

Abusing science

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Abstract

The perversion of science in the interest of ideology and greed is not a new phenomenon, but a public that is largely scientifically illiterate now is besieged by “alternative facts” and well-designed efforts to discredit legitimate science on topics ranging from vaccines to climate change. Here, we examine three topics rooted in biology and biomedicine—creationism, harms from tobacco, and opioid addiction—to show that those purveying misinformation employ a consistent pattern of intellectual dishonesty to delegitimize science that challenges their ideological positions. Individual scientists and the scientific community at large should confront and counter these attacks on the intellectual integrity that is at the heart of the scientific enterprise.

KEYWORDS

creationism, ideology, intellectual dishonesty, misinformation, opioids, scientific illiteracy, tobacco

“The foundation of morality is to have done, once and for all, with lying.”

Thomas Henry Huxley, keynote address at the inauguration of Johns Hopkins University

12 September 1876

1 | INTRODUCTION

In August 2017, the National Association of Biology Teachers (NABT), in the United States, published an editorial titled “Teaching Biology in the Age of ‘Alternative Facts’”.¹ Biology teachers in the U.S. certainly were accustomed to being besieged by the alternative facts of creationism, especially as that movement morphed from its religious foundations to the charades of “creation science” and “intelligent design,” failed attempts to make the Christian creation

myth less overtly violative of the Establishment Clause of the U.S. Constitution's First Amendment.

Given that history, why would NABT's board feel compelled to issue a broader statement on “alternative facts” and the challenges they present to teachers and students? The editorial explains as follows:

In an age of “fake news” and “alternative facts,” our society is constantly bombarded with disinformation designed to undermine the principles under which scientific inquiry operates and cast doubt on conclusions derived through the scientific enterprise.... Our members understand that the recent efforts to cast doubt on the science of climate change or the process of evolution are no more valid than past campaigns that attempted to cast doubt on the deleterious health effects of tobacco use or the benefits of immunization for individuals and society....When

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science denialism goes unchallenged, each instance not only impacts that specific area of science, but serves to undermine all of science, with dramatic and harmful effects.¹

As the editorial indicates, the range of scientific topics threatened by disinformation is broad, and the 2020 coronavirus pandemic quickly became subject to the same threats, ranging from inaccurate, even dangerous, speculation issued by the White House² to frank scams designed to bilk a nervous public out of its money.³

When confronting such misinformation, is it sufficient for scientists simply to remind the public that science does not recognize “alternative facts” and designates them as “errors”? We think not. When confronting willful misinformation, it is important to be clear about the objectives of those who are inventing and promulgating “alternative facts” in the current political climate. Those responsible are not seeking to engage the public in abstruse and nuanced discussions about epistemology. Their intent, rather, is to delegitimize valid science, to obfuscate the issues at hand, and to confuse a public that has low scientific literacy.^{4–6} To counter those efforts, the public needs to understand the often-malign motives of the individuals and entities responsible, and it needs the tools to distinguish valid information from sheer nonsense.

Motives for the invention and promulgation of “alternative facts” often have their roots in ideology—political, religious, economic, and otherwise. In trying to combat willful misinformation and “alternative facts,” therefore, one must do more than provide the correct information. The “deficit model” of improving science literacy by merely providing accurate content is known to be inadequate because scientific knowledge is linked to attitudes about science.⁵ The history of the evolution/creation controversy makes clear, for example, that scientists cannot simply “throw facts at the problem,” as Eugenie Scott, long-time director of the National Center for Science Education, often said, and the steady accumulation of evidence that supports descent with modification, including comparative genomic sequencing, has had little or no impact on creationists. Both of us have asked creationists to identify scientific evidence that would convince them of the validity of evolution. The unequivocal answer has been, “there is none.”

In the face of such intransigence, one must consider the best use of time, intellectual energy, and resources, and one must understand and address the ideologies that make its adherents embrace erroneous information and that leave them refractory to legitimate science. Further, one must be clear on the meaning of “ideology” itself, especially in the context of science-related controversies.

Throughout this paper, our definition of ideology will follow that of David Joravsky, developed in *The Lysenko Affair*,⁷ his detailed analysis of one of history's most notorious and

long-lived ideological attacks on the integrity of science. According to Joravsky:

When we call a belief “ideological,” we are saying at least three things about it: although it is unverified or unverifiable, it is accepted as verified by a particular group, because it performs social functions for that group. “Group” is used loosely to indicate such aggregations as parties, professions, classes, or nations. “Because” is also used loosely, to indicate a functional correlation rather than a strictly causal connection between acceptance of a belief and other social processes.⁷

The intent of the several examples that follow is to demonstrate the pattern of willful ignorance and duplicity that underlies assaults on the integrity of science driven by ideology. There are other examples, of course, but those we have chosen have their roots in the abuse of biology and biomedicine. For each topic we review briefly the underlying science, falsehoods promulgated by the abusers, intended audience(s), mechanisms for distribution, underlying ideologies, damage, and potential repair.

2 | CREATIONISM

Perhaps no issue at the interface of biology and American society has the staying power and pervasive cultural reach of creationism and its factual and ideological conflicts with evolution theory. The conflicts derive largely from the unending growth of scientific and technological knowledge that contradicts the pleasant creationist fictions of Judeo-Christian scripture and their accounts of the origin of the universe and life on earth.

Readers of this journal know that evolutionary biology and its related disciplines such as geology posit an ancient age for the universe, our planet, and its biota. Evolution also demonstrates the relatedness of all species through descent with modification and the appearance of *H. sapiens* as a product of the same natural processes that produced all other life on earth. Charles Darwin established the mutability of species and the centrality of natural selection in the generation of earth's biodiversity and in the appearance of design in living things.^{8,9}

Although it is not monolithic – there are varieties of creationism – the creationist belief system is rooted in a broad, interrelated network of falsehoods that challenge virtually all assumptions of evolution theory and seek to affirm scriptural accounts of life's origin and diversity. The Genesis account of creation is, according to its adherents, the true and inspired word of God. Creationist literature asserts that the universe

and life on earth are anything but ancient; young-earth creationists have settled on roughly 6000 years. Species are said to be immutable and were specially created by a supernatural entity, the God of Judeo-Christian scripture. Intelligent design, the most recent putatively scientific iteration of creationism, leaves the designer unnamed so as to escape legal sanction in court cases that adjudicate creationism's religious intent. According to creationists, *H. sapiens* was created by God in his image. Furthermore, the fit of a species to its niche is claimed to be evidence of an intelligent designer, not the result of cumulative, iterative selection acting on naturally occurring inherited variation.

Creationism's underlying ideology is a powerful and toxic blend of religion and social engineering, performing social functions for those who insist on the validity and authority of revealed knowledge and those with a commitment to a religious foundation for the basic structure of society, including governance. The relentless drive to insert creationism into public schools reflects the desire of its adherents to ensure that public education reflects sectarian principles.^{10,11}

A secondary motivation, if not precisely an ideology in the Joravsky sense of the term, is greed. Individuals and entities whose educational materials promote creationist perspectives, for example, stand to profit from adoption of those materials by religious institutions or by public schools whose administrations support creationist perspectives in the curriculum. Similarly, those who run creationist theme parks such as the Ark Encounter and the Creation Museum, both in Kentucky, derive revenue from those attractions,¹² notwithstanding their scientific bankruptcy.

Intended audiences for creationism are expansive and reflect the underlying ideology. The general public, students, and teachers, for example, are targets of creationist content that seeks to support the validity and acceptance of the movement's underlying religious perspectives. On the other hand, creationists often target school boards, state legislatures, and the courts at all levels in their continuing, but largely unsuccessful efforts to secure political and legal sanctions for the inclusion of creationist content in public institutions.

Distribution of creationist ideology occurs through well-established religious institutions, especially fundamentalist Christian churches in the United States, and through their associated print and electronic media. In Islamic countries such as Turkey, creationist textbooks have reflected the perspectives of leading American creationist organizations and have enjoyed support of the national government,¹³ in this case with the intent of weakening long-standing public support for a secular society and government.

Creationist organizations in the U.S., such as Answers in Genesis and the Discovery Institute, produce "research" that purports to demonstrate the scientific validity of creationism, though the relevant work products rarely if ever find their way into legitimate, peer-reviewed scientific journals. The

aggrieved authors claim discipline-wide conspiracies on the part of scientists to bar creationist "research" from the scientific literature, a charge that itself performs a social function by bolstering the assertion that religious freedom is under attack by a secular society.

The mainstream media often has been complicit in the promulgation of creationist views by its insistence on "presenting both sides of the evolution/creationism controversy," a classic example of the false equivalence of some competing ideas. In reality, there are not two equal sides of this issue; there is science and there is pseudoscience and mysticism.

Creationist propaganda calls the cadence on a march toward ignorance for thousands of members of the adult public and for thousands of students who are exposed to mysticism masquerading as science. This assault on scientific integrity damages the public's understanding of biology in particular. It is, of course, possible to teach biology without addressing evolution—it happens all the time¹⁴—but it is not possible to understand biology if one does not realize that evolution is the central organizing concept of the entire discipline.¹⁵

Beyond biology, creationist propaganda damages science in general in at least three ways. First, creationists assert repeatedly that "evolution is only a theory",¹⁶ a claim that reduces a theory to little more than an ephemeral guess, when science actually views a theory as a compelling conceptual framework that explains and organizes a large body of observations and experimental results. Indeed, "theories are the end points of science",¹⁷ not the speculative beginnings. Second, creationism begins with a set of conclusions and acknowledges only data that support them, a perversion of deductive reasoning. Science, by contrast, relies on a combination of (honest) deductive processes, which use questions and hypothesis-testing to go where the data lead, even if the destination is not what one had hoped, and inductive processes. Indeed, Darwin's work was itself a monument to the power of inductive reasoning as he collected detailed observations over decades until he was able to shape them into a general theory, arguably the most impressive act of synthetic thinking in the history of biology. Third, the use of political and legislative tactics to compel inclusion of creationism in the public-school curriculum circumvents the standard processes by which scientific content is vetted, accepted as part of the corpus of scientific knowledge, and, ultimately, incorporated into science education.

Finally, creationism does serious damage to secular societies and governance by seeking to overturn the underlying assumptions of separation of church and state, and to religion by forcing it to reject overwhelming scientific evidence and to adhere to patently erroneous—even ridiculous—propositions to explain the history and nature of life on earth.

Repair of the damage to science and society done by creationism is problematic given that surveys show public attitudes toward evolution have remained virtually unchanged

for decades.¹⁸ About half of the American public, for example, still accepts that all life on earth was created withing the last 10,000 years by a supernatural entity and has remained unchanged since that time. Damage control, especially in the United States, may be the only real option for science and scientists because, as Gary Wills¹⁹ has written, creationism will never disappear because “the Bible will never stop being the central book of Western civilization.”

Scientists and science educators who have dealt with the leaders of the creationist movement for many years know that it generally is pointless to argue with them; they are essentially impervious to scientific data and to reason. The better use of time and resources is to determine where these leaders are attempting to influence policies—educational, political, legal—and to meet the battle there. The law, for example, clearly is on the side of science,²⁰ and one should use it to blunt attempts to insert religious dogma into the science curriculum.

Too often, working scientists fail to take creationist efforts seriously, dismissing them as so absurd as to be unworthy of attention. History shows that view to be dangerously mistaken, and scientists should be willing to help oppose any attempts to insert creationist dogma into science education.

One should not, however, tackle these issues without substantive, experienced assistance. The National Center for Science Education (<https://ncse.ngo/>) is a very good place to start when looking for such help. Furthermore, scientists, no matter how well versed in evolution theory, should resist invitations to debate creationists. Such events are not really debates—creationists are unconstrained by the truth—but rather performances by creationist hucksters. A classic example of the willful perversion of science in such events is the claim that the second law of thermodynamics precludes evolution. That assertion was standard debate fare for the late Duane Gish, former director of the oxymoronic Institute for Creation Research. Gish, who held a PhD in biochemistry from University of California, Berkeley, clearly knew better, but he perpetuated the lie nonetheless before lay audiences.

There still is benefit and hope in dealing with students, some of whom have been sold the false notion that they must choose between evolution and their faith. Experienced educators who are knowledgeable in biology and scripture can help guide such students through this challenge, but that skill requires more than an understanding of evolution; it requires as well a deep understanding of the social functions creationism performs for the believer.

3 | SMOKING IS HARMLESS

Tobacco has a long history in America, beginning with its cultivation by Native Americans, but the commercialization of tobacco by early British colonists—and the profits

it generated—would provide, centuries later, an incentive for the abuse of science using sophisticated methods that now serve as a playbook for other industries and ideologies. Despite tobacco's pre-Revolutionary origins as a commodity, it was not until the early twentieth century that cigarettes replaced chewing tobacco as the major consumer tobacco product. Before long, rapidly increasing lung cancer diagnoses, which had been rare, began to raise concerns about the harmful effects of smoking.²¹

Studies from the 1920s through the 1940s linked smoking with lung cancer, but these had been retrospective and relied heavily on smokers' self-reported—and often unreliable—use of cigarettes, which allowed tobacco companies to criticize any potential cause and effect relationship. The results of the first large prospective study were published in an article in the *Journal of the American Medical Association* in 1954, which demonstrated significant increases in deaths among cigarette smokers due to cancer and heart disease.²² The authors wrote that “... we are of the opinion that the associations found between regular cigarette smoking and death rates from diseases of the coronary arteries and between regular cigarette smoking and death rates from lung cancer reflect cause and effect relationships.”

Additional studies supported those results, and now we know a great deal more about both the hazards of tobacco use and the mechanisms by which those harms are effected. There are more than 7000 chemicals in smoked tobacco, hundreds of which are harmful and at least 69 of which are carcinogenic. The harmful effects occur when cells absorb these chemicals, which then damage DNA and disrupt normal function. The changes can contribute not only to cardiovascular disease and cancer but to a variety of other diseases, such as immune system disorders.²³ Smoking during pregnancy is a major contributor to low-birth weight babies and preterm births.²⁴

Tobacco companies, rather than respecting the emerging science, were already manipulating it toward ends that would compromise public health. According to court rulings in the landmark trial of “Big Tobacco,” nicotine levels had been manipulated in cigarettes since at least 1954 to encourage smokers to smoke more.²⁵ Leaders of the major companies lied about this fact for decades, including in hearings before Congress.²⁶ As far back as 1964, the Surgeon General of the U.S. linked cigarette smoking and disease, and tobacco companies lied about this as well even when their own research showed it to be true. Companies also used false advertising to promote low-tar cigarettes as less harmful than regular cigarettes, a tactic specially designed for older smokers to prevent them from quitting.²⁷ Older, current smokers, of course, were not the only target audience for tobacco companies. R.J. Reynolds' egregious behavior in cultivating youth smokers through its “Joe Camel” advertising campaign has been well documented, and in 1997, after a run of nine years,

the campaign was ruled by the Federal Trade Commission to have violated federal law. According to the FTC, “after the campaign began the percentage of kids who smoked Camels became larger than the percentage of adults who smoked Camels.”²⁸

The distribution of Big Tobacco's messages to promote smoking or to deny its harms were not limited to traditional advertising, such as print ads and event sponsorships. In late 1953, working through leading a public relations agency, Hill and Knowlton, Big Tobacco created an industry-sponsored research organization, the Tobacco Industry Research Committee (TIRC), that was promoted as independent but was, in fact, wholly controlled by the industry.²⁹ Similar to the organizations that would later promote creation science and intelligent design, TIRC worked to find data in support of a conclusion, in this case the conclusion that smoking was not harmful. One way this was accomplished was by recruiting prominent scientists as leaders, funding scientists who were skeptical about the emerging health consensus, and then using their results in counter-messaging.³⁰ Industry-funded research then, as now, presents potential conflicts of interest, and not all scientists are equally sensitive to, or respectful of, such conflicts. Another goal of TIRC-funded projects was to undermine mainstream research studies that did not support conclusions favored by TIRC. Common tactics included highlighting flaws in methodology or gaps in understanding the mechanisms of cancer,²⁹ which were later adapted by creationists (e.g., playing up “gaps” in transitional fossils). According to Brandt,²⁹ “The TIRC marks one of the most intensive efforts by an industry to derail independent science in modern history.”

The ultimate motive for these efforts at scientific obfuscation was not a religious or social ideology as it is for creationists, which, though misguided, at least has the merit of sincerity. The motive here is rank profit, even at the expense of tobacco customers' life and health, but the false-science “belief system” of Big Tobacco still satisfies Joravsky's definition of ideology. Their science is wrong (i.e., unverified); it is accepted as verified by tobacco executives and presumably some smokers; and it performs a social function, for example justifying an economic system that employs thousands. Profit may be the ultimate motive for the tobacco industry, but the cynical, proximate means to that end was far more sophisticated than creationists' appeal to biblical literalism. According to Brandt:

“Hill & Knowlton [the public relations agency] had successfully produced uncertainty in the face of a powerful scientific consensus. So long as this uncertainty could be maintained, so long as the industry could claim “not proven,” it would be positioned to fight any attempts to assert regulatory authority over the industry. Without their claims of no proof and doubt, the companies would be highly vulnerable in two crucial venues: regulatory politics and litigation.”²⁹

Eventually scientific proof—achieved honestly—overwhelmed the disreputable science and doubt suffered a serious, but perhaps not fatal, blow. As the tide turned against smoking, the tobacco industry faced both greater regulatory control and lawsuits won by plaintiffs. The damage, however, had been done. Millions of American smokers are addicted to nicotine, and the harms caused by smoking are by now familiar. Even today, after sharp drops in the number of smokers, an estimated 480,000 people die annually from cigarettes in the U.S. More than 90 percent of lung cancer and 80 percent of chronic obstructive pulmonary disease is caused by smoking.³¹ Smoking is also estimated to cost the U.S. \$170 billion per year in direct medical costs, and \$300 billion overall.³²

Public health officials have been trying for decades to reduce the health and economic toll of smoking by supporting campaigns to help current smokers quit and to prevent smoking in the young. Given that 95 percent of tobacco smokers began before they were age 21, the most-effective way to reduce harm is to prevent the development of a new generation of smokers.³³

Unfortunately, we now see some of the same Big Tobacco tactics being used to raise doubts about the potential harms of e-cigarettes, which are essentially nicotine-delivery devices. Juul, the largest of the e-cigarette companies, is now owned in large part by Altria, the parent company of Philip Morris, and Vuse is owned by Reynolds American. These Big Tobacco players have an obvious interest in maintaining, and growing, the pool of people addicted to nicotine, and claims that e-cigarettes are intended primarily to help adults quit smoking are undercut by the companies' marketing.

Indeed, regulators are alarmed by the popularity of vaping among minors, which was driven largely by first-wave products with fruit and candy flavors that are appealing to children. E-cigarette use jumped 78 percent among high schoolers and 48 percent among middle-schoolers in just one year, from 2017 to 2018. In a statement of concern from the Food and Drug Administration, then-commissioner Scott Gottlieb outlined steps he intended to take to prevent the use of e-cigarettes by children.³³ Predictably, lobbyists for tobacco companies, including Altria and Reynolds American, have aligned against legislation to regulate and tax e-cigarettes.³⁴

It still is too early to tell whether e-cigarette companies will attempt to corrupt science in the systematic ways that tobacco companies used to promote smoking. Scientists, public health advocates, and educators, however, should be prepared to counter such disinformation campaigns. K-12 education, public and private, must do a better job teaching the methods and nature of science, not just its content, but long lag times and an ever-increasing number of important science issues currently being undermined (e.g., anti-vaxx, climate change) suggest this will not be sufficient. Efforts should include enlisting the media, traditional and social, to help educate the public about the differences between honest science and the

intellectually dishonest “science” peddled by those with alternative motives. Money from pro-science philanthropists to support such efforts and promotion by key influencers may help level the playing field.

4 | FOLLOWING A COMMON PLAYBOOK

Creationism and the hoax of harmless smoking are hardly the only examples of science corrupted in the service of ideologies unrelated to science. With some variation, the tactics used so successfully by creationists and Big Tobacco have been adopted and used by other groups with agendas that range from medicine to the environment. The recent polarization of American politics and society, the denigration of expertise as elitist, and the media's tendency to provide legitimizing, “both sides” coverage of issues, even when undeserved, seem only to have exacerbated this problem.

Opioids provide an interesting example where sloppy scholarship, dishonest marketing, the evolving practice of medicine, the co-opting of scientific and medical leadership, and greed combined to create an addiction epidemic that has roiled the country for more than two decades. It all began in 1980 with a one-paragraph letter by Jane Porter and Hershel Jick in the *New England Journal of Medicine* that made a simple observation: based on hospital records, narcotic addiction was rare in patients with no history of addiction. This was not a formal study, and there was no information about the narcotics being used or their dosage, frequency, or duration.³⁵ Over time other researchers cited this letter without context or qualification and, in some cases, later apologized for having never read it. An important missing caveat was that Porter and Jick's observation was based on hospitalized patients, not outpatients being prescribed drugs for self-administration.³⁶

Unfortunately, this letter ended up serving two masters: a drug industry energized by Madison Avenue-style marketing and a medical community in the midst of a changing paradigm, namely that pain was being undertreated and should be viewed as a “fifth vital sign”.³⁶ By the mid-1990s, disreputable physicians, many of whom had been sanctioned, began opening pill mills across Appalachia. At the same time, Purdue Pharma developed OxyContin as a time-release drug and promoted it as a less-addictive painkiller in spite of having provided no supporting data to the FDA. They falsely claimed that the narcotic was harder to extract (and thus abuse) than other painkillers when their own studies indicated that 68 percent of the oxycodone could be extracted when crushed and liquified. Phony graphs were also used in marketing to give the impression that the plasma levels of oxycodone were steady when, in fact, they spiked in the users' blood and then crashed. Purdue Pharma ultimately was called to account, reminiscent of Big Tobacco, when three

executives pled guilty to misdemeanor false branding and paid a \$634M fine.^{36,37}

If manipulated and fraudulent science were not enough, the opioid industry also followed the Big Tobacco playbook by cultivating physicians, institutions, and organizations willing to support pharma's message that opioids were safe and non-addictive. As alleged in a lawsuit filed by the Massachusetts Attorney General in 2019, “Purdue hired the most prolific opioid prescribers in Massachusetts as spokesmen to promote its drugs to other doctors. Purdue funded the Massachusetts General Hospital Purdue Pharma Pain Program and an entire degree program at Tufts University to influence Massachusetts doctors to use its drugs.”³⁸ Tufts even promoted a Purdue Pharma employee to Adjunct Associate Professor in 2011.³⁹

Leading advocacy groups and professional societies also played a role by lobbying on behalf of the opioid industry's marketing and prescribing practices while accepting their donations. In 2016, the Centers for Disease Control and Prevention (CDC) issued guidelines for primary care providers who prescribe narcotics for non-cancer chronic pain. Those guidelines encouraged the preferential use of non-opioid pharmacologic agents, highlighted the risks of addiction, and identified the drugs most likely to cause harm and the patients most at risk.⁴⁰ The drug industry did not approve. According to a report from the U.S. Senate's Homeland Security and Governmental Affairs Committee (HSGAC), The American Pain Society, the U.S. Pain Foundation, the Academy of Integrative Pain Management, and the American Academy of Pain Management accepted more than \$6M from narcotics manufacturers from 2012-2017.⁴¹ Altogether the report identifies more than a dozen groups receiving almost \$9M from five manufacturers. What did all this largess buy the industry? In part, active opposition to the development and issuance of the CDC guidelines by a majority of the groups identified in the HSGAC report. According to the report: “Many of the groups discussed in this report have amplified or issued messages that reinforce industry efforts to promote opioid prescription and use, including guidelines and policies minimizing the risk of addiction and promoting opioids for chronic pain”.⁴¹

The internet, celebrity culture, and targeted marketing through social media such as Facebook make it easier to spread anti-science messages to receptive groups than in decades past. Andrew Wakefield's reputation in the scientific community may be in shambles thanks to his fraudulent research claiming a link between autism and the measles, mumps, and rubella vaccine, but his public profile remains high and he is an unfairly maligned hero to the anti-vaxx community.⁴² The TV personality Jenny McCarthy runs a non-profit called Generation Rescue that continues to provide a forum for Wakefield's dishonest claims,⁴³ which have caused real harm in the form of depressed vaccination rates in

Great Britain and the United States.⁴⁴ What was Wakefield's motivation? The now-familiar motivator of greed, in this case an elaborate scheme to get rich from lawsuits generated by vaccine fears.⁴⁵

Today there are also organizations, largely on the political right, that exist solely or in part to cast doubt on science that does not comport with their ideology of opposition to regulation. Not surprisingly this opposition often provides a side benefit: bolstering the economics of specific industries. Some of these organizations are respected think tanks with political philosophies strongly favoring free enterprise, such as the American Enterprise Institute and the Hoover Institution, which sometimes provide a forum for climate-change skeptics.^{46,47} Others identify themselves as grassroots organizations while functioning primarily as lobbying groups for fossil fuel and other industries, such as the Koch-funded Americans for Prosperity.

The non-profit Association of American Physicians and Surgeons is a particularly interesting example. Through its publishing arm, the *Journal of American Physicians and Surgeons*, this trade association provides a forum for commentary about free-market medicine (often not evidence-based), polemics against regulation in medicine, and sometimes fringe science that has nothing to do with medicine but does align with its overall anti-regulation ideology. Articles have cast doubt, for example, on the existence of climate change as a global threat, or trumpeted its benefits.^{48,49} Others have questioned HIV as the cause of AIDS⁵⁰ and offered a sympathetic airing of anti-vaxxers' fringe view that autism is linked to vaccines, despite evidence to the contrary, even providing a forum for the discredited Andrew Wakefield.^{51–53}

5 | CONCLUSION

Intentional perversion of science in the service of ideology makes clear the validity of the following assertion by neuroscientist and philosopher Sam Harris:

“The core of science is not controlled experiment or mathematical modeling; it is intellectual honesty. It is time we acknowledge a basic feature of human discourse: when considering the truth of a proposition, one is either engaged in an honest appraisal of the evidence and logical arguments, or one isn't”.⁵⁴

Intellectual honesty is the heart of all scholarship, irrespective of the discipline, and the translation of scholarship for the public should honor it, not debase it in the interest of ideology or greed. A public that has low scientific literacy and numeracy now faces a growing wave of misinformation, and that public will struggle to separate valid science from nonsense.^{4–6} These trends bode ill for public awareness and acceptance of legitimate science and serve as an injunction for individual scientists and the scientific community to push

back aggressively against all attempts to misrepresent the methods and results of sound research.

Strategies to counter the abuse of science vary and depend on the nature and context of the abuse in question. Some strategies may be specific and highly targeted, while others may be more far-reaching. For example, one of us (JDM) threatened legal action against his children's public-school district if a creationist candidate for the board of education made good on his promise to mandate the teaching of creationism in the biology curriculum. On a broader scale, an organization both of us have worked for, the Biological Sciences Curriculum Study, assisted in a number of evolution/creationism court cases whose decisions had implications at state and national levels.

Whatever the context, prevention of and opposition to the abuse of science begin with the integrity of individual scientists and the scientific community at large, as invoked by Thomas Huxley and Sam Harris. Scientists should model that integrity in their work and should discuss it explicitly with their trainees—the next generation of scientists. Perhaps it is time as well to consider a complete ban on industry-funded research for individual scientists working in academia and other non-industry settings to remove incentives for bias in reporting of results and to help ensure the public that research agendas are not determined by corporate interests. Science education for the general public—formal and informal—should emphasize the expectation of intellectual honesty in its treatment of the nature and methods of science. It serves little purpose to impress upon students the steps in “the scientific method” if those steps do not reflect a commitment to ethical conduct.

REFERENCES

1. Finazzo S, Melton B, Cowles E, et al. NABT: Teaching Biology in the Age of “Alternatives Facts”. *Am Biol Teach*. 2017;79(6):433.
2. Rogers K, Hauser C, Yuhas A, Haberman M. *Trump's suggestion that disinfectants could be used to treat coronavirus prompts aggressive pushback*. New York Times, 2020, April 24, page 1A.
3. Roberts P, Brunner J, Malone P. “Hundreds of millions of dollars” lost in Washington to unemployment fraud amid coronavirus joblessness surge. *Seattle Times*, 2020, May 21.
4. Miller JD. Public understanding of and attitudes toward scientific research: What we know and what we need to know. *Public Underst Sci*. 2004;13(3):273-294.
5. Allum N, Sturgis P, Tabourazi D, Brunton-Smith I. Science knowledge and attitudes across cultures: a meta-analysis. *Public Underst Sci*. 2008;17(1):35-54.
6. Pew Research Center. *A look at what the public knows and does not know about science*; 2015. <https://www.pewresearch.org/science/2015/09/10/what-the-public-knows-and-does-not-know-about-science/>. Accessed June 18, 2020.
7. Joravsky D. *The Lysenko Affair*. Chicago: University of Chicago Press; 1970.
8. Darwin C. *On the Origin of Species by Means of Natural Selection*. A facsimile of the first edition, 1859. Cambridge, MA: Harvard University Press; 1964.

9. Ruse M, Travers J. *Evolution: The First Four Billion Years*. Cambridge, MA: Harvard/Belknap Press; 2009.
10. Jacoby S. *The Age of American Unreason*. New York: Pantheon Books; 2008.
11. Stewart K. *The Good News Club: The Christian Right's Stealth Assault on America's Children*. Philadelphia: Perseus Books; 2012.
12. Eigelbach K. *See how Answers in Genesis finances its Creation Museum and publishing operation*; 2016. <https://www.wcpo.com/news/insider/see-how-answers-in-genesis-finances-its-creation-museum-and-publishing-operation>. Accessed May 28, 2020.
13. Edis T. Cloning creationism in Turkey. *Reports of the National Center for Science Education*, 19(6); 1999. <https://ncse.ngo/cloning-creationism-turkey>. Accessed June 12, 2020.
14. Apodaca M, McInerney JD, Sala OE, Katina L, Crisci JV. A concept map of evolutionary biology to promote meaningful learning in biology. *Am Biol Teach*. 2019;81(2):79-87.
15. Dobzhansky TH. Nothing in biology makes sense except in the light of evolution. *Am Biol Teach*. 1973;35(3):125-129.
16. National Academy of Sciences and Institute of Medicine. *Science, evolution, and creationism*. Washington, DC: National Academies Press; 2008.
17. National Academy of Sciences. *Science and creationism: A View from the National Academy of Sciences*. Washington, DC: National Academies Press; 1998.
18. Masci P. *Darwin in America: The evolution debate in the United States*. Pew Research Center: Religion & Public Life, 2019, February 6. <https://www.pewforum.org/essay/darwin-in-america/>. Accessed May 24, 2020.
19. Wills G. *Under God: Religion and American Politics*. New York: Simon & Schuster; 1990.
20. Matsumura M, Mead L. *Ten major court cases about evolution and creationism*. National Center for Science Education; 2016. <https://ncse.ngo/ten-major-court-cases-about-evolution-and-creationism>. Accessed 28 May 2020.
21. Mendes E. *The Study That Helped Spur the U.S. Stop-Smoking Movement*. American Cancer Society, <https://www.cancer.org/lates-t-news/the-study-that-helped-spur-the-us-stop-smoking-movement.html>. Accessed May 3, 2020.
22. Hammond EC, Horn D. The relationship between human smoking habits and death rates: a follow-up study of 187,766 men. *J Am Med Assoc*. 1954;155(15):1316-1328.
23. Centers for Disease Control and Prevention. *How tobacco smoke causes disease: The biology and behavioral basis for smoking-attributable disease: A Report of the Surgeon General*. National Center for Chronic Disease Prevention and Health Promotion (U.S.); Office on Smoking and Health; 2010.
24. Pereira PP, Da Mata FA, Figueiredo AC, de Andrade KR, Pereira MG. Maternal active smoking during pregnancy and low birth weight in the americas: a systematic review and meta-analysis. *Nicotine Tob Res*. 2017;19(5):497-505.
25. United States v. Philip Morris USA Inc, et al. 449 F. Supp. 2d 1, United States District Court for the District of Columbia; 2006. Docket Number: CIV.A. 99-2496(GK).
26. Truth Initiative, <https://truthinitiative.org/research-resources/tobacco-prevention-efforts/5-ways-tobacco-companies-lied-about-dangers-smoking>. Accessed April 29, 2020.
27. Cataldo JK, Malone RE. False promises: The tobacco industry, "low-tar" cigarettes, and older smokers. *J Am Geriatr Soc*. 2008;56(9):1716-1723.
28. Federal Trade Commission, File No. P884517. Press release: Camel Advertising Campaign Violates Federal Law, FTC Says; Agency Charges R.J. Reynolds With Causing Substantial Injury to the Health and Safety of Children and Adolescents Under 18, May 28, 1997, <https://www.ftc.gov/news-events/press-releases/1997/05/joe-camel-advertising-campaign-violates-federal-law-ftc-says>.
29. Brandt AM. Inventing conflicts of interest: a history of tobacco industry tactics. *Am J Public Health*. 2012;102(1):63-71.
30. Proctor RN. Everyone knew but no one had proof: tobacco industry use of medical history experts in US courts, 1990-2002. *Tob Control*. 2006;15(suppl 4):iv117-iv125.
31. Centers for Disease Control and Prevention. *The Health Consequences of Smoking—50 Years of Progress: A Report of the Surgeon General*. Atlanta: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014.
32. *Federal Trade Commission Cigarette Report for 2017*. Washington: Federal Trade Commission; 2019. https://www.ftc.gov/system/files/documents/reports/federal-trade-commission-cigarette-report-2017-federal-trade-commission-smokeless-tobacco-report/ftc_cigarette_report_2017.pdf.
33. FDA Statement. Statement from FDA Commissioner Scott Gottlieb, M.D., on proposed new steps to protect youth by preventing access to flavored tobacco products and banning menthol in cigarettes. Nov. 15, 2018. <https://www.fda.gov/news-events/press-announcements/statement-fda-commissioner-scott-gottlieb-md-proposed-new-steps-protect-youth-preventing-access>. Accessed May 5, 2020.
34. Center for Responsive Politics. *E-cigarettes*; 2019. <https://www.opensecrets.org/news/issues/e-cigarettes>. Accessed May 10, 2020.
35. Porter J, Hick H. Addiction rare in patients treated with narcotics. *N Engl J Med*. 1980;302(2):123.
36. Quinones S. *Dreamland: The True Tale of America's Opiate Epidemic*. New York: Bloomsbury Press; 2015.
37. Van Zee A. The promotion and marketing of oxycontin: commercial triumph, public health tragedy. *Am J Pub Health*. 2009;99(2):221-227.
38. Commonwealth of Massachusetts v. Purdue Pharma, et al. Superior Court. C.A. No. 1884-cv-01808 (BLS2); 2019.
39. Union of Concerned Scientists. Purdue Pharma's Use of Hospital, Academic Ties Helped Fuel Opioid Crisis. April 9, 2019. <https://www.ucsusa.org/resources/disinformation-playbook-purdue-pharma>. Accessed June 12, 2020.
40. Dowell D, Haegerich TM, Chou R. CDC Guideline for Prescribing Opioids for Chronic Pain — United States, 2016. *MMWR Recomm Rep*. 2016;65(No. RR-1):1-49. <https://doi.org/10.15585/mmwr.rr6501e1>.
41. Homeland Security and Governmental Affairs Committee, U.S. Senate. Fueling an Epidemic, Report Two: Exposing the Financial Ties Between Opioid Manufacturers and Third-Party Advocacy Groups; 2018. <https://www.hsgac.senate.gov/imo/media/doc/REPORT-Fueling%20an%20Epidemic-Exposing%20the%20Financial%20Ties%20Between%20Opioid%20Manufacturers%20and%20Third%20Party%20Advocacy%20Groups.pdf>. Accessed June 14, 2020.
42. Boseley S. How disgraced anti-vaxxer Andrew Wakefield was embraced by Trump's America. *The Guardian*. 18 July 2018.
43. Yasmin S. Anti-vaxxer Jenny McCarthy's autism summit peddles dangerous treatments, features discredited doctors. *Dallas News*, 27 September 2016.

44. Smith MJ, Ellenberg SS, Bell LM, Rubin DM. Media coverage of the measles-mumps-rubella vaccine and autism controversy and its relationship to MMR immunization rates in the United States. *Pediatrics*. 2008;121(4):e836-e843.
45. Deer B. How the vaccine crisis was meant to make money. *BMJ*. 2011;342:c5258.
46. Perry MJ. American Enterprise Institute blog post; 2020. <https://www.aei.org/carpe-diem/six-facts-about-the-non-problem-of-global-warming/>. Accessed May 13, 2020.
47. Epstein RA. A Climate Change Emergency? Defining Ideas. 2019. <https://www.hoover.org/research/life-planet-thunberg>.
48. Robinson AB, Robinson NE, Soon W. Environmental effects of increased atmospheric carbon dioxide. *J Am Phys Surg*. 2007;12(3):79-90.
49. Maccabee H. Direct health effects of climate change: an overview. *J Am Phys Surg*. 2010;15(2):38-41.
50. Miller DW. Fallacies in modern medicine: the HIV/AIDS hypothesis. *J Am Phys Surg*. 2015;20(1):18-19.
51. Miller NZ. Aluminum in childhood vaccines is unsafe. *J Am Phys Surg*. 2016;21(4):109-117.
52. Wakefield AJ. The sixth extinction: vaccine immunity and measles mutants in a virgin soil. *J Am Phys Surg*. 2019;24(3):77-84.
53. Centers for Disease Control and Prevention. National Center for Emerging and Zoonotic Infectious Diseases (NCEZID), Division of Healthcare Quality Promotion (DHQP); 2018. <https://www.cdc.gov/vaccinesafety/concerns/adjuvants.html>. Updated Oct. 24, 2018. Accessed May 1, 2020.
54. Harris S. *Letter to a Christian Nation*. New York: Alfred A. Knopf; 2006.

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