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Poll Reveals Rift Between Scientists, Regular Folks

When it comes to food, energy, and education, Americans don't follow experts' lead.

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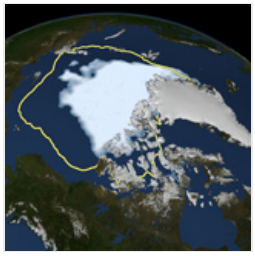

The Great Divide on Climate Change

As scientists and much of the public differ on the causes of climate change, the planet keeps getting warmer ... and the effects are adding up.

Photo Gallery

Photos From the

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A WORKER ADJUSTS A DIORAMA OF A MOON LANDING AT THE KENNEDY SPACE CENTER

Why Do Many Reasonable People Doubt Science?

We live in an age when all manner of scientific knowledge—from climate change to vaccinations—faces furious opposition. Some even have doubts about the moon landing.

By Joel Achenbach
Photographs by Richard Barnes

There's a scene in Stanley Kubrick's comic masterpiece *Dr. Strangelove* in which Jack D. Ripper, an American general who's gone rogue and ordered a nuclear attack on the Soviet Union, unspools his paranoid worldview—and the explanation for why he drinks "only distilled water, or rainwater, and only pure grain alcohol"—to Lionel Mandrake, a dizzy-with-anxiety group captain in the Royal Air Force.

Ripper: Have you ever heard of a thing called fluoridation? Fluoridation of water?

Mandrake: Ah, yes, I have heard of that, Jack. Yes, yes.

Ripper: Well, do you know what it is?

Mandrake: No. No, I don't know what it is. No.

Age of Disbelief

It's an old but troubling phenomenon: Many of us reject the evidence that scientists painstakingly compile.

Ripper: Do you realize that fluoridation is the most monstrously conceived and dangerous communist plot we have ever had to face?

The movie came out in 1964, by which time the health benefits of fluoridation had been thoroughly established, and antifluoridation conspiracy theories could be the stuff of comedy. So you might be surprised to learn that, half a century later, fluoridation continues to incite fear and paranoia. In 2013 citizens in Portland, Oregon, one of only a few major American cities that don't fluoridate their water, blocked a plan by local officials to do so. Opponents didn't like the idea of the government adding "chemicals" to their water. They claimed that fluoride could be harmful to human health.

Actually fluoride is a natural mineral that, in the weak concentrations used in public drinking water systems, hardens tooth enamel and prevents tooth decay—a cheap and safe way to improve dental health for everyone, rich or poor, conscientious brusher or not. That's the scientific and medical consensus.

To which some people in Portland, echoing antifluoridation activists around the world, reply: We don't believe you.

We live in an age when all manner of scientific knowledge—from the safety of fluoride and vaccines to the reality of climate change—faces organized and often furious opposition. Empowered by their own sources of information and their own interpretations of research, doubters have declared war on the consensus of experts. There are so many of these controversies these days, you'd think a diabolical agency had put something in the water to make people argumentative. And there's so much talk about the trend these days—in books, articles, and academic conferences—that science doubt itself has become a pop-culture meme. In the recent movie *Interstellar,* set in a futuristic, downtrodden America where NASA has been forced into hiding, school textbooks say the Apollo moon landings were faked.

In a sense all this is not surprising. Our lives are permeated by science and technology as never before. For many of us this new world is wondrous, comfortable, and rich in rewards—but also more complicated and sometimes unnerving. We now face risks we can't easily analyze.

We're asked to accept, for example, that it's safe to eat food containing genetically modified organisms (GMOs) because, the experts point out, there's no evidence that it isn't and no reason to believe that altering genes precisely in a lab is more dangerous than altering them wholesale through traditional breeding. But to some people the very idea of transferring genes between species conjures up mad scientists running amok—and so, two centuries after Mary Shelley wrote *Frankenstein,* they talk about Frankenfood.

The world crackles with real and imaginary hazards, and distinguishing the former from the latter isn't easy. Should we be afraid that the Ebola virus, which is spread only by direct contact with bodily fluids, will mutate into an airborne superplague? The scientific consensus says that's extremely unlikely: No virus has ever been observed to completely change its mode of transmission in humans, and there's zero evidence that the latest strain of Ebola is any different. But type "airborne Ebola" into an Internet search engine, and you'll enter a dystopia where this virus has

almost supernatural powers, including the power to kill us all.

In this bewildering world we have to decide what to believe and how to act on that. In principle that's what science is for. "Science is not a body of facts," says geophysicist Marcia McNutt, who once headed the U.S. Geological Survey and is now editor of *Science,* the prestigious journal. "Science is a method for deciding whether what we choose to believe has a basis in the laws of nature or not." But that method doesn't come naturally to most of us. And so we run into trouble, again and again.

SQUARE INTUITIONS DIE HARD

That the Earth is round has been known since antiquity—Columbus knew he wouldn't sail off the edge of the world—but alternative geographies persisted even after circumnavigations had become common. This 1893 map by Orlando Ferguson, a South Dakota businessman, is a loopy variation on 19th-century flat-Earth beliefs. Flat-Earthers held that the planet was centered on the North Pole and bounded by a wall of ice, with the sun, moon, and planets a few hundred miles above the surface. Science often demands that we discount our direct sensory experiences—such as seeing the sun cross the sky as if circling the Earth—in favor of theories that challenge our beliefs about our place in the universe.

LIBRARY OF CONGRESS, GEOGRAPHY AND MAP DIVISION

The trouble goes way back, of course. The scientific method leads us to truths that are less than self-evident, often mind-blowing, and sometimes hard to swallow. In the early 17th century, when Galileo claimed that the Earth spins on its axis and orbits the sun, he wasn't just rejecting church doctrine. He was asking people to believe something that defied common sense—because it sure looks like the sun's going around the Earth, and you can't feel the Earth spinning. Galileo was put on trial and forced to recant. Two centuries later Charles Darwin escaped that fate. But his idea that all life on Earth evolved from a primordial ancestor and that we humans are distant cousins of apes, whales, and even deep-sea mollusks is still a big ask for a lot of people. So is another 19th-century notion: that carbon dioxide, an invisible gas that we all exhale all the time and that makes up less than a tenth of one percent of the atmosphere, could be affecting Earth's climate.

Even when we intellectually accept these precepts of science, we subconsciously cling to our intuitions—what researchers call our naive beliefs. A recent study by Andrew Shtulman of Occidental College showed that even students with an advanced science education had a hitch in their mental gait when asked to affirm or deny that humans are descended from sea animals or that Earth goes around the sun. Both truths are counterintuitive. The students, even those who correctly marked "true," were slower to answer those questions than questions about whether humans are descended from tree-dwelling creatures (also true but easier to grasp) or whether the moon goes around the Earth (also true but intuitive). Shtulman's research indicates that as we become scientifically literate, we repress our naive beliefs but never eliminate them entirely. They lurk in our brains, chirping at us as we try to make sense of the world.

Most of us do that by relying on personal experience and anecdotes, on stories rather than statistics. We might get a prostate-specific antigen test, even though it's no longer generally recommended, because it caught a close friend's cancer—and we pay less attention to statistical evidence, painstakingly compiled through multiple studies, showing that the test rarely saves lives but triggers many unnecessary surgeries. Or we hear about a cluster of cancer cases in a town with a hazardous waste dump, and we assume pollution caused the cancers. Yet just because two things happened together doesn't mean one caused the other, and just because events are clustered doesn't mean they're not still random.

We have trouble digesting randomness; our brains crave pattern and meaning. Science warns us, however, that we can deceive ourselves. To be confident there's a causal connection between the dump and the cancers, you need statistical analysis showing that there are many more cancers than would be expected randomly, evidence that the victims were exposed to chemicals from the dump, and evidence that the chemicals really can cause cancer.

PHOTO: BETTMAN/CORBIS

EVOLUTION ON TRIAL
In 1925 in Dayton, Tennessee, where John Scopes was standing trial for teaching evolution in high school, a creationist bookseller hawked his wares. Modern biology makes no sense without the concept of evolution, but religious activists in the United States continue to demand that creationism be taught as an alternative in biology class. When science conflicts with a person's core beliefs, it usually loses.

Even for scientists, the scientific method is a hard discipline. Like the rest of us, they're vulnerable to what they call confirmation bias—the tendency to look for and see only evidence that confirms what they already believe. But unlike the rest of us, they submit their ideas to formal peer review before publishing them. Once their results are published, if they're important enough, other scientists will try to reproduce them—and, being congenitally skeptical and competitive, will be very happy to announce that they don't hold up. Scientific results are always provisional, susceptible to being overturned by some future experiment or observation. Scientists rarely proclaim an absolute truth or absolute certainty. Uncertainty is inevitable at the frontiers of knowledge.

Sometimes scientists fall short of the ideals of the scientific method. Especially in biomedical research, there's a disturbing trend toward results that can't be reproduced outside the lab that found them, a trend that has prompted a push for

greater transparency about how experiments are conducted. Francis Collins, the director of the National Institutes of Health, worries about the "secret sauce"—specialized procedures, customized software, quirky ingredients—that researchers don't share with their colleagues. But he still has faith in the larger enterprise.

"Science will find the truth," Collins says. "It may get it wrong the first time and maybe the second time, but ultimately it will find the truth." That provisional quality of science is another thing a lot of people have trouble with. To some climate change skeptics, for example, the fact that a few scientists in the 1970s were worried (quite reasonably, it seemed at the time) about the possibility of a coming ice age is enough to discredit the concern about global warming now.

Last fall the Intergovernmental Panel on Climate Change, which consists of hundreds of scientists operating under the auspices of the United Nations, released its fifth report in the past 25 years. This one repeated louder and clearer than ever the consensus of the world's scientists: The planet's surface temperature has risen by about 1.5 degrees Fahrenheit in the past 130 years, and human actions, including the burning of fossil fuels, are extremely likely to have been the dominant cause of the warming since the mid-20th century. Many people in the United States—a far greater percentage than in other countries—retain doubts about that consensus or believe that climate activists are using the threat of global warming to attack the free market and industrial society generally. Senator James Inhofe of Oklahoma, one of the most powerful Republican voices on environmental matters, has long declared global warming a hoax.

The idea that hundreds of scientists from all over the world would collaborate on such a vast hoax is laughable—scientists love to debunk one another. It's very clear, however, that organizations funded in part by the fossil fuel industry have deliberately tried to undermine the public's understanding of the scientific consensus by promoting a few skeptics.

The news media give abundant attention to such mavericks, naysayers, professional controversialists, and table thumpers. The media would also have you believe that science is full of shocking discoveries made by lone geniuses. Not so. The (boring) truth is that it usually advances incrementally, through the steady accretion of data and insights gathered by many people over many years. So it has been with the consensus on climate change. That's not about to go poof with the next thermometer reading.

But industry PR, however misleading, isn't enough to explain why only 40 percent of Americans, according to the most recent poll from the Pew Research Center, accept that human activity is the dominant cause of global warming.

The "science communication problem," as it's blandly called by the scientists who study it, has yielded abundant new research into how people decide what to believe—and why they so often don't accept the scientific consensus. It's not that they can't grasp it, according to Dan Kahan of Yale University. In one study he asked 1,540 Americans, a representative sample, to rate the threat of climate change on a scale of zero to ten. Then he correlated that with the subjects' science literacy. He found that higher literacy was associated with stronger views—at both ends of the spectrum. Science literacy promoted polarization on climate, not consensus. According to

Kahan, that's because people tend to use scientific knowledge to reinforce beliefs that have already been shaped by their worldview.

Americans fall into two basic camps, Kahan says. Those with a more "egalitarian" and "communitarian" mind-set are generally suspicious of industry and apt to think it's up to something dangerous that calls for government regulation; they're likely to see the risks of climate change. In contrast, people with a "hierarchical" and "individualistic" mind-set respect leaders of industry and don't like government interfering in their affairs; they're apt to reject warnings about climate change, because they know what accepting them could lead to—some kind of tax or regulation to limit emissions.

In the U.S., climate change somehow has become a litmus test that identifies you as belonging to one or the other of these two antagonistic tribes. When we argue about it, Kahan says, we're actually arguing about who we are, what our crowd is. We're thinking, People like us believe this. People like that do not believe this. For a hierarchical individualist, Kahan says, it's not irrational to reject established climate science: Accepting it wouldn't change the world, but it might get him thrown out of his tribe.

"Take a barber in a rural town in South Carolina," Kahan has written. "Is it a good idea for him to implore his customers to sign a petition urging Congress to take action on climate change? No. If he does, he will find himself out of a job, just as his former congressman, Bob Inglis, did when he himself proposed such action."

Science appeals to our rational brain, but our beliefs are motivated largely by emotion, and the biggest motivation is remaining tight with our peers. "We're all in high school. We've never left high school," says Marcia McNutt. "People still have a need to fit in, and that need to fit in is so strong that local values and local opinions are always trumping science. And they will continue to trump science, especially when there is no clear downside to ignoring science."

Meanwhile the Internet makes it easier than ever for climate skeptics and doubters of all kinds to find their own information and experts. Gone are the days when a small number of powerful institutions—elite universities, encyclopedias, major news organizations, even *National Geographic*—served as gatekeepers of scientific information. The Internet has democratized information, which is a good thing. But along with cable TV, it has made it possible to live in a "filter bubble" that lets in only the information with which you already agree.

How to penetrate the bubble? How to convert climate skeptics? Throwing more facts at them doesn't help. Liz Neeley, who helps train scientists to be better communicators at an organization called Compass, says that people need to hear from believers they can trust, who share their fundamental values. She has personal experience with this. Her father is a climate change skeptic and gets most of his information on the issue from conservative media. In exasperation she finally confronted him: "Do you believe them or me?" She told him she believes the scientists who research climate change and knows many of them personally. "If you think I'm wrong," she said, "then you're telling me that you don't trust me." Her father's stance on the issue softened. But it wasn't the facts that did it.

If you're a rationalist, there's something a little dispiriting about all this. In Kahan's descriptions of how we decide what to believe, what we decide sometimes sounds almost incidental. Those of us in the science-communication business are as tribal as anyone else, he told me. We believe in scientific ideas not because we have truly evaluated all the evidence but because we feel an affinity for the scientific community. When I mentioned to Kahan that I fully accept evolution, he said, "Believing in evolution is just a description about you. It's not an account of how you reason."

Maybe—except that evolution actually happened. Biology is incomprehensible without it. There aren't really two sides to all these issues. Climate change is happening. Vaccines really do save lives. Being right does matter—and the science tribe has a long track record of getting things right in the end. Modern society is built on things it got right.

Doubting science also has consequences. The people who believe vaccines cause autism—often well educated and affluent, by the way—are undermining "herd immunity" to such diseases as whooping cough and measles. The anti-vaccine movement has been going strong since the prestigious British medical journal the *Lancet* published a study in 1998 linking a common vaccine to autism. The journal later retracted the study, which was thoroughly discredited. But the notion of a vaccine-autism connection has been endorsed by celebrities and reinforced through the usual Internet filters. (Anti-vaccine activist and actress Jenny McCarthy famously said on the *Oprah Winfrey Show,* "The University of Google is where I got my degree from.")

In the climate debate the consequences of doubt are likely global and enduring. In the U.S., climate change skeptics have achieved their fundamental goal of halting legislative action to combat global warming. They haven't had to win the debate on the merits; they've merely had to fog the room enough to keep laws governing greenhouse gas emissions from being enacted.

Some environmental activists want scientists to emerge from their ivory towers and get more involved in the policy battles. Any scientist going that route needs to do so carefully, says Liz Neeley. "That line between science communication and advocacy is very hard to step back from," she says. In the debate over climate change the central allegation of the skeptics is that the science saying it's real and a serious threat is politically tinged, driven by environmental activism and not hard data. That's not true, and it slanders honest scientists. But it becomes more likely to be seen as plausible if scientists go beyond their professional expertise and begin advocating specific policies.

It's their very detachment, what you might call the cold-bloodedness of science, that makes science the killer app. It's the way science tells us the truth rather than what we'd like the truth to be. Scientists can be as dogmatic as anyone else—but their dogma is always wilting in the hot glare of new research. In science it's not a sin to change your mind when the evidence demands it. For some people, the tribe is more important than the truth; for the best scientists, the truth is more important than the tribe.

Scientific thinking has to be taught, and sometimes it's not taught well, McNutt says.

Students come away thinking of science as a collection of facts, not a method. Shtulman's research has shown that even many college students don't really understand what evidence is. The scientific method doesn't come naturally—but if you think about it, neither does democracy. For most of human history neither existed. We went around killing each other to get on a throne, praying to a rain god, and for better and much worse, doing things pretty much as our ancestors did.

Now we have incredibly rapid change, and it's scary sometimes. It's not all progress. Our science has made us the dominant organisms, with all due respect to ants and blue-green algae, and we're changing the whole planet. Of course we're right to ask questions about some of the things science and technology allow us to do. "Everybody should be questioning," says McNutt. "That's a hallmark of a scientist. But then they should use the scientific method, or trust people using the scientific method, to decide which way they fall on those questions." We need to get a lot better at finding answers, because it's certain the questions won't be getting any simpler.

Washington Post science writer Joel Achenbach has contributed to *National Geographic* since 1998. Photographer Richard Barnes's last feature was the September 2014 cover story on Nero.

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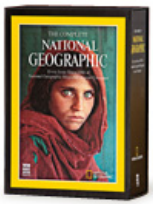

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