Canadian Journal of Philosophy (2022), 52: 3, 227–245
doi:10.1017/can.2020.34

ARTICLE

The New Worries about Science

Janet A. Kourany

Department of Philosophy, University of Notre Dame, Notre Dame, Indiana, USA
Email: jkourany@nd.edu

Abstract

Science is based on *facts*—facts that are systematically gathered by a community of enquirers through detailed observation and experiment. In the twentieth century, however, philosophers of science claimed that the facts that scientists "gather" in this way are shaped by the theories scientists accept, and this seemed to threaten the authority of science. Call this the *old worries about science.* By contrast, what seemed not to threaten that authority were other factors that shaped the facts that scientists gather—for example, the mere questions scientists pursue. Call this the *old nonworries about science.* What I suggest is that the old nonworries are turning out to be far more worrisome than the old worries, and I use recent goings-on such as the "Death of Evidence" protests in Canada, the "replication crisis," and the ongoing feminist critiques of science to illustrate my case. All this raises interesting new questions for philosophers of science to tackle.

Keywords: Values in science; feminist science studies; "Death of Evidence" protests; replication crisis; socially responsible science; epistemic affirmative action

1. Introduction

Science is based on facts, not wishful thinking or revelation or speculation—facts that are systematically gathered by a community of enquirers through detailed observation and experiment. These facts are used to ground the rest of science, the concepts and laws and theories and so on; and it is this grounding in facts that makes science the most trusted source of knowledge we have, distinguishing it from all other enterprises that claim to produce knowledge. Of course, the success of science involves other factors besides its grounding in facts: a multitude of highly dedicated, imaginative contributors, a heady dose of genius now and then, a willingness to break with the ideas of the past, generous financial and social support, the availability of mathematics and other technological tools, and other factors as well. But, its grounding in facts is the most important—the absolutely crucial and indispensable—ingredient of science's success, the ultimate source of science's authority.

So thought Francis Bacon and the other founders of modern science at the dawn of their great undertaking, and over the centuries "the facts" (or "data" or "evidence" or reports of what is observed) have continued to enjoy a starring role in science. True, the interpretation of the role has changed over time—from underwriting scientific certainty, for example, to providing scientific confirmations and disconfirmations, to signaling important scientific virtues such as accuracy, fruitfulness, robustness, and so on. But the essential nature of this supporting role of the facts to science has not changed (the facts, after all, remain the gateway to the world for an enterprise that aims to capture the goings on in that world). This is why reasons for questioning the factual basis of science are cause for alarm.

And there are such reasons. For example, in order for the facts to offer any kind of proper support for science, the facts must be independent of that science. And yet, since at least the 1960s, some of the most prominent philosophers of science have charged that what science offers as its factual

support is *not* independent of that science. Indeed, these philosophers of science have claimed that the facts of science are "theory laden," that is, shaped by the theories that scientists accept—in fact, that scientists' very observations are shaped by those theories. Some philosophers have even claimed that what scientists offer as "the facts" is simply a convention not justified by scientists' observations at all. As a result, what scientists take to be the facts has changed over time. Just as the theories of the past (even the most spectacular, such as Newton's theory of mechanics and Darwin's theory of evolution) have been overthrown or revised over time, so have the factual claims on which they were presumably based, giving way to new facts. The facts, rather than the cause of the changes, have thus appeared to be simply their effects. Needless to say, all this has seemed to threaten the authority of science. Call this the *old worries about science.*

By contrast, what seemed to philosophers of science not to threaten that authority were various other apparently humdrum ways in which what science offers as the facts is shaped by science: how it depends on the areas of research the scientific community or its funders consider acceptable and important; how it depends on the particular questions scientists pursue in those areas, their methods and tools of observation and analysis; how it depends on the publishing choices of journal editors and book publishers; and so on. Such factors lead to the uncovering and showcasing of certain facts rather than others but do not preclude the uncovering of those other facts at other times. So, no threat to the authority of science seems in question. Call this the *old nonworries about science.*

What I shall suggest is that the old nonworries about science are turning out to be far more worrisome than the old worries—are turning out, in fact, to be the *new worries about science.* With few exceptions, however, they have been the new worries of scientists, not philosophers of science. And this raises interesting questions about the role philosophers of science have played and might still play in dealing with these worries.

2. The old worries (of philosophers)

Start with the worries about the factual basis of science that occurred in the middle of the twentieth century. Voiced most prominently by American philosophers of science Thomas Kuhn and Norwood Russell Hanson, as well as Austrian-born American philosopher of science Paul Feyerabend, they had had their groundwork laid much earlier by British philosopher of science Karl Popper (also, like Feyerabend, Austrian-born). The assumption, at the time—among epistemologists as well as philosophers of science—was that in order for the facts offered by scientists to form a proper grounding for science, two conditions would have to be met:

1. The reports of the facts have to express only what the scientists directly observe as they pursue their research. That is, the reports cannot go beyond what these scientists directly observe, else the reports will say more than what can be justified by the scientists' observations.
2. What the scientists directly observe has to correspond to what is actually there in the world as measured by what others also observe. It has to contain nothing that is personal or subjective or idiosyncratic.

If these conditions are met, it was thought, then science will have a secure grounding.

But Popper and Hanson argued that these conditions cannot be met. To begin with, Popper ([1935] 1959) argued that statements that purport to describe "immediate experience" are inherently more general than the experiences that call them forth. As he put it, "an 'immediate experience' is *only once* 'immediately given'; it is unique" (76). Statements, on the other hand, even statements as pedestrian as "There is a glass of water on the table," are associated with an indefinite number and variety of such unique immediate experiences. Furthermore, such experiences can never actually *justify* the statements but can only motivate a decision to accept them. For, Popper

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

argued, only statements can enter into justificatory relations with other statements. As a result, the empirical basis of scientific knowledge is ultimately constituted by decisions to accept unjustified statements of fact. These decisions are motivated by experiences but not justified by them.

So, Popper challenged condition 1. And Hanson (1958) challenged condition 2 (and in the process, Popper's critique of condition 1 as well). For Hanson argued that when we accept a statement like "There is a glass of water on the table," we don't first have some kind of ineffable "immediate experience" that we then hypothesize to be a glass of water on the table. We simply see the glass of water on the table. The interpretation, if there is one, is simply there in the seeing from the outset. Of course, Hanson added, it takes knowledge to see this. An infant cannot see what we see when we see the glass of water on the table. The infant must first learn the language that talks about glasses and water and tables. Only then will her visual field be organized in ways that reflect that linguistic knowledge. But this means that people who have learned very different languages will see very different things. It follows, Hanson argued, that scientists who have been trained within different theoretical traditions will simply see different things and thus report what they see in different ways. The facts they glean from their observations, in other words, will be different. But this means that condition 1 is satisfied but condition 2 is not.

Kuhn (1962) applied all this to the controversies he studied in great detail in the history of science. The reason scientific advocates of older theories, even the most brilliant ones, frequently took years to accept new alternative theories and sometimes were never able to accept them, Kuhn said, was that those scientists' training shaped their observations and hence what they took to be the facts in ways that the new theories simply could not accommodate. Indeed, when advocates of competing theories tried to compare their respective theories and reach a reasoned decision regarding which theory they should all accept, they inevitably ended up "talking through each other" (109). So, theory choice in the history of science, Kuhn concluded, was a psychological affair of persuasion and gestalt switches and the like, not the reasoned comparison of fact and theory philosophers of science had always supposed. A careful look at the history of science, Kuhn argued, could support no other view.

Finally, Feyerabend (1965) maintained that nothing better could be hoped for because there is no theory-neutral fact-stating language, and hence no theory-neutral facts, to do better with. Even our ordinary language is theory laden with, Feyerabend argued, very outdated scientific theories (think of our ordinary talk of sunrises rather than earth turns, or colors and shapes that inhere in objects independently of the frames of reference from which those objects are observed). So, neither ordinary language nor any scientific language at our disposal can provide us with the theory-neutral facts with which to compare alternative theories. The upshot, said Kuhn, is that science is not progressing closer and closer to any truth fixed by nature, but is simply progressing away from "primitive beginnings."

Thus, in the hands of Popper, Hanson, Kuhn, and Feyerabend—four of the most gifted and historically informed philosophers of science of the twentieth century—the authority of science seemed completely undermined.

3. The new worries (of scientists)

Needless to say, philosophers of science were not happy with this result and spent the next decades of the twentieth century trying to respond. Their aim, of course, was to somehow salvage the authority (rationality, objectivity) of science. But scientists remained unconcerned. Instead, they forged ahead with their various research programs, and the results of those programs made possible a spectacular array of our modern conveniences: cell phones and computers and the internet, oral contraceptives and vaccines, satellites and GPS navigation, and much, much more. The intellectual breakthroughs scientists achieved were stunning. If the mission of philosophers of science was to capture scientific rationality, philosophers seemed to be doing a poor job of it. For, scientific

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

rationality appeared to be robustly healthy at precisely the moment that, to philosophers, it appeared seriously ailing.

Case #1: Twentieth-century women scientists

But a different worry about science and its factual grounding *was* beginning to occupy the minds of scientists even while Kuhn and the other philosophers of science were writing about theirs. This different worry pertained, as before, to science's shaping of what it presents as the facts, but this time the shaping was being accomplished not by using the language of some theories rather than others to report the facts but simply by carrying out some kinds of factual investigations rather than others. Women scientists were especially concerned about this mode of shaping the facts, especially the women who entered the sciences in increasing numbers during the time of second-wave feminism. What these women found reported in the outcomes of social and natural science investigations was a torrent of facts relating to men together with a dearth of facts relating to women. They found, for example, facts in archaeology about men's contributions to the great turning points of human evolution but no facts about women's contributions; facts in medicine about men's problems with heart disease and stroke and, later, AIDS as well as other diseases but few facts about women's problems with these diseases; facts in economics and political science and sociology about men's rationality and agency and leadership styles and abilities but no facts about such characteristics in women; and so on. Even the titles of the works these women scientists eventually produced—such as biologist Ruth Hubbard's "Have Only Men Evolved?" (1979), or archaeologists Joan Gero and Margaret Conkey's *Engendering Archaeology: Women and Prehistory* (1991), or economists Marianne Ferber and Julie Nelson's *Beyond Economic Man: Feminist Theory and Economics* (1993), or health researcher Sue Rosser's *Women's Health—Missing from U.S. Medicine* (1994)—even the titles of the works these women scientists eventually produced bespoke the low visibility, indeed near invisibility, of women and the high visibility of men in the accumulated facts of their disciplines.

True, women were not all invisible to the same extent within the accumulated facts of these disciplines. Certain women—black women, and poor women, and disabled women, and native women, for example—tended to be more invisible than other women, and the works that women scientists (and some men scientists too) produced, even before the time of third-wave feminism, began to draw attention to the situation. (These works included, for instance, Raymond Berger's "The Unseen Minority: Older Gays and Lesbians" (1982), Lynn Weber Cannon, Elizabeth Higginbotham, and Marianne Leung's "Race and Class Bias in Qualitative Research on Women" (1988), and Pamela Trotman Reid's "Poor Women in Psychological Research: Shut Up and Shut Out" (1993), as well as the works previously cited.) Still, there were exceptions. In certain areas of research, the usually more invisible women found themselves very much in the spotlight, although the attention was far from helpful to them. In medicine, for example, the gathered facts about Black and Hispanic women (as well as men), usually sparse (Oh et al. 2015), was extensive in the research areas associated with promiscuity (including sexually acquired diseases), underachievement, and antisocial behavior (including drug abuse, violence, and sexual assault) (Osborne and Feit 1992). And in psychology, the gathered facts about Black women (as well as men) was similarly extensive in the research areas associated with intelligence deficits (see, for example, Eysenck 1971; Jensen 1985). Of course, the gathering of facts about *all* women had *always* been extensive, in psychology and elsewhere, when it came to women's deficiencies—where men (of course, of the privileged race, class, sexual orientation, and the like) were taken as the standard for what was *not* deficient.

Twentieth-century women scientists were not the first women to worry about this way of science's shaping of the facts, however. Nineteenth-century women, not permitted, like their twentieth-century sisters, to enter the sciences, could still diagnose its shortcomings. And some, such as Caroline Kennard and Eliza Burt Gamble, did, and with gusto. As they saw it, women had

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

been thought inferior to men—intellectually, socially, physically, and even morally inferior—ever since ancient times, and so women were never expected to play any significant roles in the great exploits and achievements of humankind. Hence, no serious attention to them was ever considered warranted. Still, as Eliza Burt Gamble pointed out in her *The Evolution of Woman, an Inquiry into the Dogma of Her Inferiority to Man* (1894, vii–viii),

> With the dawn of scientific investigation it might have been hoped that the prejudices resulting from lower conditions of human society would disappear, and that in their stead would be set forth not only facts, but deductions from facts, better suited to the dawn of an intellectual age…. The ability, however, to collect facts, and the power to generalize and draw conclusions from them, avail little, when brought into direct opposition to deeply rooted prejudices.

So modern science simply followed the ancient tradition. The upshot was that the facts unearthed by modern scientific investigations, rather than undermining and displacing the old prejudicial picture of women, reinforced it instead.

Case #2: Twenty-first–century Canadian scientists

By the beginning of the twenty-first century, a second group of scientists had joined the feminists in worrying about the kinds of factual investigations pursued and not pursued in science, and how these shape science's representation of the facts and the conclusions drawn from the facts. Doubtless some of the most memorable of these scientists were the two thousand from all over Canada who marched in white lab coats through Ottawa in July of 2012 carrying a coffin and tombstones. They then staged a mock funeral on Parliament Hill "to commemorate," as one speaker (then biology doctoral student Katie Gibbs) put it, "the untimely death of evidence in Canada" (Pedwell 2012, Smith 2012). Especially memorable, also, were the more than eight hundred scientists from thirty-two countries who wrote an open letter to Canada's Prime Minister Stephen Harper thereafter in support of the marchers (Chung 2014). Among the actions that precipitated their protest:

- The Harper administration had instituted sharp cutbacks in basic research and the overall funding of important research areas such as climate, energy, and environmental research. It had even tried to shut down world-class government research programs engaged with groundbreaking industrial pollution research and climate research, such as the Experimental Lakes Area research station and the Polar Environment Atmospheric Research Laboratory (Editorial 2012).
- In place of all this government-run, environmentally relevant basic and applied research, the Harper administration had pushed for government research partnered with industry and aimed at economic development (Hoag 2011).
- The Harper government had also placed new restrictions on government scientists that impeded the free flow of information both among these scientists and between these scientists and the public, especially when that information highlighted the undesirable consequences of industrial development (Linnitt 2013).
- And the Harper government had also eliminated nonpartisan sources of scientific information that in the past had provided expert advice to the government regarding sustainable economic growth as well as other issues of science policy (Hoag 2012).

The concrete results of these actions were jarring. Thousands of government research scientists were put out of work, and many of Canada's top scientists left the country. Two hundred scientific research institutions and more than a dozen federal science libraries were closed due to cutbacks in

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

funding. Scientific books and journals were literally thrown in dumpsters, invaluable data archives dating back a century were destroyed, and reams of publicly funded data and reports from government websites were deleted. In consequence, Canada dropped out of the world's top ten research and development performers, and it was said that Canada's basic climate and environmental science, in particular, had been set back for decades (Kingston 2015; Munro 2015).

As far as the protesting scientists were concerned, then, the actions of the Harper administration meant that present and future evidence that could be used to support a strong environmental and climate policy was simply being rubbed out by the Harper government, killed off. Hence the terminology that galvanized the protesters' movement: the "death of evidence." Indeed, according to the protesters, all these actions of the Harper administration represented a political takeover of Canadian research, even a "war on Canadian science," impeding its ability to continue to make important applied as well as basic contributions to science. Not surprisingly, therefore, the ten-year reign of Prime Minister Stephen Harper and his Conservative Party ended with the Canadian election of October 2015, when the Liberal Party's Justin Trudeau was voted in as Canada's new Prime Minister.

Just a year later, however—in November 2016—the Republican Party's Donald Trump was voted in as president of the United States, and the kinds of actions that kill off scientific facts, such as major funding cuts for specific kinds of research and restrictions on communications from government science agencies, began yet again, though now in a different country. The protest *this* time, the so-called "March for Science" held on Earth Day in April 2017, was the largest science demonstration in history, taking place not only in Washington, DC (where 100,000 people gathered), but also in more than six hundred other cities all across the world (Smith-Spark and Hanna 2017; March for Science 2017). And many more protests were planned to take place (Kaplan 2017).

Case #3: Nearly all scientists today

At least one more group of scientists should be added to the two groups already mentioned, the two groups engaged with what I have called the *new worries about science.* This third group numbers among its members nearly all of today's scientists, and their concern with fact shaping in science relates to science's internal workings rather than the cultural biases that find their way into science or the governmental interference that sometimes constrains science. More particularly, their concern relates to science's current reward structures and the effect these reward structures have on scientific replication and, hence, on what science ultimately offers as the facts. Replication, of course, is the successful reproducing of experimental results. Called the cornerstone of scientific method, it is an absolute requirement for the proper grounding of science. Yet, in recent years, even attempts at replication in science have been relatively rare.

The reasons are many. For one thing, replication studies are not normally viewed as major contributions to their fields, hence they receive less funding and less attention from both scientists and the media. What's more, they are harder to publish since journals prefer original research to replications of previous research. And they take time and resources away from other projects that reflect scientists' own original research ideas. So there has been little incentive to attempt replications. And when they *are* attempted, and especially when the results are negative, there is little incentive to even try to publish them since journals have a strong disinclination to publish any kind of negative or failed experiments. Moreover, in some fields, such as biomedicine, just gathering the materials for a replication experiment can be daunting, since many such experiments require working out special agreements before the research group that did the original research can share the necessary items (such as cell lines or specially created laboratory animals or bits of DNA) with the group attempting the replication. And that's when these materials are still available and still in a useable form. Finally, having to track down the exact procedures used in the original experiment, especially if it was done years earlier with the assistance of graduate students or postdocs and

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

described in notebooks no longer available, can be a deal breaker for scientists in any field, especially given publish-or-perish pressures (Price 2011; *Economist* 2013; Sheldrake 2015; Engber 2016; Hastings 2017).

The upshot: replication has been judged to be crucially important to science, but at the same time it has been treated as insignificant within the reward structures of science—an alarming situation, to say the least. As a result, serious efforts are now underway to motivate the doing and publishing of replication studies regardless of their outcomes. Funds have been allocated, a few large-scale replication studies have followed, and the results have been depressing. In every case, a surprisingly *low* percentage of the studies previously thought to be replicable *were* replicated (including studies done by the best scientists using the best methods and published in the best journals). For example, in 2012 it was reported in *Nature* that scientists at the biotechnology company Amgen had attempted to replicate fifty-three "landmark" cancer studies, but only six of the fifty-three attempts were successful (11 percent) (Begley and Ellis 2012). In 2015, it was reported in *Science* that a collaboration of 270 researchers from all over the world had attempted to replicate 100 psychological studies that had been published in three top-tier psychology journals in 2008, but only 39 of those attempts were successful (Open Science Collaboration 2015). In 2016, a survey reported in *Nature* of 1,576 scientists from a variety of fields—chemistry, biology, physics and engineering, medicine, and earth and environmental science—found that more than 70 percent of those scientists had tried and failed to reproduce at least one other scientist's experiment and more than 50 percent had even failed to reproduce one of their own experiments (Baker 2016). In 2018, it was reported in *Nature Human Behaviour* that an attempt to replicate twenty-one social science experiments published between 2010 and 2015 in *Science* and *Nature* yielded only thirteen successes, though even in the successful thirteen the observed effect was on average only about 75 percent as large as in the original experiments (Nosek et al. 2018). And the list goes on.

All this has precipitated a "replication crisis" across science, but especially in psychology and biomedical research. As scientists see it, they and their colleagues, under pressure to pursue, at an uncomfortably rapid pace, ever new and different—read "novel and original"—investigations rather than the more lackluster replication investigations science requires, end up shaping science's inventory of facts in intolerable ways. Indeed, they end up introducing into science legions of interesting new facts many of which, scientists are now declaring, are not facts at all.

4. A comparison of the old and new worries about science

Philosophers of science have been nearly as unimpressed by all these ("new") worries of scientists as scientists had been by philosophers' ("old") worries. True, there are exceptions. Feminist philosophers of science, for example, have been as dismayed as feminist scientists by the ways women and females in general have been ignored or in other ways shortchanged by science; a few philosophers of science living in Canada at the time of the Death of Evidence marches have written papers on the situation (see the papers by philosophers of science Stathis Psillos [2015], Maya Goldenberg [2015], and Ingo Brigandt [2015], as well as legal theorist Helena Likwornik [2015], in the *Canadian Journal of Philosophy* symposium "Science, Values and the 'Death of Evidence' in Canada" and also the paper by philosopher of science Heather Douglas [2015] in the *Bulletin of the Atomic Scientists*). And there is now serious interest among some philosophers of science regarding the replication crisis, as shown by two sessions and a lunch gathering devoted to it at the November 2018 meeting of the Philosophy of Science Association (see also, Bird 2018 and Guttinger 2018). Still, the groundswell of attention that philosophers of science had devoted to the old worries is nowhere to be seen. Why is that?

At least one reason may be that the fact shaping at the heart of the new worries has appeared to philosophers of science quite pedestrian. After all, the old worries concerned science's shaping of what it presents as the facts via the theories scientists accept and thus via the fact-stating languages scientists employ. So, the old worries had to do in a very real sense with fact *construction.* And this

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

construction ran rather deep, as can be seen, for example, by the circumstance that the facts expressed in the language of any theory precluded acknowledgment of the facts expressed in the languages of all its competitors. By contrast, the new worries concern science's shaping of the facts via the research projects scientists pursue. So, the new worries have merely to do with fact *discovery* or *selection* from the array that are available rather than fact construction. What's more, such discovery or selection occurs via quite humdrum mechanisms: the areas of research the scientific community or its funders consider acceptable and important, the particular questions scientists pursue in those areas and their methods and tools of observation and analysis, the publishing choices of journal editors and book publishers, and so on. Hence, none of these discoveries of fact appears to preclude any other discoveries of fact at either the same or other times. In short, the new worries appear to concern a far more trivial shaping of the facts of science than the old worries.

Add to this the sheer novelty of the old worries and the shopworn nature of the new. The talk of theory-laden facts, theory-laden observations, the nonexistence of a theory-neutral language, and the other ingredients of the old worries constituted in their day fascinating new contributions to the philosophical scene—far more provocative and exciting and even, in many ways, more insightful and historically informed than what went before. And these contributions came with supportive backing from promising new ideas in the psychology of perception and the philosophy of language. By contrast, what I have called the new worries about science are only new relative to these old worries. That is to say, they simply came after the old worries. In other respects, these so-called new worries are actually quite old. I already pointed out, for example, how twentieth-century women scientists echoed the critiques of their nineteenth-century would-be-scientist sisters regarding the privileging of men in the facts of science. And I could have added scientists' responses to the political suppressions of science that antedated the recent Death of Evidence and March for Science movements—the protests directed at the treatment of climate science and other areas of science by the George W. Bush administration in the United States, for example, or, most famously, the protests directed at the treatment of genetics under Stalin or physics under Hitler, as well as the protests through the centuries directed at the treatment of Galileo by the Catholic Church. Only the replication crisis might actually be new.

Such considerations as these must be the reasons the new worries about science have not enjoyed more attention from philosophers of science—at least have not enjoyed the attention that the old worries had. But are these considerations ultimately persuasive and, hence, are philosophers of science in the right to continue largely ignoring the new worries of scientists? When we reflect again on the cases that currently illustrate the new worries of scientists, it appears that the fact shaping at their heart is not quite so pedestrian as the above suggests. To begin with, the discovery of facts featured in these cases *does* preclude the discovery of other facts, just as the acknowledgment of facts in the old worries precluded the acknowledgment of other facts. For example, the hundreds of years of fact gathering regarding men and males in general *did* preclude all sorts of other research projects that would have made sense if only various kinds of facts about females had been gathered. And the years and sometimes decades of cancer and other sorts of biomedical research that assumed and built upon nonreplicated, nonreplicable results did preclude—because additional funding or additional researchers were not available—other more promising lines of research yielding more useful information.

Moreover, the mechanisms by which all this fact gathering and preclusion of fact gathering occurred were far from humdrum. Of course, they included choices of research areas and methods and publication venues and the like, but what underlay all of this was the commitment to certain values over others (Elliott 2017)—for example, the commitment to androcentric and racist values over egalitarian values or proindustry values over environmental values. The new worries, in short, concern science's shaping of the facts via the *values* scientists (or their funders) accept just as the old worries concerned science's shaping of the facts via the *theories* scientists accept. Might these new worries, nonetheless, still fail to be as fascinating and provocative now in their day as the old worries were in theirs? But what if they do fail in this way? The old worries, though fascinating and

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

provocative, still failed in many ways to apply to actual science, given that scientists were continually doing what the old worries claimed they could not do—for example, compare alternative theories against a set of facts that did not presuppose any of the theories. And this is a crucial failure for a contribution to philosophy of science, a field whose central aim is to be relevant and helpful to science. By contrast, the new worries exactly express what goes on in science as attested to by the scientists themselves.

5. A role for philosophers of science

Should the new worries about science receive serious attention from philosophers of science—at least as serious a level of attention as the old worries received? I have suggested that there are no viable arguments against it. But there are also strong arguments for it. After all, as was explained at the outset, science's grounding in facts is an essential ingredient of science's success, an essential source of science's authority. But the new worries of scientists as well as the old worries of philosophers call into question, though in different ways, just this grounding. It makes eminent sense, then, for both scientists and philosophers of science to carefully consider the concerns that have been raised by both camps and deal with them constructively. It makes especially good sense for philosophers of science to do this—hence to deal, now, with the new worries of scientists—since these new worries raise issues that scientists have barely begun to recognize, issues that are distinctly philosophical. I see at least three such issues.

The first issue that philosophers of science should consider: Scope

The first issue concerns the scope of the new worries about science. As should have been clear from the outset, the scope of the old worries was very broad: talk of theory-laden facts, theory-laden observations, the nonexistence of a theory-neutral language, and the rest was intended to apply to all of science. But what is the scope of the new worries? Unlike the old worries, the new worries were illustrated by three specific cases, though it was also suggested, or at least taken for granted, that other cases could be provided, such as race and class analogues of the first case (the one focused on gender) and the mentioned Bush, Hitler, Stalin, and the Catholic Church analogues of the second case (the one focused on the Harper administration). It was clear, however, that scientists did not consider these cases to be representative of all of science. On the contrary, the suggestion was that these three cases were considered by scientists to be aberrations of what science is in general, or what science is at its best, or at least what science is supposed to be. Is there a more general problem here, however, comparable to the old worries of philosophers?

Return, again, to our three illustrations of the new worries of scientists. The years—and, in the first case, centuries—of research at issue in these illustrations brought a great number and variety of facts to light. At the same time, this research, as previously noted, also consigned an even greater number and variety of facts to the dark, namely all those facts that would have been uncovered if different research decisions (for example, different methodological or staffing or publication decisions) had been made along the way. In this manner, the research in our illustrations shaped what science now presents as the facts. But *any* scientific research program produces this kind of ongoing shaping of the facts that science presents. So, the scope of the new worries about science is entirely general—as general as the scope of the old worries.

The new worries about science raise another issue of scope more interesting than this, however. For, the fact shaping that occurred in our three illustrations had a special feature: the facts consigned to the dark tended in each case to be antithetical to the facts brought to light or, at least, to the conclusions drawn from them. Recall, for example, the gender-related facts that women confronted when they entered the sciences in increasing numbers during second-wave feminism—the facts in archaeology about the prehistoric achievements of men, the facts in biology about the all-important contributions to evolution of men and males in general, the facts in economics and political science

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

and sociology about the rationality and agency and leadership abilities of men, the facts in psychology about the intellectual, emotional, and moral strengths of men, and so on. All these facts supported not only each other but also the general conclusion that men are far more capable than women, and hence deserving of better jobs, better wages, better educational opportunities, better treatment all around, both in the home and outside it. And, of course, this was precisely the conclusion drawn from these facts. But the facts that past research had consigned to the dark—the facts that the research of feminist scientists began bringing to light—directly opposed this conclusion. And similarly for the other two cases we considered: the facts that the new replication studies are bringing to light, the facts originally consigned to the dark by the push to do more "novel and original" kinds of investigations rather than lackluster replications, all too frequently oppose the facts gathered and conclusions put forward by even the most celebrated investigations of the past. And the facts relating to environmental problems and global warming that Harper's funding cutbacks and muzzling of scientists "killed" were expected to oppose the facts and their conclusions arising from the new government-industry research partnerships Harper planned to support—at least that's what the killing has been supposed to be about.

So, the more interesting issue regarding the scope of the new worries about science is just this: how widespread is this oppositional feature in the fact shaping that occurs all over science, and are there other kinds of features that should also claim our attention? Such a question is of obvious epistemic importance: ignoring the evidence that threatens our claims is always a poor strategy, and if this strategy occurs frequently in science, science is in big trouble. But the question of scope is also of obvious social importance, since the social consequences of the ignore-threatening-evidence strategy can be dire (think, for example, of the cancer patients whose treatment was based on some of the nonreplicated, nonreplicable research studies, the cancer patients who are no longer with us).

The second issue that philosophers of science should consider: Prevention

All this raises a second issue that should be of interest to philosophers of science, namely what can be done to prevent the kinds of cases that now cause the new worries about science. Recall that the new worries concern the kinds of factual investigations pursued and not pursued in science, and how these shape science's representation of the facts and the conclusions drawn from the facts. Recall, also, that what lies behind all this are the values that scientists (or their funders) accept. That is to say, it is *values* that ultimately shape what science presents as the facts, and the cases central to the new worries about science are cases in which these values are just not the right ones. Indeed, in the three cases we considered, these values were, respectively, androcentric (and ultimately, also, racist, classist, and other) values rather than egalitarian values, proindustry rather than environmental values (and these, doubtless, also involve other values as well), and what might be called pro-"novel and original" rather than proreplication values. In each of these cases unacceptable social values[1] skewed the facts gathered (and/or preserved) in epistemically as well as socially unfortunate ways, leading to the flawed inferences previously described. So, the way to prevent these kinds of cases would seem to be to exclude from research such unacceptable values. But what does it mean to say that these values were *just not the right ones*—were *unacceptable*? And hence, how will we recognize which values need to be excluded from science and which included, and how all this might be done?

Think back to the dawn of modern science. It was then that a promise was made: if society would but support the new undertaking, society would be richly rewarded not only with unprecedented insights into the workings of the universe but also with all the benefits such insights would provide.

[1]I am treating the preference for "novel and original" studies here as a social—a cultural—value. The replication crisis has been billed as requiring a change in the *culture* of science. As noted previously, scientists all understand the importance of replication. They (and their funders and journal editors, etc.) have just admired "novel and original" work more and have privileged it accordingly.

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

Indeed, Francis Bacon, one of the chief architects of the new science as well as one of its more exuberant press agents, promised that the knowledge science would offer would "establish and extend the power and dominion of the human race itself over the universe" for the benefit of all humankind (see [1620] 1960, 117–19). What this meant was that science would make humans once again the masters of nature as they had been in the Garden of Eden—would recue them from the "immeasurable helplessness and poverty" that was their fate after the Fall. In other words, science would make humans once again "peaceful, happy, prosperous and secure" ([1603] 1964). Bacon offered as examples of the benefits he expected from science such items as the curing of disease and the preservation and prolongation of life, the control of plant and animal generation, the development of new materials and new modes of transportation ("through the air" and "under water"), and even new methods of defense ([1627] 2008)—anticipating, in the process, many of the discoveries and inventions we all enjoy today.

Essentially the same promise was made again and again over the next four centuries by other distinguished representatives of the scientific establishment (most famously by Vannevar Bush (1945) in the twentieth century; for more details, see Kourany 2021), though typically these reiterations of Bacon's promise lacked the theological trappings of the original. By the end of the twentieth century, the promise had become known as the *contract between science and society* (see, for example, Krishna 2014; Hooke 2015; Rohe 2017), and it kept the majority of the public gladly supporting science. In short, science has been billed, right from the start, as a resource for all, to help all of us flourish. And it is this that determines the acceptability or unacceptability of the values that shape science and science's representation of the facts: values that support the kind of research that promotes human flourishing are the right ones, values that don't are not.

Return, then, to the cases central to the new worries about science. As I said, these are cases in which the values involved—the androcentric (and ultimately, also, racist, classist, and other) values, proindustry values, and pro-"novel and original" values—are just not the right ones. More particularly:

Regarding the androcentric (and other) values in our first case: women (of various classes, races, sexual orientations, and so on) are more than half of the humans that science is supposed to serve. So, science should be providing the wherewithal for these women to flourish along with the men. At a minimum, science should not be providing the wherewithal for these women to be at a disadvantage relative to the men for this would not be consistent with the flourishing of women. But this is precisely what scientific research shaped by androcentric (racist, etc.) values has done, as we have seen. So, while science shaped by such values helps some of humanity to flourish, it does not help all to flourish, whereas egalitarian values would help all to flourish. Hence, egalitarian values are the acceptable values to guide science and science's fact-gathering activities, not these other values. (Of course, this argument for egalitarian values becomes even stronger when we explicitly consider the flourishing of the various groups of minority men along with the flourishing of the majority men.)

Regarding the proindustry values in our second case: the government research that the Harper administration supported, the research shaped by proindustry values, actually might have helped Canadian citizens flourish. On the most positive (for Harper) interpretation, what was in the offing from this research was the stimulation of Canada's (sagging) economy together with the industrial development of Canada's strengths, including Canada's rich oil and other natural resources (Hoag 2012). All this could have led to more jobs and greater economic well-being for Canadian citizens, just what polls showed Canadian citizens most cared about. It is just that what was in the offing from the government research that the protesters supported, shaped as it was by environmental values (such as that the environment is valuable in itself and should be protected and preserved for its present and future inhabitants), was a more long term, more sustainable kind of flourishing for Canada's citizens, free from the worst fallout from climate change and industrial pollutants.

Regarding the pro-"novel and original" values in our third case: the present valuing of "novel and original" research, especially at its current accelerated pace, does seem to produce an impressively wide array of scientific contributions, but these do not necessarily lead to human

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

flourishing—frequently, just the opposite. The valuing of replication studies, on the other hand, has a much better chance of leading to human flourishing, hence is the more acceptable value. Of course, what is still necessary in addition to this is the valuing of research that actually answers to human needs.

The way to prevent the sorts of cases that now cause the new worries about science, then, would seem to be to exclude from research the above kinds of values—that is, values that guide research in ways that fail to promote human flourishing.

Might philosophers of science have a role to play in these preventive efforts?

Note that scientists and science policymakers, without the help of philosophers of science, are already working on the necessary preventive efforts, and the strategies they have been using are impressively diverse. One such strategy is, as we have seen in our second case, the galvanizing of public sentiment and public pressure against science funders' (usually governments') shaping (or reshaping) of scientific research in accordance with the unacceptable values, achieved through such activities as marches and other sorts of demonstrations organized by scientists as well as open letters signed by scientists (large numbers of scientists or especially influential scientists). Another such strategy is the passing of legislation by science policymakers to restrict scientists from designing their research in accordance with the unacceptable values (or to incentivize them to design their research in accordance with acceptable values). An example of this kind relating to our first case is the passage in 1993 of the National Institutes of Health Revitalization Act that mandated the inclusion of women and minority men as subjects in NIH-funded, US medical research.[2] Yet another such strategy is the introduction of new initiatives to exclude the unacceptable values from the culture of science—to fully transform science in accordance with acceptable values. An example of this kind relating to our third case is the creation of the Center for Open Science (COS) and its Open Science Framework (OSF), which provides tools and infrastructure for researchers to preregister studies and share their data. The aim is to increase openness, transparency, inclusiveness, and collaboration in research practices in order to more efficiently and successfully yield reproducible results (see Nosek 2018 for the center's comprehensive strategic plan, and Elliott 2020 for an analysis of some of its central ideas and their significance). And there are other strategies as well, such as the endowment of prizes and awards to encourage the doing of research infused with acceptable values, and fellowships to encourage and equip the individuals who will most likely do that research.

These strategies of scientists and science policymakers are important ways to exclude unacceptable values from science, and thereby prevent the kinds of cases that now cause the new worries about science. Nevertheless, these strategies still leave much to be accomplished. Consider just one illustration: the legislative strategy as exemplified by the National Institutes of Health Revitalization Act (for what follows, see Rosser 1994; Weisman and Cassard 1994; Meinert 1995; Sherman, Temple and Merkatz 1995; Schiebinger 1999, Schiebinger et al. 2020; Mazure and Jones 2015; Oh et al. 2015; Ovseiko et al. 2016; Dusenbery 2018; Perez 2019). In our first case it fell far short of its goal: androcentric as well as racist values continued to shape biomedical research despite passage of the Revitalization Act. There were at least three reasons for this.

First, many in the biomedical research community did not support the Revitalization Act's goals. Of course, they had their reasons—for example, that including women of child-bearing age in drug studies could jeopardize the health and safety of any fetuses the women might be carrying; that men

[2]In the congressional hearings that motivated passage of that legislation, Rep. Patricia Schroeder and Rep. Olympia Snowe, cochairs of the Congressional Caucus for Women's Issues, "lambasted NIH leaders, and the medical research community as a whole, for compromising women's health. 'American women have been put at risk by medical practices that fail to include women in research studies,' said Rep. Patricia Schroeder. 'NIH's attitude has been to consider over half the population as some sort of special case,' Rep. Olympia Snowe charged" (Dusenbery 2018, 25).

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

and women were so alike, anyway, that results obtained from studying men could always be validly applied to women; and finally (and quite inconsistently with the last), that women, with their menstrual cycles, oral contraceptives, hormone therapies, pregnancies, and so on, would introduce too many complications to make "clean" results possible if they were included in the studies. But these scientists also had in mind their bottom line: that including women in clinical trials (especially minority women, as well as, of course, minority men), or including female animals, tissues, or cells in earlier stage studies, would require much larger studies, more expense, and more work if done properly—that is, so as to ensure that an adequate analysis of results by sex, race/ethnicity, and gender would be possible. And, in any case, they were resistant to changing old, familiar procedures.

Second, the provisions of the Revitalization Act were just too weak to ensure any significant change. Indeed, the only medical studies to which the Revitalization Act applied were NIH-funded Phase III clinical trials—the final stage after earlier, smaller trials indicated safety and promise. In consequence, most basic research with animal models continued to focus on male animals and exclude females, most studies at the tissue and cellular levels either failed to report the donor sexes of the materials studied or reported that they were male, and early phase clinical trials (i.e., Phase I and II trials) didn't always include women, majority or minority, or minority men. In addition, biomedical research funded by industry or foundations—that is, *most* biomedical research—also didn't always include women, majority or minority (or minority men), since the Revitalization Act applied only to NIH-funded research.

Third, compliance with the Revitalization act was not properly monitored or enforced. So even in the case of the medical studies to which the Revitalization Act did apply—NIH-funded Phase III clinical trials—majority and especially minority women (and men) remained under-enrolled relative to their representation in the patient population, and the published results frequently did not include a breakdown by sex, race/ethnicity, and gender. As a result, "women are still invisible. Researchers said, 'Okay, we included women,' but they weren't required to report their research by sex [and we can add here, race/ethnicity], so women's side effects and responses to medications and diseases were still invisible" (Janice Werbinski, founding president of the American College of Women's Health Physicians and executive director of the Sex and Gender Women's Health Collaborative, whose goal is to inform students and clinicians in sex-and gender-appropriate medicine; quoted in Dusenbery 2018, 36).

True, because of the Revitalization Act more attention was directed to health conditions (such as breast cancer) that only or predominantly affect women, a second area of research mandated by the Revitalization Act that had been neglected before. But problems surrounded the response to this mandate of the Revitalization Act too. For one thing, the relative lack of attention to many diseases that especially affect women still continued after the Revitalization Act was passed, such as autoimmune diseases, which affect women three times as often as men, and depression, which affects twice as many women as men and is "the leading cause of disease burden in the world" (Johnson et al. 2014, 18). For another thing, at least some of the increased attention to health conditions that especially affect women indicated, not the decreasing hold of androcentric values on biomedical research, but the increasing hold of the pharmaceutical industry's values. A case in point: the sudden appearance in medical diagnostics of new "diseases" such as "premenstrual dysphoric disorder" (PMDD) and "hypoactive sexual desire disorder" (a kind of "female sexual dysfunction" or FSD), along with new, FDA-approved "effective treatments" for them, such as Sarafem (a rebranding of Prozac, "now in appealing pink and purple pills") (Fernandez Pinto 2018). Of course, some women seemed to welcome the new disease diagnostics and treatments: at one meeting with "hypoactive sexual desire disorder" patients arranged by the Food and Drug Administration (FDA) in order to assess the drug treatment Addyi (flibanserin), for example, the majority of the women spoke so strongly in favor of the drug that the FDA ultimately granted approval even though it had denied approval on two previous occasions. But a careful analysis of the meeting and its aftermath shows that all those women who spoke so favorably were affiliated with

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

the pharmaceutical industry, that they clearly outnumbered the women not affiliated with the industry, and that they did most of the talking at the meeting (see Holman and Geislar 2018).

The upshot: "Steps have been taken in the United States to remedy the underrepresentation of women and the inadequate attention to sex and gender differences in research and regulatory approvals. However, progress has been painfully slow—stalling for long periods or sometimes reversing direction—and, consequently, not nearly enough progress has been made" (Carolyn Mazure, director of women's health research at Yale; see Mazure and Jones 2015, 2). But remember, the Revitalization Act was only intended to exclude androcentric and racist values from NIH-funded biomedical research in the United States. Even if it had been completely successful, it would still have left those values intact in most of the biomedical research in the United States as well as the biomedical research in other parts of the world.[3] And, of course, androcentric and racist values would still have been left intact in psychology and political science and economics and all the other sciences in which they now continue to shape the research being done. Indeed, analyzing the limitations of the Revitalization Act was just a quick illustration of what the present strategies of scientists and science policymakers still leave to be accomplished if *all* unacceptable values, not simply androcentric and racist values, are to be excluded from *all* of the sciences, not simply biomedical research, thereby preventing the kinds of cases that now cause the new worries about science. There is, then, much still to be done. So, this is the second issue I see for philosophers of science to tackle.

But are philosophers of science up to the job?

There are at least four reasons to think that they are. First, normative issues, both epistemic and ethical/political, and the arguments and counterarguments that go along with them are emphasized in the training of philosophers of science, as in the training of all philosophers—just the kind of background that would be helpful for this second issue. Second, philosophers of science have been engaged with central questions concerning values and science for some time now, again a perfect entree to this second issue. Third, many philosophers of science are now committed to dealing with socially important issues like this one, as shown by the formation of groups such as SRPoiSE (The Consortium for Socially Relevant Philosophy of/in Science and Engineering), JCSEPHS (The Joint Caucus of Socially Engaged Philosophers and Historians of Science), and SPSP (Society for Philosophy of Science in Practice) and the workshops, publications, events at the Philosophy of Science Association meetings, and other activities these groups have sponsored.[4] And fourth, a case in point, feminist philosophers of science have *already* made important contributions regarding this second issue—have, in fact, been doing so for decades—but many other philosophers of science have done so as well (for recent contributions concerned with race, or both race and gender, see Fernandez Pinto 2018; Biddle 2020; Havstad 2020; Kourany 2020b). So, this second issue should be both a welcome challenge for philosophers of science and a doable one.

The third issue that philosophers of science should consider: Rectification

There is at least one more issue regarding the new worries that I think philosophers of science should consider. It concerns the question of rectification in addition to the prevention just discussed—rectification for the inappropriate kinds of factual investigations pursued in the past

[3]Concluded an international team of medical, gender, and policy researchers from the UK, Spain, Canada, Argentina, Qatar, Oman, Australia, Denmark, Germany, Sweden, Belgium, the US, Brunei Darussalam, Zambia, Malawi, Italy, and South Africa, for example: "Growing global investment in biomedical research is unlikely to result in outstanding science that benefits women and men equitably if current levels of conscious and unconscious gender bias in health research persist" (Ovseiko et al. 2016, 8).

[4]For more information about these groups and their activities, see their websites at http://srpoise.org/, https://jointcaucus.philsci.org/, and https://www.philosophy-science-practice.org/.

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

in addition to prevention of the same kinds of inappropriate factual investigations continuing in the future—and the question is most pressing in relation to our first illustration of the new worries about science and its various (racial, ethnic, LGBTQ, ablest, and other) analogues. In order to see this, start with a thought experiment. Imagine a race in which half the runners have been made to carry heavy weights on their shoulders and imagine that midway through the race there is a desire to make the race a fair one. What might be done to achieve this goal? One possibility would be to stop the race, take the weights off the shoulders of the runners who are carrying them, and then resume the race. This would hardly do the trick, however, for the disadvantage of the weights for the first half of the race would not have been overcome. A second possibility would be to stop the race, transfer the weights from the one group of runners to the other, and then resume the race. This would equalize the disadvantage of the weights for the two groups and thereby yield a fair race, but at the cost of treating the previously unweighted runners in the same cruel way the first group had been treated. By contrast, a third possibility would avoid this problem while still producing a fair race. It would be to give the previously weighted runners a head start for the second half of the race, providing an advantage to compensate for the previous disadvantage without harming the other runners in any way.

This last possibility is the idea of affirmative action elaborated during the era of civil rights legislation in Martin Luther King's 1964 book *Why We Can't Wait* and Lyndon Johnson's 1965 graduation address at Howard University. Both men used a race metaphor to make the justification of their idea clear. King framed it this way: "It is obvious that if a man is entered at the starting line of a race three hundred years after another man, the first would have to perform some impossible feat in order to catch up with his fellow runner." "Something special" needs to be done "'for' him now to balance the equation and equip him to compete on a just and equal basis" (King 1964, 165). Johnson framed the metaphor slightly differently: "You do not take a person who, for years, has been hobbled by chains and liberate him, bring him up to the starting line of a race and then say, 'you are free to compete with all the others,' and still justly believe that you have been completely fair. Thus it is not enough just to open the gates of opportunity. All our citizens must have the ability to walk through those gates" (Johnson 1965). In other words, to make the race of our thought experiment fair, the previously weighted runners have to be given "something special," some kind of head start after their weights are removed—enough of a head start that they "all … have the ability" to win, that is, are all now as likely to win the race as the other runners.

The above thought experiment helps us consider how we might deal with science's centuries old treatment of women and other marginalized groups. It suggests and at the same time offers an assessment of three possible responses. The first response amounts to removing all androcentric, racist, ablest, heterosexist, classist, and other unacceptable values from science (the weights on half the runners)—that is, amounts to replacing them with egalitarian values (all runners free of weights, in other words treated equally). Such a response would dramatically increase the gathering of facts serving the interests of women and marginalized men while still continuing the gathering of facts serving the interests of the previously privileged men. It would ensure that all future research would always generate information helpful to all—the prevention plan described previously (in the context of the second issue for philosophers of science to tackle). But like the first possible fix in our thought experiment, it would do nothing to overcome the disadvantages of the past—the huge inventory of facts gathered over the centuries that continue to serve the interests of only some while they undermine the interests of all the rest. The situation portrayed in this first response, in other words, would exactly correspond to the man in King's metaphor who starts a race three centuries after his fellow runner, although the time would be closer to four centuries for the women and marginalized men.

But what if the androcentric, racist, classist, heterosexist, and so on values of the past were replaced, now and for the next few centuries, not with egalitarian values but, instead, with estrocentric and other values privileging the previously unprivileged, leading to research focused on the previously unprivileged. The facts gathered would then be about *their* needs and experiences,

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

exploits and accomplishments, with methods and concepts and assumptions and questions supporting that aim. Like the second possible fix in our thought experiment, this *would* overcome the disadvantages of the past for all of these individuals, for it would eventually yield equal inventories of facts serving the interests of all. But it would do this at the cost of treating the previously privileged men in the same unconscionable way women and the other men had been treated in the past (and all too often are still treated now). Such an inegalitarian science, in short, would be as unacceptable as the present and past inegalitarian sciences.

This leaves the third possible response offered in our thought experiment, the affirmative action response, which seems to be the only acceptable response. It calls for an *epistemic* affirmative action program for science, one in which research serving the previously privileged would continue while research serving the others would be given extra advantages. The problem is that it leaves the nature of the extra advantages completely undefined. It also leaves undefined the conditions under which such an epistemic affirmative action program would be called for (whether it would apply, for example, to our other two cases, the ones regarding the Harper administration and the replication crisis). Working all this out would be the third of the new issues philosophers of science might fruitfully explore if they take seriously the new worries about science. And I have at least three reasons—the first three of the reasons previously given—for thinking that philosophers of science are up to the job of dealing with this third issue too.

The Choice

The new worries of scientists, then, raise three issues that philosophers of science can help to resolve: the scope of the problem regarding the factual basis of science these worries disclose, the way to prevent the problem from continuing in the future, and the way to rectify its occurrence in the past where such rectification is called for (including the conditions for determining when that is). Note how different all this is from the old worries of philosophers. Those worries called attention to a problem regarding the factual basis of science that only philosophers acknowledged, a problem that *seemed* (*to philosophers*) to threaten both the validity of science and the possibility of genuine scientific progress. The new worries, by contrast, call attention to a problem regarding the factual basis of science that scientists already acknowledge and that it is high time philosophers acknowledge, a problem that *actually* threatens both the validity of science and the possibility of scientific progress—genuine social as well as epistemic progress. I leave it to the reader to determine which worries should command more attention.

Acknowledgments. Early versions of this paper were presented at the Universidad de los Andes, Bogotá (published as Kourany 2020a) and the University of Alberta. I would like to thank the audiences at both universities for their very helpful questions and suggestions and their wonderfully lively discussions. I would also like to thank Ingo Brigandt and an anonymous reviewer for their extremely careful reading of the paper, their probing questions, and their astute recommendations for its further development.

Janet Kourany is associate professor of philosophy and concurrent associate professor of gender studies at the University of Notre Dame, where she is also a fellow of the Reilly Center for Science, Technology, and Values. Her research areas include philosophy of science, science and values, feminist philosophy, and ignorance studies.

References

Bacon, Francis. [1603] 1964. "The Masculine Birth of Time." In *The Philosophy of Francis Bacon*, edited and translated by Benjamin Farrington. Liverpool: Liverpool University Press.

Bacon, Francis. [1620] 1960. *The New Organon and Related Writings*. Edited by Fulton H. Anderson and translated by James Spedding, Robert Leslie Ellis, and Douglas Denon Heath. New York: Liberal Arts Press.

Bacon, Francis. [1627] 2008. *The New Atlantis*. Project Gutenberg EBook #2434. https://www.gutenberg.org/files/2434/2434-h/2434-h.htm.

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

Baker, Monya. 2016. "1,500 Scientists Lift the Lid on Reproducibility: Survey Sheds Light on the 'Crisis' Rocking Research." *Nature* 533 (May 26): 452–54.

Begley, C. Glenn, and Lee M. Ellis. 2012. "Drug Development: Raise Standards for Preclinical Cancer Research." *Nature* 483 (7391): 531–33.

Berger, Raymond. 1982. "The Unseen Minority: Older Gays and Lesbians." *Social Work* 27 (3): 236–42.

Biddle, Justin B. 2020. "On Predicting Recidivism: Epistemic Risk, Tradeoffs, and Values in Machine Learning." *Canadian Journal of Philosophy*.

Bird, Alexander. 2018. "Understanding the Replication Crisis as a Base Rate Fallacy." *The British Journal for the Philosophy of Science* (August 13) axy051. https://doi.org/10.1093/bjps/axy051.

Brigandt, Ingo. 2015. "Social Values Influence the Adequacy Conditions of Scientific Theories: Beyond Inductive Risk." *Canadian Journal of Philosophy* 45 (3): 326–56.

Bush, Vannevar. 1945. *Science, the Endless Frontier: A Report to the President*. Washington DC: US Government Printing Office.

Cannon, Lynn Weber, Elizabeth Higginbotham, and Marianne Leung. 1988. "Race and Class Bias in Qualitative Research on Women." *Gender and Society* 2 (4): 449–62.

Chung, Emily. 2014. "Foreign Scientists Call on Stephen Harper to Restore Science Funding, Freedom." CBC News, October 20. https://www.cbc.ca/news/technology/foreign-scientists-call-on-stephen-harper-to-restore-science-funding-freedom-1.2806571.

Douglas, Heather. 2015. "Reshaping Science: The Trouble with the Corporate Model in Canadian Government." *Bulletin of the Atomic Scientists* 71 (2): 88–97.

Dusenbery, Maya. 2018. *Doing Harm: The Truth about How Bad Medicine and Lazy Science Leave Women Dismissed, Misdiagnosed, and Sick*. New York: HarperOne.

Economist. 2013. "How Science Goes Wrong." *The Economist* (October 21). https://www.economist.com/leaders/2013/10/21/how-science-goes-wrong.

Editorial. 2012. "Death of Evidence: Changes to Canadian Science Raise Questions That the Government Must Answer." *Nature* 487 (July 19): 271–72. https://www.nature.com/articles/487271b.

Elliott, Kevin. 2017. *A Tapestry of Values: An Introduction to Values in Science*. New York: Oxford University Press.

Elliott, Kevin C. 2020. "A Taxonomy of Transparency in Science." *Canadian Journal of Philosophy*.

Engber, Daniel. 2016. "Cancer Research Is Broken: There's a Replication Crisis in Biomedicine—and No One Even Knows How Deep It Runs." *Slate* (April 19). http://www.slate.com/articles/health_and_science/future_tense/2016/04/biomedicine_facing_a_worse_replication_crisis_than_the_one_plaguing_psychology.html

Eysenck, Hans J. 1971. *The I.Q. Argument: Race, Intelligence, and Education*. New York: Library Press.

Ferber, Marianne A., and Julie A. Nelson, eds. 1993. *Beyond Economic Man: Feminist Theory and Economics*. Chicago: University of Chicago Press.

Fernandez Pinto, Manuela. 2018. "Democratizing Strategies for Industry-Funded Medical Research: A Cautionary Tale." *Philosophy of Science* 85 (5): 882–94.

Feyerabend, Paul. 1965. "Problems of Empiricism." In *Beyond the Edge of Certainty: Essays in Contemporary Science and Philosophy*, edited by Robert G. Colodny. Englewood Cliffs, NJ: Prentice Hall.

Gamble, Eliza Burt. 1894. *The Evolution of Woman, an Inquiry into the Dogma of Her Inferiority to Man*. London: G. P. Putnam's Sons.

Gero, Joan, and Margaret Conkey. 1991. *Engendering Archaeology: Women and Prehistory*. Oxford: Blackwell.

Goldenberg, Maya. 2015. "Whose Social Values? Evaluating Canada's 'Death of Evidence' Controversy." *Canadian Journal of Philosophy* 45 (3): 404–24.

Guttinger, Stephan. 2018. "A New Account of Replication in the Experimental Life Sciences." *Philosophy of Science* 86 (3): 453–71.

Hanson, Norwood Russell. 1958. *Patterns of Discovery: An Inquiry into the Conceptual Foundations of Science*. Cambridge: Cambridge University Press.

Hastings, Conn. 2017. "Are Replication Studies Unwelcome?" *Frontiers* (May 1). https://blog.frontiersin.org/2017/05/01/are-replication-studies-unwelcome.

Havstad, Joyce C. 2020. "Archaic Hominin Genetics and Amplified Inductive Risk." *Canadian Journal of Philosophy*.

Hoag, Hannah. 2011. "Canadian Research Shift Makes Waves." *Nature* 472 (269). https://www.nature.com/news/2011/110419/full/472269a.html.

Hoag, Hannah. 2012. "Canadian Budget Hits Basic Science." *Nature* (March 30). https://www.nature.com/news/canadian-budget-hits-basic-science-1.10366.

Holman, Bennett, and Sally Geislar. 2018. "Sex Drugs and Corporate Ventriloquism: How to Evaluate Science Policies Intended to Manage Industry-Funded Bias." *Philosophy of Science* 85 (5): 869–81.

Hooke, William. 2015. "Reaffirming the Social Contract between Science and Society." *Eos* 96 (March 17). https://doi.org/10.1029/2015EO026333.

Hubbard, Ruth. 1979. "Have Only Men Evolved?" In *Women Look at Biology Looking at Women: A Collection of Feminist Critiques*, edited by Ruth Hubbard, Mary Sue Henifin, and Barbara Fried. Cambridge, MA: Schenkman.

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

Jensen, Arthur R. 1985. "The Nature of the Black–White Difference on Various Psychometric Tests: Spearman's Hypothesis." *Behavioral and Brain Sciences* 8 (2): 193–263.

Johnson, Lyndon B. 1965. "*To Fulfill These Rights*" (commencement address, Howard University, June 4). https://teachingamericanhistory.org/library/document/commencement-address-at-howard-university-to-fulfill-these-rights.

Johnson, Paula A., Therese Fitzgerald, Alina Salganicoff, Susan Wood, and Jill Goldstein. 2014. *Sex-Specific Medical Research: Why Women's Health Can't Wait: A Report of the Mary Horrigan Connors Center for Women's Health and Gender Biology at Brigham and Women's Hospital.* https://www.brighamandwomens.org/assets/bwh/womens-health/pdfs/connorsreportfinal.pdf.

Kaplan, Sarah. 2017. "Six Months Later, the March for Science Tries to Build a Lasting Movement." *The Washington Post*, October 23. https://www.washingtonpost.com/news/speaking-of-science/wp/2017/10/23/six-months-later-the-march-for-science-tries-to-build-a-lasting-movement/?utm_term=.7f9d9fb22413.

King, Martin Luther Jr. 1964. *Why We Can't Wait*. New York: Harper & Row.

Kingston, Anne. 2015. "Vanishing Canada: Why We're All Losers in Ottawa's War on Data." *Maclean's*, September 18. https://www.macleans.ca/news/canada/vanishing-canada-why-were-all-losers-in-ottawas-war-on-data.

Kourany, Janet A. 2020a. "What Grounds Do We Have for the Validity of Scientific Findings? The New Worries about Science." In *What Is Scientific Knowledge? An Introduction to Contemporary Epistemology of Science*, edited by Kevin McCain and Kostas Kampourakis. New York: Routledge.

Kourany, Janet. 2020b. "Might Scientific Ignorance Be Virtuous? The Case of Cognitive Differences Research." In *Science and the Production of Ignorance: When the Quest for Knowledge Is Thwarted*, edited by Janet Kourany and Martin Carrier. Cambridge, MA: MIT Press.

Kourany, Janet. 2021. "Bacon's Promise." In *Science, Freedom, Democracy*, edited by Péter Hartl and Ádam Tamás Tuboly. New York: Routledge.

Krishna, Venni V. 2014. "Changing Social Relations between Science and Society: Contemporary Challenges." *Science, Technology, and Society* 19 (2): 133–59.

Kuhn, Thomas. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Likwornik, Helena. 2015. "Who's Afraid of the Big Bad Wolf? The Interweaving of Values and Science." *Canadian Journal of Philosophy* 45 (3): 382–403.

Linnitt, Carol. 2013. "Harper's Attack on Science: No Science, No Evidence, No Truth, No Democracy." A*cademic Matters* (May 30). https://academicmatters.ca/harpers-attack-on-science-no-science-no-evidence-no-truth-no-democracy.

March for Science. 2017. "The Science behind the March for Science Crowd Estimates." https://medium.com/marchforscience-blog/the-science-behind-the-march-for-science-crowd-estimates-f337adf2d665.

Mazure, Carolyn, and Daniel Jones. 2015. "Twenty Years and Still Counting: Including Women as Participants and Studying Sex and Gender in Biomedical Research." *BMC Women's Health* 15 (94). https://doi.org/10.1186/s12905-015-0251-9.

Meinert, Curtis L. 1995. "The Inclusion of Women in Clinical Trials." *Science* 269 (5225): 795–96.

Munro, Margaret. 2015. "Canadian Budget Pushes Applied Research." *Nature* 520 (7549). https://www.nature.com/news/canadian-budget-pushes-applied-research-1.17305.

Nosek, Brian. 2018. "Center for Open Science: Strategic Plan." https://osf.io/x2w9h/?_ga=2.229634078.387483559.1586144282-1348813086.1586144282.

Nosek, Brian A., Colin F. Camerer, Anna Dreber, Felix Holzmeister, Teck-Hua Ho, Jürgen Huber, Magnus Johannesson, Michael Kirchler, Gideon Nave, and Thomas Pfeiffer. 2018. "Evaluating the Replicability of Social Science Experiments in *Nature* and *Science* Between 2010 and 2015." *Nature* 2 (August 27): 637–44.

Oh, Sam S., J. Galanter, N. Thakur, M. Pino-Yanes, N. E. Barcelo, M. J. White, D. M. de Bruin, R. M. Greenblatt, K. Bibbins-Domingo, A. H. Wu, L. N. Borrell, C. Gunter, N. R. Powe, and E. G. Burchard. (2015). "Diversity in Clinical and Biomedical Research: A Promise Yet to Be Fulfilled." *PLoS Medicine* 12 (12), e1001918. https://doi.org/10.1371/journal.pmed.1001918.

Open Science Collaboration. 2015. "Estimating the Reproducibility of Psychological Science." *Science* 349 (6251).

Osborne, Newton G., and Marvin D. Feit. 1992. "The Use of Race in Medical Research." *Journal of the American Medical Association* 267 (2): 275–79.

Ovseiko, Pavel V., Trisha Greenhalgh, Paula Adam *et al.* 2016. "A Global Call for Action to Include Gender in Research Impact Assessment." *Health Research Policy and Systems* 14(50), https://doi.org/10.1186/s12961-016-0126-z.

Pedwell, Terry. 2012. "Scientists Take Aim at Harper Cuts with 'Death of Evidence' Protest on Parliament Hill." *The Globe and Mail*, July 10. https://www.theglobeandmail.com/news/politics/scientists-take-aim-at-harper-cuts-with-death-of-evidence-protest-on-parliament-hill/article4403233.

Perez, Caroline Criado. 2019. *Invisible Women: Data Bias in a World Designed for Men*. New York: Abrams Press.

Popper, Karl. [1935] 1959. *The Logic of Scientific Discovery*. London: Hutchinson. Originally published as *Logik der Forschung.* Vienna: Verlag von Julius Springer, 1935.

Price, Michael. 2011. "To Replicate or Not to Replicate?" *Science* (December 2). https://www.sciencemag.org/careers/2011/12/replicate-or-not-replicate.

Psillos, Stathis. 2015. "Evidence: Wanted, Alive or Dead." *Canadian Journal of Philosophy* 45 (3): 357–81.

Reid, Pamela Trotman. 1993. "Poor Women in Psychological Research: Shut Up and Shut Out." *Psychology of Women Quarterly* 17 (2): 133–50.

https://doi.org/10.1017/can.2020.34 Published online by Cambridge University Press

Rohe, Wolfgang. 2017. "The Contract between Society and Science: Changes and Challenges." *Social Research: An International Quarterly* 84 (3): 739–57.

Rosser, Sue. 1994. *Women's Health—Missing from U.S. Medicine*. Bloomington: Indiana University Press.

Schiebinger, Londa. 1999. *Has Feminism Changed Science?* Cambridge, MA: Harvard University Press.

Schiebinger, Londa *et al.* 2020. "Designing Health and Biomedical Research." *Gendered Innovations in Science, Health and Medicine, Engineering, and Environment*. International Collaborative Project. http://genderedinnovations.stanford.edu/methods/health.html.

Sheldrake, Rupert. 2015. "The Replicability Crisis in Science." *Nature* (September 1). https://www.sheldrake.org/essays/the-replicability-crisis-in-science.

Sherman, Linda Ann, Robert Temple, and Ruth B. Merkatz. 1995. "Women in Clinical Trials: An FDA Perspective." *Science* 269 (5225): 793–95.

Smith, Teresa. 2012. "Scientists Stage Mock Funeral to Protest Cuts to Research." *Canada.com*, July 11. http://www.canada.com/business/Scientists+stage+mock+funeral+protest+cuts+research/6913396/story.html.

Smith-Spark, Laura, and Jason Hanna. 2017. "March for Science: Protesters Gather Worldwide to Support 'Evidence.'" CNN.com. https://www.cnn.com/2017/04/22/health/global-march-for-science/index.html.

Weisman, Carol S., and Sandra D. Cassard. 1994. "Health Consequences of Exclusion or Underrepresentation of Women in Clinical Studies (I)." In *Women and Health Research*, vol. 2, edited by Anna C. Mastroianni, Ruth Faden, and Daniel Federman, 35–40. Washington, DC: National Academy Press.

Cite this article: Kourany, J. A. 2022. The New Worries about Science. *Canadian Journal of Philosophy* 52: 227–245, doi:10.1017/can.2020.34