Threats to Science: Politicization, Misinformation, and Inequalities

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Abstract

Science is often considered the best available route to knowledge, and thus, essential for societal progress. Yet, contemporary science faces several challenges. These include politicization, misinformation, and inequalities. Druckman outlines each of these threats, detailing the ways in which they can undermine the optimal production and application of science. He provides an overview of various research agendas on each – as covered in this special issue. Without minimizing the seriousness posed by each threat, he also suggests that existing work provides reason for hope that the scientific enterprise can address these challenges and continue to improve societal well-being.

The scientific enterprise leads a precarious existence. It produces systematized knowledge that constitutes an unrivaled information source on which to base decisions. Yet, science also incentivizes criticism, cannot provide definitive proof, and is practiced by a relatively small, homogenous group of experts. These latter features make science vulnerable to threats that undermine its usefulness. These threats include the misappropriation of science for reasons orthogonal to the creation of knowledge (e.g., political motives), misinformation where inaccurate claims appear in the guise of science, and inequality where select and often vulnerable groups become disenfranchised. While these threats are not new, societal and technological trends in the twenty-first century have served as an accelerant. The experience of COVID-19 highlights this reality – it has been riddled with partisans misusing and misconstruing science, misinformation so pervasive that the pandemic was also labeled an infodemic, and vast inequities in illness, morbidity, and economic hardship. This volume offers a synthetic treatment of these three threats to science: politicization, misinformation, and inequality. It brings together leading scholars in each area who present empirically grounded discussions of major research agendas. The essays in each section also build upon one another to isolate the distinct nature of each threat, and, perhaps more importantly, to offer insights on what steps can be taken in response. The hope is that readers are not left feeling deflated by overwhelming challenges, but rather are inspired by guidance on how to address threats to advancing science and improving societal well-being.

The COVID-19 Pandemic Illustrates Threats to Science

How the COVID-19 pandemic unfolded in the United States illustrates how politicization, misinformation, and inequalities threaten science. An October 2019 Johns Hopkins report concluded that the U.S. was relatively better prepared than every other nation to

deal with a pandemic in terms of prevention, detection, response, health care, risk environment etc. (The Global Health Security Index 2019). Yet, by September 2020 – only six months after cases first started surging – America accounted for more than 20 percent of all COVID-19 deaths despite accounting for only 4 percent of the world's population. Why did the U.S. perform so poorly when it came to saving lives? A large part of the answer concerns a failure to fully utilize science due to politicized belief systems, misinformation, and inequities.

Consider politicized belief systems. Perhaps more than any other country, COVID-19 polarized the U.S., dividing Democrats and Republicans at the elite (Fowler, Kettler, and Witt 2021; Lipsitz and Pop-Eleches 2020) and mass levels (Allcott et al. 2020; Druckman et al. 2021; Gadarian, Goodman, and Pepinsky 2021; Gollwitzer et al. 2020). This division was exacerbated by the 2020 presidential election and the concomitant challenges to democratic norms. In the summer of 2020, one study from Pew Research Center found that 77 percent of Americans believed that the nation had grown more divided since the arrival of COVID-19, a response 2.8 standard deviations higher than the mean of the other 13 nations in the study and 1.6 standard deviations higher than the second-highest nation, Spain (Dimock and Wike 2020). As a result of this division, politics, rather than science, drove many decisions about how to deal with the pandemic. This is a stark example of how politicization can lead to less-than-ideal scientific decision-making; at the same time, though, not all threats stemmed from politicization.

During COVID-19, other challenges emerged, such as variations in lived experiences that affected trust in scientific institutions and scientific recommendations. This, along with the circulation of misleading statements with no basis in scientific principles, created an environment ripe for misinformation, a second threat. Even before many knew of COVID-19, anti-vaccine activists were tweeting that the virus was a scam produced by eventual vaccine

manufacturers for profit (Cornwall 2020; Van Bavel et al. 2020, 464). Misinformation – while certainly not contained to the U.S. – was uniquely promulgated by U.S. leaders (i.e., President Trump) (Evanega et al. 2020). This led the public to develop misperceptions about the pandemic, which, in turn, negatively correlated with public health compliance and vaccine behavior (Roozenbeek et al. 2020).

Finally, the heterogeneity of the country in terms of social groups and economic inequities made the U.S. particularly vulnerable. The pandemic divided the country, leaving the well-off to create microcosm worlds shielded from first-hand visions of the pandemic's impact, while others were left vulnerable to the disease and in dire situations. For instance, early in the vaccine rollout, a 50-year-old White male doctor in the Northeast, earning more than $200,000, was seven times more likely to be vaccinated than a 45-year-old Black female nursing assistant in the South, earning less than $50,000 (Lazer et al. 2021). These types of economic and racial divides resurrect histories of unequal access to science (with systemic exclusion), and reflect the inequalities present in the production of science itself.

These three dynamics – politicization, misinformation, and inequality – threatened and, in many cases, undermined the effectiveness of science-based solutions in addressing the pandemic. This had disastrous consequences in the U.S. Alas, these threats extend beyond COVID-19 to the use of science in many domains across the world. Examples include climate change, energy production, stem-cell research, evolution, vaccines, genetically modified food, and more. The cultural authority long enjoyed by science no longer exists in an information ecosystem where anyone can claim expertise and share pseudoscience (Lupia 2013). Concomitant with this information evolution has been growing political polarization (Iyengar et al. 2019; McCarty 2019) and inequality (Horowitz et al. 2020). These trends pose threats to the widespread use of

science as a guide to decision-making. Put another way, politicization, misinformation, and inequality mean that science may not be used when making policy or individual decisions. Given the insights that science can provide, this means less than optimal behavior that can have catastrophic societal consequences.

Assessing Threats to Science

The issue contains distinct sections on politicization, misinformation, and inequality. Each includes five articles that offer a portrait of threats and antidotes. Some of their insights are surprising – for instance, the authors who write on politicization make clear that its effects are nuanced, as political inclinations compete with other considerations. The misinformation articles similarly introduce complexity to the conceptualization of scientific misinformation, how science itself contributes to it, and how interventions can play a role in addressing it. Inequality is obviously a thorny issue without easy fixes, but the articles in this section provide direction on taking essential steps towards a more equitable and inclusive science. The three sections of the issue intersect insofar as the threats themselves can work in concert – for instance, particular approaches to decision-making make people susceptible to misinformation that can exacerbate inequalities. Thus, an intervention in any of those domains can influence the others. I illustrate some of these connections by providing an overview of each of the sections.

Politicized Science?: Using Science Information in Making Decisions

The massive national investment in science is premised on the idea that it will prove useful. The American public largely shares this perspective. For example, in 2018, 92 percent of Americans agreed that science creates more opportunities for the next generation, while 84 percent agreed that the federal government should provide funds for scientific research. Also, a near majority of 44 percent expressed a "great deal of confidence" in the scientific community,

which has been a stable perception since 1973 (Khan et al. 2020). Despite these numbers, however, there has been growing concern that science has become politicized, meaning actors exploit the uncertainty inherent in science to pursue self-interested agendas (Oreskes and Conway 2010). The politicization of climate change is well documented, with financial and political interests leading individuals and groups to orchestrate large-scale misinformation campaigns (Cook and Pearce 2019). Such efforts can lead people to reject the science (Bolsen, Druckman, and Cook 2014; Bolsen and Druckman 2015; van der Linden 2015), and instead employ less systematic criteria in their decisions. In their meta-analysis, Hornsey et al. (2016) find that political orientations and worldviews overshadow other variables such as education and experiencing extreme weather events in explaining climate change beliefs. Other scientific issues, including evolution, fracking, gun ownership, and vaccines have been politicized (Kahan 2015); of course, COVID-19 reactions also epitomized politicization, with partisanship becoming such a driver of health decisions that it was "pernicious enough to threaten the health of citizens" (Gollwitzer et al. 2020, 1195; also see Allcott et al. 2020; Clinton et al. 2021; Druckman et al. 2021).

An additional concern involves an emergent asymmetry in trust in science, with a decline among conservatives (Gauchat 2012; although see Lee 2021). These types of dynamics have led scientists to express grave concern about the authority of science. For instance, in 2010, *Nature* published an editorial stating, "there is a growing anti-science streak… that could have tangible societal and political impacts" (2010, 133). In 2019, the forward to Naomi Oreskes's book *Why Trust Science*? begins with the message, "Science confronts a public crisis of trust" (Macedo 2019, 1).

This would constitute a fundamental threat to science – if people do not rely on science due to politicization, or if they do not trust it, then incentives to invest in science may wane. Yet, there is the puzzle of reconciling the narrative of science under siege with the supportive poll numbers presented earlier. This accentuates the need to step back and consider how individuals make decisions that involve scientific information. This will not only reveal whether politicizing forces overwhelm other considerations, but also clarify the role of other factors that affect the authority and usefulness of science. The first section of the volume includes five essays that investigate – across issues – how people use scientific information.

First, Lewandowsky and his colleagues explore the potential conflict between people's worldviews and scientific evidence. They detail how these conflicts can lead to science denial that includes fake experts, logical fallacies, impossible expectations, cherry-picking evidence, and conspiracy theories. These techniques constitute a threat, a la the above politicization discussion. However, Lewandowsky et al. make clear that this does not mean worldviews should be put aside when considering science-based decision-making. In fact, they explain – using examples from COVID-19 – that a better response to science denial requires understanding people's lived experiences. For instance, denying the danger of COVID-19 may serve as an adaptive strategy for those who would otherwise be in untenable psychological situations (e.g., economically vulnerable frontline workers). Therefore, interventions that encourage precautionary measures among such populations will not be successful unless they recognize the unique challenges these individuals face. To be clear, the authors are not apologists for denialist tactics; rather, they argue that the motivation for such tactics is often not political, but is instead reflective of circumstance. As such, scientific trust requires acknowledging people's life situations and not presuming a political agenda.

In the second essay in this section, Stark and his colleagues look at politicization from a distinct angle, asking whether people rely on heuristics such as partisan cues when they form their opinions on politicized policies, or whether they engage in more systematic assessments of information. They explore this question using the Affordable Care Act, a policy for which the parties clearly staked out positions and so one might expect partisan group affiliations to dominate. They present a novel model of attitude formation that predicts people form policy opinions based on a person's certainty about whether a provision is in the legislation (e.g., fines for the uninsured, drug rebates for seniors), whether they favor or oppose the provision, and the importance of the provision to them personally. They find strong support for their model; while partisanship matters, certainty, favorability, and importance play a sizable role in shaping overall support. This suggests that, even on science relevant issues where parties polarize, citizens will still engage with and assess information, rather than simply taking party cues. This implies that information quality and its impact on people's factual beliefs remain important, even when science is politicized – a point to which I return in the next section on misinformation.

Hegland and colleagues continue this line of inquiry in the section's third essay, focusing on the polarization of COVID-19. They point out that on other issues – such as climate change – polarization took time, but with COVID-19, partisan polarization took hold almost immediately. They seek to understand the underlying factors, focusing on trust in information from health officials, the conservative media ecosystem that minimized the threat of COVID-19, and basic partisan social identity (with politicization affirming those identities). They use nearly weekly data from more than a year to track reactions to COVID-19 (e.g., concern, behaviors). They find that much of the partisan gap can be explained by variation in trust in health institutions; while they also find direct partisan effects, these substantially decline after the 2020 election. These

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findings accentuate that politicized science is more than just partisans simply taking sides –

rather, it may reflect how much partisans feel they can believe the science. It makes clear that

maintaining trust is fundamental for science to play a role in individual decision-making.

The first three papers provide a vital reminder that factors beyond partisanship can

threaten the use of science – including varied life experiences, informational content and beliefs,

and trust in institutions. Those who promote science must carefully consider the role of these

variables. Another tension concerns the extent to which science can and/or should be free of

moral value judgments (e.g., Douglas 2015; Suhay and Druckman 2015). This involves more

than the practice of science and includes the impact of moral values on the use of science. A

sizable literature reveals that moral framing can shape science relevant beliefs. For example,

Feinberg and Willer (2013) show that messages that frame environmental issues in terms of the

conservative values of purity and sanctity lead conservatives, who typically oppose

environmental legislation, to become more supportive – because the argument resonates with

their cherished values (Feinberg and Willer 2019; Wolsko, Ariceaga, and Seiden 2016). Voelkel

and his colleagues build on this literature in their paper. They focus on the issue of immigration,

where social science knowledge can be quite relevant, particularly concerning the positive

economic impact of legal immigration. In a set of three experiments, the authors find that an

argument about economic impact is persuasive – increasing support for legal immigration –

when joined with a moral framing emphasizing loyalty and patriotism (e.g., America's

prominent position owes much to immigrants, who helped drive productivity by working hard).

They also report that the loyalty frame alone stimulates support, albeit with marginal

significance, while the economic information alone does not. This suggests that fact based

(social) science information is enhanced in the presence of moral frames, and that the

information itself may not be vital for persuasion. Moreover, they find this to be the case across parties / ideologies, suggesting – as other papers in this collection do – that other factors matter independent of politicizing partisan dynamics.

As Voelkel and colleagues show, moral considerations and communications shape the impact of science; the final essay in this section, by Bayes, follows them by exploring a research agenda on a concept known as moral conviction and how it may aggravate people's tendencies to differentially respond to scientific information based on whether it supports their preferred position on a given social or policy issue. Moral conviction occurs when a person's position is not only their preferred position, but what they feel is the morally correct one. Drawing from and expanding on existing literature (e.g., Liu and Ditto 2013; Skitka et al. 2021), Bayes argues that people are more likely to misinterpret or disbelieve scientific information that does not support their moral convictions, and to lose respect for scientists and other scientific authorities that produce such information. As such, moral conviction poses a threat to science if, rather than fully engaging with one another on competing moral perspectives when considering science, citizens instead degrade and dismiss science that supports viewpoints other than their own

There is little doubt that politicization threatens the use of science – actors can undermine the relevance of scientific considerations in decision-making for reasons orthogonal to the quality of the science. This certainly occurs on some issues by partisan actors in pursuit of electoral, financial, and/or ideological agendas. While this threat has received substantial attention, it does not fully capture how individuals process science. The essays in this section, taken together, provide a much-needed introduction to other considerations that shape the role of science in opinion formation: lived experience, policy information (and possibly misinformation), trust in institutions, moral frames, and moral conviction. Individually, none of

these should be treated as a "threat" per se, but collectively, they reveal that the role of science is contingent on various non-science factors. For science to fulfill its full capacity in informing opinions, these distinct criteria require study, appreciation, and engagement. This is quite feasible, and the papers here provide superb guidance on how to ensure science reaches its full potential.

Misinformation

Misinformation is not new – indeed, a 1919 *Science* article on the Spanish flu discusses, with dismay, how some well-informed people believe discredited information (Soper 1919). Yet, the last decade has seen increasing concern about misinformation, particularly when people endorse false beliefs about objectively verifiable information – beliefs that the political advisor Kellyanne Conway famously called "alternative facts" (e.g., Grinberg et al. 2019; Jerit and Zhao 2020; Lazer et al. 2018). Such beliefs can have insidious consequences when they lead to misperceptions, which occur when people's beliefs about factual matters are not supported by evidence or expert opinion (Nyhan and Reifler 2010, 305). For instance, disagreement about basic facts (e.g., the state of the economy) can engender negative perceptions of political adversaries (Kennedy and Pronin 2008; Reeder et al. 2005), including the other side's favored media outlets (Arceneaux, Johnson, and Murphy 2012), which renders political compromise difficult.

Misinformation about science poses a distinct challenge. Science exists to provide systematic knowledge to improve decision-making (Levy et al. 2021; Scheufele and Krause 2019). Thus, misinformation, and the misperceptions that may follow, may lead people to no longer use science, even though it "is our best guide to developing factual understandings" (Dietz 2013, 14082). If people do not appropriately use science, investments in it become less essential. More

concretely, consider three consequences of misinformation. First, misinformation undermines the scientific community's ability to provide systematic knowledge to "help nonscientists make better decisions" (Lupia 2013, 14048). Second, inaccurate beliefs from misinformation can cause individuals to become worse off than when they were simply uninformed. When individuals form subjective attitudes from misperceptions, their decisions do not occur randomly, but become systematically and deleteriously skewed (Kuklinski et al. 2000, 792-793). Third, on the collective level, "misinformation may form the basis for political and societal decisions that run counter to a society's best interest" (Lewandowsky et al. 2012, 107). This is apparent when public attitudes and public policies diverge from the scientific consensus on topics such as climate change, genetically modified organisms (GMOs), or vaccines (Flynn, Nyhan, and Reifler 2017; Scheufele and Krause 2019).

The COVID-19 pandemic cast particular light on the threat of science misinformation. The World Health Organization (2021) has identified a COVID-19 infodemic, which entails "too much information including false or misleading information in digital and physical environments during a disease outbreak. It causes confusion and risk-taking behaviours that can harm health[…] An infodemic can intensify or lengthen outbreaks when people are unsure about what they need to do to protect their health and the health of people around them." In the case of COVID-19, science misinformation led people to ignore health advice, and to become hostile toward groups that people misattributed as being responsible for the pandemic (Van Bavel et al. 2020; also see Swire-Thompson and Lazer 2019).

The second section of this volume takes up the threat of science misinformation. Yet, even defining what "science misinformation" entails is tricky: the evidentiary standard is ambiguous because the scientific method never allows one to prove a hypothesis (i.e., there is not

a clear standard for what constitutes a "false belief"). Southwell and colleagues address the question of how to conceptualize and define scientific misinformation. The authors offer a definition that 1) specifies a clear baseline (i.e., relative to the best available scientific evidence, misinformation is information that counters statements by those who adhere to scientific principles), 2) recognizes the contextual nature of misinformation (e.g., as knowledge accumulates, what is misinformation can change), and 3) emphasizes the public aspect (e.g., misinformation is publicly available). As such, scientific misinformation is a collective problem. Moreover, the authors offer an instructive paradigm for measuring scientific misinformation across media and situations. This is a difficult but essential task, one that will help scholars and practitioners identify areas where misinformation might pose the gravest threats.

In the next paper, Krause et al. continue to refine the conceptualization of scientific misinformation by making a strong case against upholding a dichotomy of misinformation versus not misinformation. Instead, they argue that not all potential misinformation is created equal. Scientific uncertainties and sociopolitical sources of error make it more difficult to assess claim accuracy or provide corrections in some information domains than others. Furthermore, the harm that is likely from any given misinformation will vary, depending on context-specific factors, including the ease with which it spreads. Based on these differences, the authors provide a framework for helping policymakers and researchers identify where efforts to intervene and correct misinformation should be focused. This framework serves as a critical reminder that investments in correcting misinformation are not straightforward, and that striving to eliminate all misinformation is not a panacea.

The third paper in this section – by Swire-Thompson and Lazer – focuses on health information, and follows the logic of the prior two papers by identifying the nuanced ways that

problematic information enters the public domain. The authors point to four mechanisms that generate health misinformation: predatory journals that publish for profit regardless of academic merit, pseudoscientists who resemble scientists but provide misinformed advice, scientific misconduct and fraud, and miscommunication of science by intermediary communicators such as the media. These are serious sources of misinformation that threaten the use of science, but the authors offer a "call to arms" by providing guidance on how to combat the threats. Examples include encouraging legitimate journals to become open access, maintenance of a credible list of predatory journals and pseudoscientists, emphasizing that expertise is domain specific, improving safeguards to signal retracted papers (e.g., labeling them in Google Scholar searches), and encouraging scientists to be more cautious in approving press releases. These problems can be addressed, but it will require a sustained effort.

The final two papers in this section offer applied perspectives by directly exploring techniques that people can employ to prevent being misperceived (particularly on social media). Traberg and her colleagues describe the widely praised inoculation approach. The theoretical idea goes back to work in the 1960s that metaphorically suggests persuasive communications can be counteracted in advance with inoculation messages (just as a vaccine inoculates people from a disease). This idea was further developed, refined, and perfected by the authors and some of their colleagues to fight misinformation. Specifically, an inoculation involves alerting people of the threat of misinformation and then using a refutational pre-emption by providing them with the tools to rebut misinformation. The authors review the compelling evidence for this approach, which includes basic inoculation communications and gamified interventions such as the widely used *Bad News* game. This turns battling misinformation into a source of entertainment, akin to work on edutainment.

In the last paper, Pennycook and Rand discuss research regarding another impressive approach to limiting the sharing of misinformation – the accuracy prompt. This has generated a massive amount of work and interest. It starts from the premise that many people share misinformation on social media because they fail to think about its accuracy, not because they want to share misinformation or because they cannot distinguish falsehoods from truth. The key, then, is to nudge people to consider accuracy that shifts their attention so that they do not share misinformation (e.g., it leads them to focus more on accuracy and less on social factors such as maximizing likes). The authors offer a formal model, which is particularly valuable as it clarifies how their accuracy prompt differs from other theories that focus on, for example, partisan motivations (theories that the authors empirically challenge). They then discuss the empirical evidence from 20 experiments on the effects of the prompt; the data suggest a 72 percent increase in discernment due to the prompt. The strength of these results, along with the efficiency of the intervention, are promising. The authors conclude with a set of outstanding questions, including how the accuracy prompt would work with other techniques, such as crowdsourcing identification of misinformation and educational interventions (e.g., inoculation).

Misinformation may be the most widely discussed contemporary threat to science, and for good reason, given science inherently should be a source of useful information. If it is not, then investment in it becomes questionable. The articles in this section offer crucial guidance. They clarify the complexity of defining scientific misinformation and bring to light considerations that are unique in the domain of science. The papers also identify structural sources of uncertainty that stem from the practice of science itself and the interface between the production of science and the communication of science – a process that is far from seamless. There is reason for optimism insofar as institutional fixes exist and they are in the scientific

community's interest to pursue (e.g., communicating uncertainty more effectively, addressing predatory journals). And there also are compelling applied interventions available to help people navigate a world where scientific misinformation quickly spreads. However, one interesting observation concerns the difficulty of connecting the impressive inoculation and accuracy prompt interventions to the definitional considerations discussed in the earlier papers. This exemplifies the inherent challenge of translational research (and is not meant as a critique). There is no reason to presume the threat of scientific misinformation cannot be addressed and these papers provide conceptual, structural, and cognitive guidance on how to do so.

Inequality

The final section of the volume explores a distinct type of threat, concerning inequalities and science. Here, the threat can be thought of in epistemological or moral terms. There exist long-standing vast disparities in who participates in the scientific enterprise. For example, in 2017, women accounted for just 29 percent of those employed in U.S. Science and Engineering, while under-represented minorities (Blacks, Hispanics, Indigenous populations) composed only 13 percent. Both these numbers fall well below their proportions of the college educated workforce (52 percent for women and 17 percent for underrepresented minorities) (Khan et al. 2020). This has implications for mentoring and role-modeling, as well as for ensuring that the concerns of varied communities play a role in setting the science agenda. Moreover, it undercuts the incorporation of different perspectives and ways of knowing that can be vital to advancing science (e.g., Page 2008; Smith-Doerr, Alegria, and Sacco 2017). This therefore constitutes a threat to the advancement of science.

When it comes to the impact of science, inequalities manifest in cruelly ironic ways. Those with low socio-economic status, minority groups, and other subpopulations face unique

challenges in situations where access to science could prove essential. For instance, as the Intergovernmental Panel on Climate Change (2014, 54) explains, "People who are socially, economically, culturally, politically, institutionally, or otherwise marginalized are especially vulnerable to climate change…. This heightened vulnerability is rarely due to a single cause. Rather, it is the product of intersecting social processes that result in inequalities in socioeconomic status and income, as well as in exposure. Such social processes include, for example, discrimination on the basis of gender, class, ethnicity, age, and (dis)ability." The United States Global Change Research Program (2018) further notes that the most vulnerable segments of the public are also those who tend to have the least access to information and least voice in climate planning and governance. These inequalities appear in a host of other domains such as health, technological access, environmental hazards, food choices, and more. As mentioned, COVID-19 made such inequalities extremely clear, with demographic minority populations experiencing dramatically higher illness and mortality rates and much more economic insecurity (e.g., Andrasfay and Goldman 2021; Perry et al. 2021). The irony is that, despite such disparities, these populations are much less studied. For example, racial minorities are less represented in clinical trials (e.g., Nazha et al. 2019), and less studied in terms of their attitudes, beliefs, and knowledge. On the latter, Welles (2014, 2) explains the historic dictum: "researchers may have made the case that it was simply too difficult to work with underrepresented populations and statistical outliers. These people are, by definition, less plentiful in the population. So, they can be harder to find, more expensive to recruit, and more time-consuming to work with. Although ethically and empirically inexcusable, researchers working with tight budgets and limited time frames may have felt that it was not viable to work with non-majority populations." This, then, is a moral threat – that is, insofar as science

constitutes a public good, a strong case can be made that it should not be differentially available (and its use by one need not prevent its use by others). If certain individuals face systematic exclusion from participation in science or from reaping the benefits of science, that is a threat which minimizes the epistemological value of the science itself, as well as the reach of its potential benefits.

The final set of essays in this issue address how inequalities limit the power of science. Few, if any, communities have faced as many challenges in the U.S. as the Indigenous population. They experience vast exposure to climate threat, but receive scant support from the federal government – including relatively less aid from the Federal Emergency Management Agency and insufficient support for basic infrastructure maintenance (Flavelle and Goodluck 2021).[1] The first paper in this section, by Suiseeya and colleagues, explores the relationship between climate science and environmental justice by detailing the experiences of the Ojibwe Nations (some members of whom are co-authors of the paper).The authors argue that by focusing on climate change as solely an emissions problem, and by excluding the traditional ecological knowledges (TEK) held by the Ojibwe and other Indigenous groups, mainstream science perpetuates climate injustices and limits potential solutions. TEK provides valuable knowledge outside the realm of mainstream science. For instance, over generations, Ojibwe learned how to read signs in nature to explain walleye spawning, something biologists were unable to identify. It also provides a different framework for considering the climate change problem that recognizes it as a breakdown of relations between humans and the Physical, Plant, and Animal worlds and urges solutions that consider multiple past and future generations. The paper makes clear that science can benefit from recognizing other ways of knowing without

having to abandon mainstream science, and that translating science to action is just only when affected communities enter the process.

In the next paper, Lewenstein focuses on public engagement with science, particularly citizen science, one manifestation of which involves public participation in research. The idea is to incorporate those affected by the science into the entire process, from data collection to analysis. The benefits of incorporating different perspectives are clear. Yet, as Lewenstein assesses participation in citizen science projects, he finds that while some projects incorporate diversity, the overall demographics of participants reflect empowered people. He further details various challenges, including how to balance the benefits and potentially detrimental effects of citizen science, and how to challenge the social order, given that scientists themselves and/or corporate interests may maintain control over projects. He concludes that while citizen science may have helped science in some ways by making it more participatory, it has not yet succeeded in incorporating marginalized voices into the process. Future endeavors can build on the approach to address the threat of homogeneous perspectives in the practice of science.

The next paper, by Schuldt and his colleagues, moves to how people view the concerns of marginalized groups when it comes to science related topics. This is a crucial area – the lack of diversity in science means some groups' concerns may not be fully appreciated. Then, if there are biased perceptions of those concerns by the enfranchised population, science may never be directed to benefit marginalized groups. Schuldt et al. build on some of the authors' prior work, where they show that racial and ethnic minorities and lower income groups express greater concern about environmental hazards (and suffer more from them) but are perceived by Whites and high-income groups to be less concerned. They assess whether the same dynamics occurred with COVID-19. Here, the results are a bit different, with people under-estimating concerns of

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Latinos and Asian-Americans (by a lot) but not for Blacks. Individuals also underestimate the concerns among Whites. Also, unlike in the environmental context, people believed racial and ethnic minorities to be more worried than Whites. These contrasting results likely reflect media coverage and discourse about disparities during COVID-19. Regardless, any such misperceptions can threaten collective action and, as the authors eloquently state, affect "questions scientists ask, what problems get prioritized, and who benefits from science."

The last two papers address a prevailing problem implicit in the paper just discussed – the lack of data from disparate populations when it comes to science beliefs and behaviors. Most public data come from the general population, making it difficult to understand distinct belief systems, concerns, and experiences. In their paper, Viswanath and his colleagues highlight the problem of data absenteeism. They explain that populations do not get studied due to an over-reliance/valuing of probability samples and the difficulty of reaching smaller, marginalized populations (e.g., due to a lack of access to technologies). Further, some in these populations do not trust the system, face logistical hurdles, and fear mistreatment. The authors describe how community-based participatory research can be used for data collection of hard-to-reach populations. This approach emphasizes the co-production of knowledge, recognizing diverse types of expertise, compromise between the community and the researcher, and communication of results to the community. They provide successful examples from their own work. The result, as the authors state, is a more inclusive science of science communication. Additionally, it simultaneously introduces distinct perspectives to the process while facilitating access to science in communities that are often overlooked.

The final paper, by Bayes, Druckman, and Safarpour, starts from a similar perspective as Viswanath et al. They point out that inequalities could be partially addressed with targeted

interventions that provide access to scientific information. This requires knowledge of the access, interests, and beliefs of diverse groups, which is lacking due to limited data collections. The authors outline various sampling approaches one can take to reach different populations, such as list sampling, density sampling, purposive sampling, and response-driven sampling. Doing so, though, also introduces unique administrative considerations: there must be attention to differences in language and conceptual understandings, as well as an appreciation for distinct relationships between variables. Bayes and colleagues emphasize the role of community partnerships in these efforts, with the goal of studying different populations on their own terms. This not only ensures higher quality data, but also aids the communication of relevant knowledge.

In sum, inequalities in the production and distribution of science threaten its usefulness. The lack of diverse perspectives may limit advances, and, regardless, means certain individuals may not have opportunities available to others. It also unfairly disenfranchises some from enjoying the benefits of science. Addressing such inequalities is no easy matter, given they surely reflect systemic discrimination. As such, institutional solutions need to be part of the equation. The papers in this section provide insights that can inform such efforts, including the importance of appreciating other ways of knowing, attention to diversity in participatory initiatives, recognizing and accurately assessing the concerns of disparate groups, and efforts to collect data from varying communities. Ultimately, such endeavors can contribute to a more equitable scientific landscape.

Conclusion

Science plays a crucial role in modern societies. It informs individuals and polities in ways that contribute to better decisions. It is for this reason that governments invest so much in

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science. For instance, the U.S. government invests nearly $40 billion in medical research via the National Institutes of Health and $8 billion in science research via the National Science Foundation. Private foundations contribute billions more to the production of scientific knowledge. Yet, that knowledge competes with other ways of knowing and is vulnerable to misuse and unjust access. The papers in this issue take up these concerns by assessing three major threats to the production and application of science. These threats – politicization, misinformation, and inequality – have serious consequences. Yet, the ingenuity that has generated transformative science can also be used to address threats and help science play a role in improving societal well-being. That much is clear from the papers in this volume.

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[1] That said, it is important to note that several vulnerable communities, including Indigenous groups, have been leaders in calling for climate justice (e.g., the Standing Rock protests around the Dakota pipeline). Indeed, some data suggest people of color in the U.S. are more concerned than Whites about climate change (e.g., Ballew et al. 2020).