

## Science denied: Why does doubt persist?

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The sign in front of the tall display case at the Smithsonian Institution's Museum of Natural History lures visitors to "meet one of your oldest relatives." Inside stands a morganucodon, a mouse-like animal from the Late Triassic period, 210 million years ago. "A close relative of this tiny creature was the first mammal on earth," the sign says. "Its DNA was passed on to billions of descendants, including you."

Nearby, hominid skulls, ancient tools and maps of early migrations spell out humanity's deep past. Surely, such a mix of strong visuals and clear explanations brings the theory of evolution to life for young minds, right? "You'd be surprised," says a guide who has answered countless questions since the collection, called the Hall of Human Origins, opened two years ago. "I've heard visitors call evolution a

secular conspiracy to eliminate God. They tell me that they bring their kids here to show them how ridiculous the other side is."

The facts of evolution may be written in stone and bone and DNA, but close to half the American public "accepts a biblical creationist account of the origins of life," according to the Pew Research Center for People & the Press. Evolution is just one front in a broader conflict between science and individual belief. Climate change is another: according to a 2009 Pew survey, about half of Americans doubt that human activity contributes to global warming, despite strong scientific evidence that it does. Smart and caring parents, swayed by a purported though discredited link between vaccines and autism, are refusing to immunize their children. Other issues are also returning to the hot-button table, among them fluoridation of public drinking water.

While doubters of evolution are often linked to the political or religious right, the rejection of science knows no social, economic or ideological bounds. Fifty years ago, the opposition to fluoridation came from the John Birch Society and other right-wing groups that equated the practice with Communism. These days the charge is led by left-leaning organic foodies and eco-activist organizations such as the Sierra Club and change.org. Anti-vaccine sentiment is highest among the better educated, the more affluent and the more environmentally conscious. Looking to find higher than normal rates of vaccine noncompliance? "Go to any Whole Foods market," one public health official remarked.

A few Metro stops from the Smithsonian Institution, Sean B. Carroll, a 1983 graduate of the Sackler School of Graduate Biomedical Sciences, is working to change the country's often distorted conversation about science. An evolutionary developmental biologist and author of books that engagingly explain evolution, DNA and other science to lay readers (he is also a regular talking head for science documentaries), Carroll was recently named vice president for science education at the Howard Hughes Medical Institute. It's his job to find ways of fostering public respect for, understanding of and enthusiasm about science.

Nobody knows more about public disrespect for science than another Tufts alumnus, Paul Offit, A72. Offit is chief of the Division of Infectious Diseases and the director of the Vaccine Education Center at the Children's Hospital of Philadelphia and a co-inventor of the anti-diarrhea vaccine RotaTeq, one of those vaccines supposedly linked to autism. He is the author, most recently, of *Deadly Choices: How the Anti-Vaccine Movement Threatens Us All*. Offit's outspokenness has made him the target of vaccine opponents, their invective occasionally punctuated with physical threats (as detailed in a *Wired* cover story in 2009). The abundant science that backs up his confidence in vaccines has done nothing to change their minds.

## **Stories People**

Tell As a society, we are indeed a contradictory lot. We welcome, even demand, medical and other advances from our scientists, yet we choose not to believe those same experts when their research rebuts notions we hold dear. This denial of science is certainly grist for psychology journals. But does it really matter?

Carroll thinks it matters a lot. "Otherwise, why would a happy scientist with a very fulfilling research career bounce between Madison, Wisc., and Washington, D.C.?" he asks. Instead of working in his genetics laboratory at the University of Wisconsin, where he is a professor, he has begun to spend most of his time at the campus-like offices of the Howard Hughes Medical Institute, just outside of Washington. Carroll has a long history with the institute as a principal investigator, but he now has access to its vast resources for his broader mission of bringing science to the public.

His ability to bridge hard science and popular culture is evident from the artifacts in his institute office. In one corner is a detailed model of HMS Beagle, the ship that carried Charles Darwin on his epic five-year voyage nearly two centuries ago. A nearby wall displays a poster for the 1980 movie *Airplane*, autographed by Carroll's friend Jerry Zucker, the comedy's executive producer. "Be careful where you hang this," wrote Zucker. "I don't want you to lose your funding."

Yet Carroll's most formidable advantage in the fight against science denialism may be his sense of what makes people tick. Humans, he says, are creatures of stories: "It's why we read books and go to the movies and hang out at the water cooler." In fact, he says, the power of stories—even wrong or misguided ones—is such that "people who refuse to get vaccines are maybe not to be blamed. There's no one regulating how much truth and how much bullshit is out there."

Instead of bemoaning the situation, he says, the scientific community must counter the b.s. with reliable, compelling stories of its own. And with that in mind, he aims "to produce inspiring, content-rich films about great science and great scientists." The Hughes Institute, historically low-profile and focused on research, is getting into the film business.

Carroll acknowledges, however, that in the business of spinning stories, science is at a competitive disadvantage. "Science is in an asymmetric fight to stick to the rules of professional conduct," he explains. "We are about evidence and weighing evidence. Because we are not going to issue statements that could smack us in the face, we can't use the media in the same way."

## **Cognitive Bias, Not Reason**

Paul Offit's experience with the vaccine furor underscores this difficulty. "All I have on my side is reason," he says. "I keep getting asked if I believe that autism is associated with vaccines. It doesn't matter what I believe. All that matters is what the data show."

Something else tilts the playing field toward those untroubled by an allegiance to scientific rigor: "What if the message of one story is more appealing than another?" Carroll asks. "If you have been told that you have been specifically created by a higher being with some plan for your life, that can be a bit more reassuring than thinking that you're just one of billions of genetic combinations that has come about at this moment in time after millions of years of hominid evolution, with no plan and no explicit purpose."

Science is waging an uphill battle against the phenomenon known as cognitive bias—which Seth Mnookin, a Boston-based writer, defines as "a set of unconscious mechanisms that convince us that it is

our feelings about a situation and not the facts that represent the truth." The Panic Virus, his book debunking alleged links between vaccines and autism, takes a hard look at such biases.

In an interview, Mnookin seconds Carroll's remarks. "The common thread with hot-button issues such as climate change, vaccines and evolution is that the arguments that go against scientific evidence are typically more satisfying," he says. "You are never going to convince broad swaths of the public by using data. It's not how the human brain works. With autism, for example, science can't really tell us much more than we knew a decade ago. All science can say is that it is not caused by X or Y, while the other side says, I know exactly why autism is happening and how you can make it better." For parents desperate to protect their children against an enigmatic and devastating neurological disorder, which side holds more appeal?

David Ropeik, a former TV journalist whose latest book is *How Risky Is It, Really? Why Our Fears Don't Always Match the Facts*, has become a student of "confirmation bias"—people's tendency to give greater credence to arguments that support their beliefs and grasp for ways to discredit facts that don't. "We like to think that we're smart, rational beings, but most of our perceptions are subjective and powerfully influenced by instinct and emotion," Ropeik says.

And in today's world, such biases get a power boost from the Internet. Support for cherished opinions is not only in the eye of the beholder but at the fingertips of the Googler, as Mnookin notes in *The Panic Virus*. "One of the first effects of [the] hyper-democratization of data was to unmoor information from the context required to understand it," he writes. "On the Internet, facts float about freely and are recombined more according to the preferences of intuition than the rules of cognition: Mercury is toxic, toxins can cause development disorders, mercury is in vaccines; ergo, vaccines cause autism."

Ofit voices a similar complaint. "A whole group of people believe they can Google the word vaccine and know as much as any doctor," he says. "These are often upper-middle-class people who are in control, who are their own bosses. In this postmodern thinking, anyone's attitude and belief is as valid as anyone else's simply because they have it."

In Dunedin, Fla., a recent (and unsuccessful) movement to halt fluoridation of the public water supply drew strength from online claims like this one, posted by change.org: "Current and historical studies document that non-naturally occurring fluoride water additives cause harmful illness and disease to adults and children."

One of the town's anti-fluoridation leaders was Bree Cheatham, who helps run the local food co-op and is active in progressive causes. She has a ready response when asked about decades of research that have shown fluoride to be safe and effective. "With any issue, it goes back to corporations with lots of money," she says. "They are not looking at humanity or community—they are looking at profit. Science doesn't matter, because I know who pays for it. I don't want it, and I don't need to know about it." Never mind that the Centers for Disease Control has recognized water fluoridation as "one of 10 great public health achievements of the 20th century," ranked between family planning and recognition of tobacco use as a health hazard.

## Doubt in the DNA

Cheatham is right about one thing: science should not always be accepted without question. Some scientists allow funding or other non-empirical agendas to taint their research. They may adjust data and findings to cater to corporate sponsors. Or they may fail to speak up when big business withholds inconvenient findings about a product—as in the case of Vioxx, the prescription painkiller that Merck marketed for years, all the while concealing data about the increased risk of heart attack and stroke.

Carroll knows that such tainted research goes on, and he accepts that skepticism is in America's DNA. "Doubt goes way back in this nation," he says. "The government lied about Vietnam, and politicians lie about lying. Corporations have lied about what they dump into rivers, and tobacco companies and pharmaceutical companies have lied. There's good reason to be skeptical about information we get." But, he adds, "you have to be discriminating in the authorities you're going to doubt."

Offit, for example, makes a poor target for charges of corporate bias. Though he did receive compensation when Children's Hospital sold the RotaTeq patent, he makes no money from the sale of any vaccine. And far from being an all-vaccines-are-good absolutist, he was the only member of the CDC's advisory panel to oppose a proposal to give smallpox vaccine to Americans shortly after 9/11 as an antidote to real or imagined terrorist threats. At the time, he felt that the potential risk from the vaccine outweighed the danger of citizens getting smallpox.

Nor is he a pure apologist for big pharma, which he agrees "can act unethically and even illegally," although when it comes to vaccines, he feels the industry has been generally ethical. But none of that prevented Robert F. Kennedy Jr.—speaking at a 2008 anti-vaccine rally in Washington—from calling Offit a "poster child for the term 'biostitute.'"

The involvement of celebrities like Kennedy, magnified by social media, only intensifies many of the influences behind science denialism. The model and actress Jenny McCarthy, whose son has been diagnosed with autism, regularly reinforces the cognitive biases that lead parents to blame the disorder on childhood vaccines. Says Offit, "She gets on TV and believes she is an autism expert, but she is an expert on her son. I don't try to change her mind. I can only hope to influence other people who may be influenced by her."

The repercussions of ignoring scientific evidence can be grave. Offit cites the example of Apple's founder and CEO, Steve Jobs, who died last October of pancreatic cancer at the age of fifty-six. Several sources, including Jobs' biographer Walter Isaacson, contend that Jobs put off potentially lifesaving cancer surgery for nine months after his diagnosis in 2003, choosing instead to pursue alternative medicine.

"Jobs learns that he has a neuroendocrine tumor," says Offit. "That is an eminently treatable tumor with early surgery. Jobs, however, is a smart guy with a lot of resources. He is a Buddhist and vegetarian, and he knows better. So he decides to drink a lot of fruit juices and does other alternative medicine. By the time he has surgery, it's too late. The tumor has metastasized, and he is on a downward spiral that ultimately kills him. I am amazed that Steve Jobs made that decision, and you and I can argue that it was

not reasonable, but that was his choice." Such disregard of hard facts "is worse than know-nothingism," Offit observes. "It's like thinking you know something, when you don't."

## **Danger Ahead**

Science denialism works its harm on a larger scale as well. For instance, when parents, driven by baseless fears, resist vaccinating their kids, the wall of immunity that has kept measles, whooping cough and other childhood diseases at bay for decades can break down. In some geographic regions, that is happening already.

"We are starting to see outbreaks of measles bigger than they were in 1996," Offit says. "California has had the biggest outbreak of whooping cough since 1947." France and other European nations also report more measles cases. Rebecca Martin, head of the Office for Vaccine-Preventable Diseases and Immunization at the World Health Organization, is worried. "There's been a buildup of children who have not been immunized over the years," she explained in an Associated Press interview last year. "When you have enough people who have not been immunized, then outbreaks can occur."

Ropeik, the author on risk, speculates that such events may be the hard slap needed to bring public officials to their senses. "People who oppose vaccines will not be changed, no matter the evidence, but they are putting themselves and society at risk," he says. "So government's role is to step in and, in the case of vaccinations, make it harder for people to opt out, which you can now do in many states by simply saying you have a philosophical opposition. You should have to prove a real religious exception. And if your kid is not vaccinated, he or she can't go on that weekend trip to Washington during measles season."

The dangers of rejecting science are nowhere more apparent than in our country's stalled progress on climate change. Evidence is strong that the planet is indeed warming, and that such warming will have real consequences. Evidence is also strong that human activity contributes to warming. Nevertheless, critics persist in the belief that climate scientists are driven by ideology instead of research and that they are trying to mislead the public for political purposes.

But the wages of science denialism are not always obvious. According to Carroll, Americans' resistance to the theory of evolution, while less noxious than measles outbreaks or climate woes, has had a real impact.

"Thirty years ago," he says, "there was not much interest in evolution within the life sciences community. Life scientists were interested in biological mechanisms, but they were studying them without an evolutionary context. Now it's a different ballgame. As we've leaped forward and conquered biological frontiers on so many fronts, all of life science now sees that evolution is the fundamental thread that holds together the whole picture of life on earth." But public education has not yet caught up to that reality. Evolution is still "under taught and underemphasized."

Science denialism could have serious economic consequences, Carroll argues. "If we don't value science and education, there is not a lot of incentive for people to pursue those fields, which means we will see

less implementation of knowledge in our public policy. We'll have forfeited an edge in science that the world has envied for sixty years."

Americans' resistance toward science is hardly new. Witness the 1925 "monkey trial," in which John Scopes, a Tennessee biology teacher, was prosecuted for the crime of teaching evolution. What's different today is that the nation is infinitely more dependent on science. That makes it all the more important, Carroll says, for today's schoolchildren—tomorrow's scientists, engineers, researchers, parents and voters—to learn the centrality of evolution and other science to how the world works and humans develop.

Carroll aims to give vivid form to such lessons in the educational videos he is overseeing on evolution and other topics. The Hughes film production unit will spend \$60 million over the next five years. ("I'm putting Howard's money where my mouth is," Carroll deadpans.) Under his creative stamp, he promises there will be no talking heads, no dull graphics, just great storytelling. "Teachers deserve all the help we can give them," he says. Provided by Tufts University

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