the water, as it were—to do the collection work themselves, or in which there isn't enough funding to cover the salaries of more scientists to do the work—which are many.

The concept of citizen science has been around for a long time. For example, the National Audubon Society has held an annual Christmas Bird

Count since 1900, during which experienced birders lead volunteers in collecting data on local bird populations.[892] But the advent of widespread wireless and cellular technology in the last 10-15 years has quickly changed the landscape and expanded the possibilities for this type of research.

"It's really been a lock-step evolution with that technology and citizen science," Keene Haywood said. "Absolutely, smartphones have had a huge impact from a contributory perspective." Collecting data on smartphones makes the process easier and faster than ever before. Our phones also contain a lot of sensors, and scientists are continuously finding new ways to employ them to creatively collect more types of data.

Smartphones allowed for the development of what is perhaps the most famous example of citizen science: the iNaturalist app.

"iNaturalist was really a big game changer," Haywood said. The app allows anyone to take photos of plants and animals and upload them to a database. Once professionals vet these images and identifications for accuracy, they release them into a global database that scientists can use for research. The database is also available to the public. (My family and I have been using iNaturalist for years and have learned a ton about the flora and fauna around us.)

Haywood told me iNaturalist is an example of a contributory project, the most common of the three models of citizen science. This model develops stringent protocols on how to collect data and then allows the public to participate in the collection process. However, the public doesn't have input in designing the project or research questions.

My shark tagging trip would fall into the contributory project category, too.

The less common collaborative project model includes the public, to some degree, in helping to design the protocols for a project. And then there is the co-collaborative project model, in which the public works with scientists from the ground up to design a project, giving the public substantial input.

"Those are much rarer," Haywood said. "They're harder to do, but they can yield some pretty good results." They're sometimes used when citizens are trying to enact a policy change to address a localized problem. For instance, research that uncovered the water quality crisis in Flint, Michigan, was a result of a co-collaborative citizen science project. Illnesses were occurring locally, and a woman in the community became suspicious of the water. She brought together a group of other concerned citizens and found a hydrologist at Virginia Tech who helped the group design testing protocols to collect accurate and useful water quality data. It was their research that identified high lead concentrations in the water.

Can non-scientists collect quality data? Yes, if the project is appropriately designed for non-scientists, and the citizen scientists are well trained in how to collect the data.

A larger challenge, though, is designing projects that are sustainable in terms of both participation and funding. People often get hyped up at the beginning of a project but disappear after collecting data for a while. "Then you end up with your rock stars, who stay with the project for a long time, and they can actually collect a lot of data," Haywood told me. "You can have a few people collecting a ton of really good data, so you don't necessarily need hordes of people doing things." The trick is figuring out how to continue to engage enough people to keep the project going.

"The ones who are really enthusiastic about it, they really love it and they will spend a lot of their time collecting data and trying to understand the question," Haywood said "It surprised a lot of trained scientists, the level of enthusiasm and curiosity that people have. They want to do this."

Keeping a project alive also requires funding for data servers, people to manage them, and scientists to evaluate the data. Thankfully, funders, including federal government entities like the NSF, have started to recognize the value of citizen science and become more willing to support it.

A professional organization, the Citizen Science Association, has also formed to advance the practice. It publishes an open-source journal called *Citizen Science: Theory and Practice*.[893]

Like adults, K-12 students can benefit greatly from citizen science, which can "get kids out of the screen and into the real world," Haywood said. It can "help them build powers of observation and questioning that might not be so easy to do in a classroom."

Citizen science can also show them the importance of data, how data collection works, and what kind of questions you can start to answer when you have enough information.

Despite these important benefits, incorporating such projects into K-12 science curriculum can be challenging. On this subject, Haywood pointed me to educator Anne Haywood, who happens to be his wife. Anne Haywood is the founder and director of Mountain to Sea Education, an organization that develops innovative, interdisciplinary education programs to give kids hands-on experiences to engage with the natural environment.[894] Many of these programs involve citizen science.

"There is so much potential to make science really relevant to what's happening in students' lives and connect them with scientists and researchers," she told me.[895] While some progress has been made in recent years to connect science learning to the real world, there are "a lot of forces holding things back."

Some of those forces include groups that lobby against accurate science education (such as intelligent design proponents), lack of sufficient teacher training, over-stuffed classrooms, and under-resourced schools. State curriculum and testing standards that determine the content teachers must prioritize in the classroom are also substantial, which means that to be used in schools, citizen science projects need to be oriented toward checking off some of these standards.

Although the concept of STEM projects has gained some momentum in recent years—that is, projects that integrate science, technology, engineering and/or math to tackle a scientific problem—the standard courses colleges expect high school students to take for entry can limit progress in this area. In high school, most advanced science courses, such as AP Chemistry and AP Biology, remain separated from each other and require a rather specific recipe of activities to prepare students for their AP exams.

"So much is required that there is very little flexibility to do something new," Anne Haywood said.

But it's not impossible to integrate citizen science into K-12 classrooms. Doing so requires motivation and advocacy from districts, teachers, and even parents. Many of these projects, however, don't have to be done on top of other curriculum; if they're well designed, they can replace some current activities.

For both adults and kids, getting your hands dirty, or wet and shark burned, is the best and most captivating way to engage in and learn about how science works. Citizen science offers a fantastic opportunity to do so. Here are some ideas to get started:

- Check out the poster child for modern citizen science: download the iNaturalist app and get started exploring nature.
- Visit www.citizenscience.gov to learn about federally funded citizen science projects
- Take a look at National Geographic's Citizen Science page to learn about more projects: https://education.nationalgeographic.org/resource/citizen-science-projects
- Visit citizen science hubs Zooniverse (https://www.zooniverse.org) and SciStarter (https://scistarter.org)
- For conservation- and climate-themed citizen science projects, check out Adventure Scientists (https://www.adventurescientists.org)
- Advocate for citizen science in your kids' schools
- If you participate in a project, be sure to follow up after to learn about the results of the study or studies that used your data

Additional Opportunities

Beyond citizen science, there are many additional ways to further your understanding of science. Becoming more knowledgeable about science on a personal level is important for making informed behavioral, purchasing, and voting decisions, as well as protecting ourselves from manipulation. It's fun, too. Advocating for a more scientifically minded public and evidence-based policymaking is also crucial to improving the systems that impede us from fully harnessing the benefits of science to better society. Below are a few more ways to engage in this process.

Participate in Clinical Research

Becoming a research subject is not for everyone, but it can be an interesting way to learn more about how clinical research works and produces different qualities of evidence, as well as to contribute to our scientific understanding of a subject. Some studies require a commitment as simple as spending a few minutes filling out a one-time survey. Others may require substantially more time, extensive follow-up, and/or invasive treatments. Patients often engage in invasive studies because they've run out of other treatment options, but there are many innocuous studies that require minimal investment of time and risk. If you participate in research, be sure to inquire how to access the finished study so you can make sense of how your data contributed to the study's findings.

Subscribe to Quality Science Journalism

The reality is that quality science journalism is often locked behind a paywall. We aren't entitled to free, quality journalism, and it could disappear if we stop paying for it entirely. If you can afford it, consider purchasing a subscription to a high-quality, less biased publication that hires dedicated science journalists who, more often than not, cover the subject skillfully. If not, search for free resources that fit this bill as closely as possible. (See the Appendix for tips on identifying credible publications.)

Advocate For Meaningful and Accurate Science Curriculum in Schools

We need to advocate for hands-on K-12 science curriculum that features real-world research opportunities, such as citizen science. By the time kids graduate from high school, they should be familiar with the broad principles this book presents, including being able to articulate what modern science is and isn't, its value to society, its limitations, the concept that claims about the physical world require sufficient evidence, how quality of evidence varies, and how players distort scientific information for gain.

Media literacy in classrooms is also vital to reducing vulnerability to scientific manipulation. (See the Appendix.)

Learning basic statistics is highly valuable for interpreting the scientific information we encounter in daily life, as well. We should encourage math tracks that require statistics.

One of numerous challenges to providing quality science education is the fact that groups around the country actively promote teaching religion in the science classroom. Religious beliefs are, by definition, not scientific. We need to stand firmly against any form of pseudoscience making its way into science curriculum.

Moving toward effective science education requires advocacy at every level, from engaging with teachers, administrators, and school boards; to demanding state-level standards that include useful science curriculum; to voting for science-minded state and local officials who make education funding decisions; to voting for a president who takes seriously the appointment of a science-minded Secretary of Education; to encouraging colleges and universities to accept, and even advocate for, high school science and math courses designed to help prepare students to encounter scientific information in the real world.

Protect Democracy and Vote in Primaries

Much of our failure to sufficiently apply science to society's advantage, such as our long-standing refusal to meaningfully address climate change or to fund an effective public health infrastructure, is due to two factors: the devaluing of science and the lack of interest in paying for things that would actually improve our lives. Again, these are active choices we've made, and we can choose a better path forward.

First, commit to protecting democracy itself—that means, in the very least, eliminate (or, more realistically, reduce) gerrymandering, remove barriers to voting, and accept the results of free and fair elections. Without a functional democracy, we have no voice in how the government funds research and its application or employs scientific evidence to set policy.

Second, vote in primary elections. Most people don't. But this is where contests are decided in areas that lean strongly toward one political party, which characterizes many jurisdictions. The people with the most extreme political views are the ones who tend to show up for primaries, and they end up selecting the most extreme candidates, who don't represent the views of most Americans. We can stop that from happening by voting in primaries.

Third, vote for candidates at every level who have demonstrated an understanding of science and its value and are committed to funding scientific innovation and its implementation, as well as setting evidence-based policies.

Talk About Scientific Issues that Spark Social Controversy in Everyday Conversation

Sara Peach, from *Yale Climate Connections*, was one of the first people to draw my attention to the importance of what I now call making "everyday mentions" about scientific issues that spark social controversy, such as the fact that climate change, evolution, and COVID-19 are real. These mentions don't have to be lengthy conversations, monologues, or attacks. They simply state the fact that you stand with the scientific consensus—and that your position is a normal one to have. Regarding climate change, Peach suggested something as simple as telling a friend you're starting a meatless dinner night and asking for recipe suggestions as a non-confrontational way to show that you're thinking about the importance of reducing greenhouse gas emissions.

Repetition makes information familiar and therefore easier to understand, which makes us more likely to believe it than unfamiliar information. This brain processing shortcut can leave us vulnerable to manipulation when bombarded with repetitive scientific misinformation, but it can also provide a pathway for spreading accurate scientific information.

Don't Be Fooled Into Complacency

We can take action to safeguard ourselves from scientific manipulation, and we can make healthier behavioral choices for ourselves, our communities, and our environment. But we can't let these actions lull us into thinking that voluntary, personal choices *alone* can solve the systemic problems that prevent us from sufficiently funding, applying, or regulating science and technology to most effectively benefit society. Intentional blame shifting away from the underlying causes of a systemic problem to the individual, such as BP's PR campaign that launched the individual carbon footprint calculator as a solution to climate change, is common across sectors. But systemic problems require systemic solutions from those instigating them; there are no silver bullets for complex issues. Companies and interest groups that cause or perpetuate these immense problems need to commit to and invest in systemic changes.

This doesn't mean we're off the hook for taking individual action, but it means that these actions only make a significant difference when, collectively, they push toward systemic change. Some of the biggest challenges we're facing, and will continue to face, as a nation are the climate crisis and our limping public health and health care systems. Mutual action is required to address these issues, and we can, as individuals, contribute to this cooperative movement. Politically, citizens can support policies that move us away from fossil fuels toward renewable energy and that invest in improving dilapidated health systems. We can also vote with our wallets by, whenever possible, refusing to enable companies that prevent us from reaching these goals, and instead supporting those that bring us closer to them.

Scientists Must Speak for Science

I hope I've dispelled the common myth that science can speak for itself. In fact, those who profit from distorting scientific information speak considerably louder than dry, dusty journal articles. Scientists can commit to learning to more effectively communicate to the public the process and value of science in general and in their particular fields. Stepping out of the lab and becoming more vocal advocates for science and its applications to better society—even when that means dipping a toe into politics and demanding evidence-based policies and investment—is a critical component of building a more scientifically literate and science-driven country.

Responsibly Consume Health and Science Information

And, of course, actively and continuously employing the concepts introduced in this book to become a more discerning and less vulnerable consumer, and/or producer, of health and science information can help you to interact with science for your benefit and society's.

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