The Pragmatic and the Religious Functions of Science

Matthew J. Brown*

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Introduction

"Science is like religion," it is sometimes said, or perhaps, "Science is merely another religion." In popular conversations, science and religion are equated for various reasons: to point out that science involves "believing where we cannot prove" (Kitcher 1983), or that it involves "faith" in some sense. In a more extreme register, it can be a nod to relativism, an argument that scientific "knowledge" is nothing more than a set of beliefs among other competing beliefs or knowledge-claims, none more valid than the rest. The science-as-religion idea is sometimes bolstered by philosophical arguments, such as a version of the thesis of underdetermination of theory by data, according to which radically different theories and assumptions can be equally well supported by the same empirical data. Those who attend to the social dynamics of science find analogies with religion as well, for instance, in the ways in which a scientist changing allegiance from one theory or research tradition to another resembles something akin to a "conversion experience" (Kuhn [1962] 1996), or in the degree to which political struggles among parties to a scientific controversy bears resemblance to disputes among members of different religious denominations. Call this idea, that science and religion are the same sort of thing, that science is a religion or like a religion, *science-as-religion*, or *religionism* for short; and the opposite view, that the two are inherently very different sorts of things, *anti-religionism*.[1]

This line of thinking runs up against a powerful objection: in a profound sense, unlike religion, *science just works*. That science is a highly pragmatically successful endeavor, enabling accurate and reliable powers of prediction and control, seems obvious. While not all sciences are equally successful in this

*Center for Dewey Studies, Southern Illinois University, matt.brown@siu.edu, http://matthewjbrown.net

[1]The terminology is not particularly apt, but no agreed-upon terms seem to exist. "Religionism" ordinarily means being strictly devoted to or even extremely zealous about a religion, but I do not mean to import that connotation here. Note also that this distinction is orthogonal to the usual debate in science and religion discussions about whether science and religion are in conflict, totally independent, or subject to harmonious integration.

regard, overall the scientific approach has proven to be pretty good at prediction and control of the world around us, while religion, whatever its benefits, offers no such practical track record. Science has given us incredibly precise predictions of astronomical, microphysical, and chemical phenomena, as well as medical, transportation, communication, and computational technology beyond the imaginings of prior generations. For many, this is the primary way to understand the significance of science: the primary function of scientific methods, theories, laws, models, techniques, etc. is to enable us to predict and control the parts of the world that interest us. Let us call this "the *pragmatic function* of science." That it is an important function of science is clear and relatively uncontroversial.

A more controversial, extreme *pragmatism* would argue that this primary function of science is also the whole story with science; according to such a pragmatist, science just *is* problem-solving inquiry that helps expand our ability to predict and control the world around us when our habits and practices fail us.[2] Even in the realm of so-called "pure" or "basic" science that seems to have little practical applicability, there is often a very high degree of precise and accurate prediction and ability to create and manipulate phenomena. While the bizarre subatomic particle behaviors that are exhibited in high-energy supercolliders seem to have little use on a practical level, the pragmatist can still insist that our theories predict their behavior with a high degree of accuracy and our experimentalists can manipulate and control that behavior in highly specific ways. Likewise, our ability to predict astronomical phenomena goes well beyond our practical needs for calendar-making or space travel into realms with no practical significance that we currently anticipate.

What the pragmatist lacks is an account of those aspects of science that are not closely connected to our practical capacity to predict and control. In other words, the pragmatist seems unable to explain both inquiry that is governed by standards and values orthogonal to predictive and experimental precision and accuracy, including as the crafting of grand theories of universal scope that synthesize many of the local achievements of a scientific field. Scientific *realists* have pointed to these gaps as examples of the inadequacy of this sort of pragmatism. According to scientific realism, the aim of science is to produce a true picture of the world, and the picture of the world it has produced deserves our belief, at least in most of its details.[3] Some pragmatists have fired back against the realists dismissively, arguing that the aspects of science that exceed

[2]Pragmatic approaches to science of various sorts are enjoying renewed attention in philosophy of science. Some argue that pragmatic and contextual factors determine the amount of evidence necessary to justify a claim (Miller 2014). Others argue that pragmatic factors and values largely determine the aims of science Kitcher (2011). Pragmatic accounts are now popular in the analysis of laws of nature and causation (Mitchell 1997; Andersen 2017), scientific explanation (Douglas 2009), and scientific progress (Douglas 2014; Kitcher 2015). Not all such pragmatists are committed to the extreme version of pragmatism described above. In my book *Science and Moral Imagination* (2020), I set out an account of empirical science as problem-solving inquiry that enhances our practices of prediction and control in response to problematic situations. I follow Dewey quite closely in this respect. I am even tempted by a version of the much-maligned pragmatist theory of truth (see Brown 2015).

[3]See Chakravartty (2017) for a thorough introduction to the varieties and complexities of scientific realism.

the concerns of prediction and control are merely metaphysical or religious claptrap, a failure of the Enlightenment to carry out the project of disenchantment of the world thoroughly enough. This "disenchantment" was theorized by Max Weber as a process that began with the tendency of Abrahamic monotheism to eliminate magic and ritual, and continued with the scientific secularization and rationalization of the world (Mishima 2020). In Weber's words: "It means that in principle, then, we are not ruled by mysterious, unpredictable forces, but that, on the contrary, we can in principle *control everything by means of calculation*" (Weber 1917/2004, 12–13; see Mishima 2020).

What is at stake, then, between the scientific realist and the pragmatist are competing conceptions of humanism. The realist seeks a rational, scientific alternative to the religious-metaphysical worldview of "mysterious, unpredictable forces," gods, spirits, souls, magic, or miracles. It seeks to substitute a worldview composed of unseen laws of nature, forces, fields, fundamental particles, quarks, strings, etc. The extreme pragmatist sees this quest as itself of a piece with rather than a true overcoming of the religious-metaphysical worldview; metaphysics comes from a longing for the unseen, "really true" world in both cases, rather than a disenchanted world in which everything that *is* is in principle a potential subject of our control.

Religionists would, in a sense, agree with the pragmatist response against the scientific realists, though not with its pejorative tone: when we take science to produce a metaphysical worldview, science is playing the role of a religion. According to the religionists, the scientific realist illegitimately uses the pragmatic success of the parts of science concerned with practical prediction and control (what is often called "applied science") to argue for the status of a naturalistic, scientific worldview. But this is a kind of bait-and-switch; the local practices of prediction and control that are highly successful in science are only loosely connected with the grand-scale synthetic theorizing of the scientific worldview. The superiority of the scientific worldview over religious thus cannot be defended on the basis of the pragmatic successes of science.

In this chapter, I attempt to broaden the pragmatist approach in a way that threads the needle between the different concerns of the realists and those who are for and against the thesis of science-as-religion. I will argue that in addition to its pragmatic function, science also has a religious function; here I use "religious" in an entirely non-pejorative sense. This "religious function" of science explains the significance of the grand synthesizing of the scientific worldview that has no (direct) pragmatic value of its own. I will attempt to provide a pragmatic defense of this aspect of science by drawing on classical pragmatist philosophies of religion. The writings of William James and John Dewey on religion give us a way of assimilating the value of the religious function of science to a broadly pragmatist philosophy of science, thus answering rather than dismissing the concerns of the realist about the completeness of a pragmatist philosophy of science. The classical pragmatists give us a way to think of the religious function of science as a positive contribution to the construction of a naturalist, humanist worldview that is desperately needed in the present era, without an illicit argument based on the empirical successes of science.

I will first explore in greater detail what realist philosophies of science have found missing in narrowly pragmatist philosophies of science. I will argue that there are ultimately three sorts of things for the pragmatist to worry about: (1) apparently useless science, (2) non-pragmatic epistemic criteria for evaluating scientific claims, and (3) the construction and status of scientific worldviews. Next, I will explore each of these aspects of science in turn, arguing that only the third poses any real difficulty for the pragmatist. Then I will explore ideas from classical pragmatist accounts of the pragmatic function of religion, which will allow me to conclude by articulating a positive religious function for science in our society on pragmatist grounds.

What Needs to Be Explained

Science, in fact, gives us great powers of prediction and control. What more should we want from science? What is it, exactly, that the realist thinks science does that the pragmatist cannot explain? Scientists and philosophers of a realist bent have regularly insisted that we should want more, much more, from science than mere pragmatic success in prediction and control, and that science can or does deliver such things.

One common refrain is that what is central to scientific progress is *basic* or *pure science*, the pursuit of scientific knowledge wholly independent from our practical aims, interests, and activities. Such science pursues or arrives at *Truth* in the sense of accurate representation of *Reality*, or at least knowledge of the *deep structures* or *unobservable features* of our world. Science aims at, and its success is judged by, not only increasing success in prediction and control, but also increasing our power of explanation and understanding of the world, judged according to a set of *explanatory* or *superempirical virtues* or *epistemic values*; these virtues or values guide inquiry as much as the pragmatic ones, says the realist. Ultimately, the goal is not just instrumental, but to arrive at a full *scientific world-conception* or *worldview* in which we can understand the universe and our place within it. Indeed, realists commonly argue that the high degree of predictive, experimental, and technological success science has achieved would be a *miracle* if its theories were not in fact tapping into *deep truths* about the nature of the world beyond our senses.

It is generally thought that this set of values, aims, goals, and achievements cannot be accounted for by the pragmatist. Let us try to get clear about what, exactly, the lacunae are supposed to be, and then determine which pose genuine problems for the pragmatist.

As a preliminary point, while some pragmatists of the past may have been committed to philosophical views that would prevent them from acknowledging that science posits unobservable entities, the contemporary pragmatist has no such compunctions. If electrons, quarks, markets, mental states, laws, kinds, or what have you play significant roles in bodies of knowledge that enhance our abilities to predict and control, many contemporary pragmatists have no qualms about them as objects of knowledge realistically construed. There is no reason

that the pragmatist need be a strict empiricist. Indeed, the classical pragmatists frequently criticized the traditional empiricists for their view of experience; rather than understanding experience as composed of atomic sense-data (a bundle of independent and simple sensations like color and shape), the pragmatists saw experience as having depth, structure, and continuity. There's no reason that a pragmatist cannot say, first, that our main contact with electrons concerns what they can help us predict and control, and second, that on that basis we understand them as real elements of the furniture of the world.

Preliminaries out of the way, there are three challenges to the pragmatist in accounting for these aspects of science that seem to go beyond mere prediction and control.

First, there there is the question of "pure" or "basic" research with no obvious or immediate applicability. In such cases, scientists are surely doing scientific inquiry, and that inquiry is aimed at expanding our powers of prediction and control; but being able to predict and control those particular phenomena serves no particular use that we can foresee. That might be because the objections of that research are distant in time (paleontology and the biology of dinosaurs) and space (astronomy and the distant stars and galaxies). It might be because there is nothing inherently interesting about the subject to anyone but the scientists who study it, perhaps because it is too removed from our common experience and no technological application has been conceived (much recent high energy particle physics). It might be because the nature of the phenomenon forbids fine-grained prediction or any intervention whatsoever, such that no utility is on offer (physical cosmology). How can the pragmatist account for the value of such inquiry?

Second, there is the question of virtues, values, standards, or criteria for science that go beyond the pragmatic concerns of prediction and control. We can think about this challenge in a few different ways. Such superempirical epistemic standards might include things like a scientific theory's explanatory power, simplicity, unifying ability, or fruitfulness for future research. Some have tried to give pragmatic justifications for these standards, arguing for example that they make a theory easier to use, and thus more testable. In this case we reduce the supposed nonpragmatic virtues to pragmatic ones. Some would argue that such standards come in only when the evidence has run out, when empirical and pragmatic factors underdetermine theory choice. If we hold that these superempirical standards are on a par with pragmatic and empirical criteria, then there may be contexts where we choose less accurate and less "useful" theories, because, say, they provide simpler, more unifying explanations. (If we would never do this, then those standards are not actually on a par, and the challenge to the pragmatist is minimized.) If choosing such theories is a reasonable way to proceed, the pragmatist must be able to account for it.

Third, there is the question of scientific worldviews. What I will call "construction of a scientific worldview" is an important part of the creative and constructive activity of science that does not consist of empirical inquiry into specific phenomena. Scientific theorizing also involves synthesizing across a wide range of empirical inquiries, in order to provide a larger picture of the universe

(and our place in it). This form theory-construction typically builds on past achievements of observational and experimental research, but it need not and often does not have much direct contact with empirical inquiry itself. The grand theorizing by figures like Newton and Einstein sometimes have such a character; so does the work of synthetic popularization by figures like Gould, Dawkins, Hawking, and Sagan. Sometimes this work inspires, redirects, or guides future empirical inquiry, and so in retrospect its pragmatic value seems clear. In other cases, often the most ambitious cases of such work, the connection to particular empirical inquiries remains tenuous. The significance of the latter seems very difficult for the pragmatist to explain.

In what follows, corresponding to the three challenges laid out above, I seek to provide some basic evaluation from within a broadly pragmatist point of view of the following:

1. Scientific inquiry that is "useless."
2. Scientific inquiry guided or judged by standards other than prediction and control.
3. The construction of a "scientific worldview".

In the following three sections, I will explore these three topics in turn. As we will see, the first two of these challenges can be handled in a relatively straightforward way. The third challenge, however, will require us to explore in depth pragmatist views about religion and humanism in order to fully assimilate the positive significance of scientific worldviews into a pragmatist approach.

The Pragmatic Value of "Useless" Science?

In a way, ironically, those inquiries that are supposedly impractical are the easiest for the pragmatist to account for. The results of a scientific inquiry may not be "useful" in the narrow sense of immediate applicability in medicine, engineering, or policy; but nevertheless, as genuine inquiry, it might be governed by the broadly pragmatic criteria of prediction and control. Still, insofar as the pragmatist emphasizes the increase in our prediction and control of phenomena *that interest us*, there remains a problem of accounting for why we would be interested in such recherché phenomena as basic science often tackles, such as the biology of prehistoric creatures, or the behavior of distant stars.

In "Genuine Problems and the Significance of Science" (Brown 2010), I worried about this issue in the context of thinking about Philip Kitcher's (2001) account of "scientific significance" and the aims of science. According to Kitcher, the "significance" of a scientific problem or scientific inquiry can be understood as its place in a network of interconnected aims and projects, and the grounding points in this network, from which all significance ultimately flows, are obvious practical uses, on the one hand, and questions of what he calls "natural curiosity," on the other.

Consider the work of an auto mechanic. A mechanic is an inquirer, engaged in problem-solving in relation to diagnosis and repair of malfunctioning vehicles.

The work is not quite scientific, although it is notoriously difficult to draw such lines, but it draws on some science and engineering knowledge, design specifications of the vehicle, manuals, heuristics and rules of thumb, intuition hard-won by experience, and a good bit of guess-and-check. It is typically pretty unsystematic, ad hoc, in response to the specific case in front of the inquirer.

Suppose the auto mechanic consistently runs up against a problem that cannot be solved with the resources available to them. After reflecting on the pattern of failures, they determine that the source is not in a lack of skill or knowledge on the part of the mechanic, but with some principle of engineering that they regularly rely upon. In most circumstances, this principle helps the mechanic in the repair of diverse automobile engines. But in a certain number of cases, their inquiry fails, and no successful repair can be made. Most mechanics would just accept that some cars cannot be fixed, but our mechanic is particularly dogged, and becomes so consumed with the solution to the problem that they go to school for an engineering degree, hoping to determine its source, and so becomes eventually a working researcher revising the very principles of engineering that they once used as a mechanic.

Suppose our newly-minted engineering researcher consistently runs into trouble when dealing with particular principles learned from basic physics. Often those principles serve them well, but on certain occasions forming a pattern, they fail to aid the engineer in their inquiry. Our engineer reads more and more about the physics involved and realizes that the ultimate source of the problem is a gap in our knowledge of physics, finally pursuing another degree in that field so as to work on revising our understanding of the laws of physics.

In this fantasy story, we see how the work of a physicist might have traceable lines to the work of the engineer, even the auto mechanic—and such lines (understood conceptually rather than embodied in a single person) are part of the story of significance for Kitcher. But other work in physics does not seem to have such clearly traceable lines. Nevertheless, the physicists working on problems without such traceable lines of connection to practical concerns are drawn those problems as much as our fantasy mechanic-turned-engineer-turned-physicist. According to Kitcher, there are some kinds of questions about the nature of the world, life, and human nature that we are all naturally curious about. A similar story as above could be told in terms, not of practical inquiries, but of these questions of natural curiosity. According to Kitcher, for even very seemingly abstract and technical scientific inquiries, we can trace their significance back to a combination of all the practical problems and questions of natural curiosity that they bear on in some way. The amount and strength of such connections helps us compare the significance of different scientific projects.

The concern I raised in my earlier paper in response to Kitcher was that when we start weighing the value of different projects, on Kitcher's view, and we have to rank projects that might, for example, contribute to reducing worldwide deaths from malaria (or cancer or COVID-19) with projects that mainly satisfy our "curiosity," the latter would be totally swamped. "Curiosity" seems inadequate to defend anything like a robust program of basic research whose significance is largely basic knowledge rather than practical results, given the wide range

and depth of immediate practical needs that scientific inquiry might help us meet. In other words, Kitcher's account of significance seemed to me unable to provide the defense of basic research that he seemed keen to provide. So, although Kitcher's account seeks to defend basic research with little practical application on the basis of our natural curiosity, it seems like his account will systematically devalue it in favor of practically significant inquiries.

Perhaps this devaluation is the right approach, though. After all, when it comes to possibly saving human lives or satisfying our curiosity about whether megafauna from tens of millions of years ago had feathers, does it not seem inhumane to prefer the latter? When these trade off, should we not obviously prefer the former? The pragmatic point of view seems to be understood that way.

Scientists develop conceptual, material, explanatory, and methodological resources in systematic ways. They are often driven by the existence of a difficult puzzle that only a specialist can understand *as* a puzzle. Some of these have the sort of obvious lines of relevance to practical problems that I've described above. Other puzzles may only have relevance later, when systematic generalization of the puzzle solution is achieved, and the practical payoff can be seen. Vannevar Bush made a strong claim that basic science would inevitably yield useful byproducts. At the same time, he held that scientific progress depended on it being unconstrained by a focus on practical results: "Scientific progress on a broad front results from the free play of free intellects, working on subjects of their own choice, in the manner dictated by their curiosity for exploration of the unknown" (Bush 1945). In this strong form that guarantees progress and applicability from unconstrained basic research, this argument is untenable, because often basic research fails to translate to application, while mission-driven, applied research is much more fruitful on its own than Bush would admit (Sarewitz 2016). Still, this is one path by which seemingly useless science sometimes proves its use, through unanticipated future application, even when Kitcher's "lines of significance" cannot be traced beforehand.

Perhaps part of the problem concerns the way that we think about what is or isn't "useful." There is a tendency, under the regime of neoliberal capitalism, to assimilate the "useful" to the economically productive; to see scientific knowledge as useful if it contributes to technology that sells or to technocratic solutions to policy problems. Here, turning the classical pragmatist philosophy and particularly Dewey's reflections on the concept "useful" provides a crucial corrective. In *Art as Experience*, Dewey writes:

> Wherever conditions are such as to prevent the act of production from being an experience in which the whole creature is alive and in which he possesses his living through enjoyment, the product will lack something of being esthetic. No matter how useful it is for special and limited ends, it will not be useful in the ultimate degree—that of contributing directly and liberally to an expanding and enriched life. The story of the severance and final sharp opposition of the useful and the fine is the history of that industrial development through

> which so much of production has become a form of postponed living and so much of consumption a superimposed enjoyment of the fruits of the labor of others. (Dewey 1934b, 10:33–34)

And again in *Experience and Nature*:

> The existence of activities that have no immediate enjoyed intrinsic meaning is undeniable... So we optimistically call them "useful" and let it go at that, thinking that by calling them useful we have somehow justified and explained their occurrence. If we were to ask useful for what? we should be obliged to examine their actual consequences, and when we once honestly and fully faced these consequences we should probably find ground for calling such activities detrimental rather than useful.
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> We call them useful because we arbitrarily cut short our consideration of consequences. We bring into view simply their efficacy in bringing into existence certain commodities; we do not ask for their effect upon the quality of human life and experience. They are useful to make shoes, houses, motor cars, money, and other things which may then be put to use; here inquiry and imagination stop. What they also make by way of narrowed, embittered, and crippled life, of congested, hurried, confused and extravagant life, is left in oblivion. But to be useful is to fulfill need. The characteristic human need is for possession and appreciation of the meaning of things, and this need is ignored and unsatisfied in the traditional notion of the useful. (Dewey 1925, 1:271–72)

Here Dewey captures and responds to a common misconception of pragmatism and "instrumentalism," and helps us resolve some worries about "useless" inquiries and the value of curiosity. Dewey points out that the definition of "useful" must be situated not in the demands of capitalist modes of production, but within human experience, where what is useful concerns not only survival but flourishing. In this sense, delight, wonder, the enjoyment in finding a clever solution to a difficult puzzle—are all definitely useful, perhaps even more useful than those results that "contribute" in an economic sense. In any case, insofar as scientific practices of inquiry enable forms of prediction and control that contribute to the enrichment of life and experience, our "appreciation of the meaning of things," then they are useful and significant.[4]

Non-Pragmatic Criteria in Science

Some philosophers of science insist that there are standards or criteria for hypothesis acceptance or theory appraisal that are independent from the criteria

[4] It is worth noting that this expansive notion of usefulness starts to pull against the intuition that science is *unique* in how well it works. However, I think this is to the best; though science is particularly useful in certain respects, so are art, literature, activities of communal life, and perhaps even certain religious practices.

of successful prediction and control and that these nonempirical criteria may in some cases supplement or even outweigh empirical prediction and control. In some cases, it is taken as simply a brute fact about science that it answers to such nonempirical standards or "epistemic values" (Kuhn 1977). Others see these "superempirical virtues" as independent grounds for belief in the truth of a scientific theory, and thus part of a robust case for scientific realism (Churchland 1985). My response here will be relatively brief: these claims are largely confused; either the criteria in question reduce to or are instrumental to prediction and control; or they are not criteria that guide genuine scientific inquiry and belief.

One version of the idea of non-pragmatic criteria for science is simply that science aims at *more* than prediction and control, it aims at *truth*. Another version is that certain superempirical epistemic standards or values are valuable *because* they are truth promoting. We could mean two things here by "truth." One thing we might mean is *true predictions* of observation and experiment. This is just to restate the claim that science aims at prediction and control, rather than being an alternative to it.[5] Or we can mean truth in a broader sense, the truth of the whole theory in all its parts, not just the truth of the predictions it makes. Truth in this sense by definition exceeds prediction and control; but also truth in this sense cannot be considered an independent *aim* or *standard* for anything. Our only means of assessing whether we have come near to the truth in this sense is our assessment of the success of theories in facilitating successful prediction and control. We have no additional access to the truth, no way to aim at it, other than through our most successful science.[6]

This is not to deny that science achieves the truth sometimes; that is a separate issue. Nor is it to deny that science might aim *indirectly* at the truth, by aiming at successful prediction and control.[7] But the idea that science *aims* at truth directly and independently as such is a misunderstanding of what an *aim* is. To be able to aim at something, one must have some sense of how the aim might be achieved, how to recognize whether the aim has been achieved, or whether one is moving close towards achieving the aim, however indirectly. In the case of truth in a sense that goes beyond accurate prediction, we cannot meet any of these requirements (Laudan 1984, 137). If truth means that our theory accurately pictures the "underlying reality" beyond our concepts and observations, then we have no way of getting outside of our experience and conceptual frameworks to compare the picture with what is pictured. Likewise, if we want to know whether certain superempirical virtues of theories are truth-promoting, not in the sense of enabling better prediction and control, but in the broader sense, we have no independent grounds to answer this question. At best, we can say either that theories with such virtues tend to have characteristics that match

[5] Steel (2010) for example defines epistemic values in terms of truth-promotion, but argues that accurate prediction is all that such values need to promote, and so that epistemic values are independent of the issue of scientific realism. By contrast, Churchland (1985) specifically understands there to be a range of truth-promoting epistemic values that are orthogonal to predictive accuracy, and ties them to a realist framework.

[6] See arguments to this effect in Laudan (1984); Putnam (1981); Putnam (2002)

[7] Though for reasons parallel to those I describe here, I find this idea dubious.

our assumptions about what the world is like, or that they are instrumental to better prediction and control of phenomena.

An argument from the pragmatist philosopher Charles S. Peirce suggests a third option for thinking about truth as an aim (or in his terms, "regulative ideal") of science. According to Peirce, the truth is whatever belief scientific inquirers would tend to settle on in the long run of inquiry; a belief (result, hypothesis, theory) is true if it would withstand testing and evaluation to every test scientific inquirers might subject it to, without falling into doubt. This is sometimes taken to be a pragmatist definition or theory of truth, and often not considered a plausible one.[8] It is probably better understood as an elucidation of the relations between truth, belief, and inquiry (Misak 2004). This is of a piece with various other attempts by pragmatists to redefine or elucidate truth in ways that make it a tractable aim: as successful belief (James), as unrevised in the ideal limit of inquiry (Peirce), warranted assertibility (Dewey),[9] or ideal rational acceptability (Putnam 1981). This pragmatist line intrinsically links truth to success in prediction and control, rather than treating it as an independent goal or standard.

One could also understand the long-run achievement of truth as a substantive claim rather than a definitional move: if there is a truth of the matter, then scientific inquiry, taken to indefinite lengths, would settle upon it. The long-run success of science is thus evidence that science aims at truth. This is a common claim of the scientific realist. However, truth in any of these senses is, again, not an aim that inquirers could have in view *instead of* successful prediction and control. Rather, the claim is that in thoroughly exploring improvements to successful prediction and control, inquirers get the truth, in the long run. In this way, "truth" is aimed at only indirectly, through the pragmatic aims of prediction and control. The former does not provide independent standards of evaluation.

Some philosophers of science have argued for certain non-pragmatic standards for scientific inquiry as being intrinsic scientific criteria in their own right. Thomas Kuhn, for example, articulates five criteria for good scientific theories: "accuracy, consistency [with other theories], scope [of phenomena encompassed by the theory], simplicity, and fruitfulness [for future research]" (Kuhn 1977).[10] The first, accuracy, is just another term for predictive success. The other four are ambiguous: they might be understood purely as features of the theory or relations between theories, or they might be understood as characterizing relations between theory and evidence (Douglas 2013). Simplicity understood as a feature of a theory might be characterized ontologically (number of theoretical posits required), mathematically (as a property of the equations or models constituting the theory), computationally (in terms of the difficulty of making

[8] See Quine (1960), Ch 1 for a sympathetic rejection.

[9] Actually, Dewey's view is more complicated. See Brown (2015).

[10] As with other aspects of his theory of science, Kuhn is here somewhat ambiguous about whether this is a normative claim (these standards characterize a good scientific theory) or a descriptive one (these are the criteria used in typical scientific practice). It will be most useful for our purposes to interpret them normatively.

calculations), or otherwise. Understood as a relation between theory and data, simplicity means that the theory has a lower degree of complexity than the evidence it covers (Douglas 2013, 799).[11] If these non-pragmatic standards (also called epistemic standards, superempirical virtues, epistemic values, or cognitive values) are ways of characterizing the relation between theory and evidence, then meeting them is either instrumental to greater success in prediction and control, or they pick out a particular type of prediction or control as particularly valuable. They do not constitute a standard *independent* from success in prediction and control. On the other hand, if we conceive of standards like simplicity as inherent properties of theories independent of their relation to evidence, then such standards cannot be *criterial* for science at all.

To sum up what has been said so far, we have considered two types of scientific inquiry that at first glance seem not to fit the pragmatists' account of science: "useless" science that lacks immediate applicability, and science guided by non-pragmatic criteria. In both cases, we have found that the pragmatist can fully accommodate the value of the relevant science while clearing up certain misconceptions. But not all scientific activity can be understood as problem-solving inquiry directed at our capacity to predict and control. Much of the science that we find really inspiring, that informs both public understanding of science and science education, consists of attempts to synthesize and build on the results of pragmatic inquiry in order to understand *how it all fits together*. I will group such attempts under the traditional heading of "the scientific worldview" or "scientific worldviews" in the plural; it is these that constitute the greatest lacuna for the type of pragmatism under discussion here.

Scientific Worldviews

Religionists are often inclined to see the tension between science and religion in terms of a clash between very different worldviews. "The Scientific Worldview" is variously depicted in terms like materialism, mechanism, determinism, and reductionism, and as opposed to ideas like spirituality, idealism, magic, and miracles. An early exemplar of scientific worldview-building is René Descartes' treatise *The World*, written between 1629-1633 and published posthumously (Descrates 1677/1998). The book combines epistemology, physics, biology, and metaphysics to paint a picture of an entirely mechanical understanding of the physical world encompassing the nature of matter and light, astrophysics, living organisms, and the mechanics of perception (with room, however, for God and the rational soul). Descartes sought to provide a complete and systematic alternative to the worldview late medieval philosophers had created in synthesizing Aristotle and Christianity; in the process he synthesizes new scientific research and ideas with his own creative speculations. Many scientists, philosophers, educators, and

[11] If it seems difficult to disentangle simplicity understood this way from scope, that is no accident: "A theory that has broad scope over diverse evidence is also simple with respect to that diverse evidence, unifies that diverse evidence, and has explanatory power over that evidence" (Douglas 2013, 803).

popularizers have followed in Descartes' footsteps, attempting to build on the latest science to create a comprehensive account of the nature of the world.

How are the various results of science synthesized into a scientific worldview? It is a more difficult and complex matter than it may seem. On the ground, we see diversity and disunity in science. Science involves a hodgepodge of approaches, theories, concepts, and conflicting results. A frank survey of everything *actually* going on in science shows that it provides no single map of reality, that it has little or no overall organization to its theories and methods, that inconsistencies abound (see Feyerabend 1999; Dupré 1993; Galison and Stump 1996; Kellert, Longino, and Waters 2006). Even fundamental physics contains different approaches that are apparently inconsistent and so far resist combination into a successful, testable theory. Beyond the realm of theoretical physics, we're in even more of a mess. On a pragmatic and contextual account of science as problem-solving inquiry, aimed at prediction and control of phenomena that interest us, this is not much of a surprise. We might well expect science to be as diverse as our interests. In everyday science, there is no need to take it all together—specialization and contextualism help us keep the mess in hand, and localized conflicts are a spur to further inquiry.

But all this plurality, as Paul Feyerabend aptly pointed out in his later work (Feyerabend 1999), problematizes the notion of *the* scientific worldview. One way we might articulate "the scientific worldview" would be a thorough survey of this mess, a list of achievements, gaps, and internal clashes. This would be pretty convoluted, to put it mildly, not to mention self-contradictory, and it would not do the job the scientific worldview is thought to do; when we ask how it all fits together, we expect something more than *concatenation* in response. Instead, we need to ask what happens when we try to create, from a survey of this mess, a single, coherent worldview. Thanks to the messy reality of scientific practice, any attempt to craft a coherent worldview based on science is not a straightforward matter.

The construction of a scientific worldview has three features. (1) it is *selective*; it leaves a lot out, and emphasizes certain aspects of science over others. (2) it is *constructive and creative*; it stitches the remaining pieces together into a coherent and compelling story. Finally, (3) it is *philosophical*; it is part of metaphysics or ontology, not on the same footing as ordinary scientific inquiry, whose warrant is largely connected to situations of practical problem-solving and successes in prediction and control. It goes beyond particular empirical problems to paint a grand picture, but not a uniquely compelling one. In other words, the scientific worldview cannot be read off of science directly, but must instead be constructed by creative, philosophical interpretations that select certain elements of science for emphasis. Because there is a degree of free choice in deciding how to construct a worldview from the materials of science, it is probably best to think about this in terms of multiple, potentially competing scientific worldviews in the plural.

Any worldview has consequences for our lives, hopes, and sense of purpose. In *Science and Moral Imagination* (2020), I describe worldviews as "complex evaluative standpoints where particular valuations are tied up with more general

ideals, principles, and institutions, as well as factual beliefs, theoretical claims, and metaphysical commitments" (142). This emphasizes the fact that our sense of how it all fits together is never a neutral, disinterested matter, but one that touches on questions about the meaning of human life and our place in the world. This connection should come as no surprise to those familiar with constructions of scientific worldviews. Many of the most creative articulators and passionate defenders of versions of the scientific worldview—such as Jacques Monod, Carl Sagan, Richard Dawkins, Jerry Coyne—have explicitly drawn out moral or political lessons, or have argued that the scientific worldview challenges not only earlier ideas but traditional *ways of life*.[12]

As such, scientific worldviews closely connect with the traditional function of myth or religion, and a scientific worldview will have to compete with other worldviews—traditional religious, speculative philosophical, and alternative interpretations of science. These worldviews, because they are so loosely connected to the pragmatic dimensions of science, will be judged less by typically scientific standards than by philosophical, aesthetic, and ethical ones.

Why do we need a scientific worldview at all? What is the pragmatic value of such a thing? Why should we not simply rest content with the various results of particular scientific inquiries, and leave these further questions to theologians and metaphysicians (or perhaps just leave them alone)? I think there is a story for the naturalistic pragmatist to tell about why we should want a well-crafted scientific worldview. To tell it, I turn to what might seem like an odd source: pragmatist analyses of religion and religious experience.[13]

Pragmatist Accounts of the Religious

Recall a part of the quote from Dewey's *Experience and Nature*, above: "The characteristic human need is for possession and appreciation of the meaning of things" (272). We can join this to a statement from Dewey's pragmatist forerunner James that "the life of religion... consists of the belief that there is an unseen order, and that our supreme good lies in harmoniously adjusting ourselves thereto" (James 1902, 53).[14] This starts to give a flavor of the classical pragmatist philosophy of religion. According to James and Dewey, religion speaks to deep needs in human life and experience, for *meaning* on the one hand and *guidance* on the other. Insofar as religion allows us to understand and appreciate the meaning of things and to adjust ourselves to the world in a way that promotes the good, it thus performs a pragmatic function.

These pragmatist thinkers draw a distinction between two aspects of religion

[12]See also recent analyses of the ways in which the Vienna Circle's "Scientific World-Conception" is tied up with their political projects, such as Romizi (2012), and chapters 5 and 6, this volume.

[13]I do not mean here pragmatic arguments for theistic belief of the kind found in Pascal and James, which encourage belief in god on practical grounds. Whatever the merits or demerits of such arguments, I focus here instead on the views of James and Dewey on the role that religions and the religious play in human life and experience.

[14]See the interesting commentary and discussion of this quotation by Grinnell (2009), p. 163.

as ordinarily understood. On the one hand, there is institutional religion. Both thinkers exclude the institutional side from their positive account of the value and function of religion. They considered organized religion a secondary development that at best did not get at what was centrally important about religion; at worst, they saw religious institutions as tied to "creeds and cults" that interfered with the expression of religious experiences and values (Dewey 1934a, 9:21). On the other hand, there is what James calls "personal religion" and what Dewey calls "the religious," which they see as playing a positive role in helping us understand the world and our place in it, thereby providing a solution to our uneasiness about ourselves and our standing in the world, as James puts it (James 1902, 508).

Where James and Dewey differ is on the question of whether the *supernatural* is an essential feature of religion. For James, religion requires not only some "unseen order," but a mystical or supernatural order that resonates with the "higher part" of our own being (James 1902, 508). On a Jamesian account, then, it seems doubtful that a scientific worldview could perform the religious function. Dewey believes, on the contrary, that supernaturalism is an addition to the religious from the institutional side of religion; and that we can liberate the religious to better function in our lives by removing the supernatural accretion.

Supernatural belief hardens into dogma as a result of institutional forces; Dewey explores this claim at length in *A Common Faith* (1934a). But supernaturalism has its origins, not as a primitive attempt at science or philosophy, but in an aesthetic urge, Dewey argues in *Art as Experience*:

> Were the hold of the supernatural on human thought an exclusively—or even mainly—intellectual matter, it would be comparatively insignificant. Theologies and cosmogonies have laid hold of imagination because they have been attended with solemn processions, incense, embroidered robes, music, the radiance of colored lights, with stories that stir wonder and induce hypnotic admiration... Most religions have identified their sacraments with the highest reaches of art, and the most authoritative beliefs have been clothed in a garb of pomp and pageantry that gives immediate delight to eye and ear and that evokes massive emotions of suspense, wonder, and awe. (Dewey 1934b, 10:37)

In sum, religion functions as much or more so on the aesthetic plane than on the intellectual, scientific, or philosophical. This is not to dismiss the value of religion in the least; according to Dewey, the aesthetic is also the realm of experience where meanings are at their fullest. Insofar as the role of religion is to give us and help us appreciate the meaning of things, we must ultimately operate on the plane of artistic expression as much as if not more so than the merely cognitive or intellectual.

The function of religion is not only aesthetic, however, but also moral. In *A Common Faith*, Dewey emphasizes both the continuity of humanity with nature and the continuity of the human community past, present, and future, calling

this the "community of causes and consequences" that is "the widest and deepest symbol of the mysterious totality of being the imagination calls the universe" (Dewey 1934a, 9:56). The interacting network of human beings with nature throughout time is the environment in which our ideals, aspirations, and values are formed by acts of *moral imagination*, which unifies the aesthetic and moral functions of religion with its attempt to wrestle with the universe as a totality. As we use our moral imagination to shape the purposes of our lives, we make our character as we make a work of art.

It is in this relation between our values and the "mysterious totality" of the universe that Dewey, contra James, gives a *naturalistic* analysis of the role of faith and of the religious in experience. That is, he attempts to give an account of faith and religious experience without any reference to supernatural entities like spirits, souls, immaterial substances, and so on. Dewey's hope is that a naturalistic picture can help provide what traditional religion once provided in terms of social cohesion and personal meaning, but for a secular, humanistic, democratic world. One of the core concepts in Dewey's account is the concept of *natural piety*:

> The fact that human destiny is so interwoven with forces beyond human control renders it unnecessary to suppose that dependence and the humility that accompanies it have to find the particular channel that is prescribed by traditional doctrines... Our successes are dependent upon the cooperation of nature. The sense of the dignity of human nature is *as religious* as is the sense of awe and reverence when it rests upon a sense of human nature as a cooperating part of a larger whole. *Natural piety* is not of necessity either a fatalistic acquiescence in natural happenings or a romantic idealization of the world. It may rest upon a just sense of nature as the whole of which we are parts, while it also recognizes that we are parts that are marked by intelligence and purpose, having the capacity to strive by their aid to bring conditions into greater consonance with what is humanly desirable. Such piety is an inherent constituent of a just perspective in life. (Dewey 1934a, 9:18, *emphasis added*)

To practice natural piety is to approach the world with humility and reverence but not passive fatalism. In a secular age, it may be difficult to see the value in talk of "piety." But for Dewey's part, *natural piety* is a much-needed perspective attuning us to our dependence on the world for the success of our endeavors. We are in the world, Dewey is saying, not in the way that a button is in a box, but as part of a complex network of interacting dependencies. This should be a cause for humility and reverence. We are parts of the world that can act towards a reflectively chosen end to improve our lot. We form purposes and ideals reflecting not only momentary desire but our attempt to understand what is ultimately desirable.

It is in this capacity for reflective or intelligent action that Dewey finds room for naturalistic interpretations of faith and the divine. Dewey defines *faith*

as "the unification of the self through allegiance to inclusive ideal ends, which imagination presents to us and to which the human will responds as worthy of controlling our desires and choices" (Dewey 1934a, 9:23). To have faith is to believe in one's ability to bring such ideals to realization through our desires and choices, even if only in the long run. Similarly, Dewey defines *God* or *divinity* in naturalistic terms as the unity of our ideal ends, "the values to which one is supremely devoted," in our imagination (Dewey 1934a, 9:29). It is important to Dewey that such ideals are neither (yet) actualized, nor "mere rootless ideals, fantasies, utopias" (Dewey 1934a, 9:34). Rather, these ideal ends are possibilities made coherent through action in connection with conditions in nature that promote their realization. As Dewey says, "It is this active relation between ideal and actual to which I would give the name 'God' " (Dewey 1934a, 9:34).

Here, aesthetic meaning, moral values and ideals, human ingenuity and intelligence, and social cooperation come together to form secular concepts of faith and the divine (if words like "God" and "the divine" are too inseparable for you from supernaturalism, consider instead using a term like "the sacred" or "the spiritual"). Central, again, is the notion of natural piety, the humility and reverence for nature that makes our lives possible, as well as a faith in the human community to cooperate towards realizing those ideals.

According to Dewey, militant atheism and modern supernaturalism are allied in presenting an image of humanity in isolation from nature, and thus the negation of natural piety.[15] Against both, Dewey holds that the religious quality of our experience, our worldview, and our way of life is ineliminable but must be situated within the natural world of our experience. In the present day, it seems that natural piety and faith in our ideals and our community are precisely what we need more of. We need a common, secular, democratic faith that can support and encourage them.

The Religious Function of Science

Here I think we can begin to address the religious function of science. The synthetic and visionary parts of science associated with the articulation of a *scientific worldview* can, I believe, help fulfill the role of cultivating natural piety and providing the basis of a faith in our ability to realize our ideal values. There seems to be a deep human need to understand the nature of our world and our place in it, which has long been fulfilled by mythology and religion. This

[15] One might rightfully argue that Dewey is being too quick and overgeneralizing. Perhaps, because he can stipulate the definition of "militant atheism," we can permit that generalization. But it is unclear how Dewey can account for the attitudes towards nature recommended by theists as diverse as Francis of Assisi, Pierre Teilhard de Chardin, and Pope Francis, or the wide variety of thinkers sometimes grouped under the heading "ecotheology." (My gratitude to Eric Martin on this point.) Still, I think Dewey's charge is applicable to many mainstream, modern religious traditions, and captures sometime important about supernaturalism as typically conceived. That some religions treat nature itself as divine, or recommend a religious reverence towards nature, shows a complexity in the concepts of "natural" and "supernatural" that Dewey missed.

understanding is often linked with the grounding of the values of a culture. We can also point to the value of the experiences of *wonder* and *belonging* created by such an understanding, and by extension, we can see worldview-making as an imaginative and inspirational attempt to use science to help us appreciate the wonder of the universe.

Dewey found just such a cultural role for science:
"The flights of physicists and astronomers today answer to the esthetic need for satisfaction of the imagination rather than to any strict demand of unemotional evidence for rational interpretation" (Dewey 1934b, 10:37). This is the aesthetic role that was previously played by supernatural "theologies and cosmogonies." Perhaps on the somewhat darker side, in certain ways, science is also hardening into dogma in just the way that supernatural belief had done before:

> The world of physical science is no longer new and strange; to many it is now familiar; while many of those to whom it is personally unfamiliar take it for granted on authority. To a considerable extent its subject-matter is taking the place of the subject-matter of older creeds as something given ready-made, demanding unhesitating credence and passive acceptance. (Dewey 1925, 1:185)

From our perspective today, this may seem like an exaggeration. After all, are we not inundated, especially in the United States, by those who deny the authority of science? First, no; despite a few exceptions of politicized issues, the U.S. public still strongly trusts scientists and scientific knowledge (National Science Board 2020). Second, Dewey, as both a preeminent philosopher of education and a pioneer in empirical education research, was long interested in science education and concerned that the instructional methods common to science teaching focused exclusively on content, taught as timeless truths, rather than on scientific methods of inquiry. We can and should question whether treating science as something that should be accepted unfailingly by a passive public is what we want, though it certainly makes the religionist analogy more persuasive.

Let me instead emphasize the positive. Imaginatively constructing a scientific worldview can serve the positive religious function for the public identified by James and Dewey. It can give us an understanding of our place in the world, the meaning of it all, a pious relation to nature, and the faith in the ideals we seek to realize. "The scientific worldview" can help not only the secular public but also the scientific community; it can act as a motivation for scientists, something grand to work toward, a flag to rally to. For Dewey, "Faith in the continued disclosing of truth through directed cooperative human endeavor is more religious in quality than is any faith in a completed revelation" (Dewey 1934a, 9:18). This faith is on display in the everyday inquiry of scientists that in turn is consolidated by the worldview-builder.

Ultimately, this part of science, which is an activity genuinely connected with scientific inquiry, science education, and science communication, has more in common with religion than with experiment, inquiry, or technical application. This similarity should affect the way we approach scientific worldviews.

Understanding the religious function of scientific worldviews suggests complex criteria for responsible worldview construction that pulls against many current tendencies in contemporary naturalism, humanism, and scientism. In particular, we need to think carefully about the relation between our worldviews and our values and traditional ways of life.

In his very late works, Paul Feyerabend defended a thesis that he called "Aristotle's Principle," or sometimes the "Existential Criterion of Reality." The reason for the former name has to do with the way that he interprets Aristotle's response to Parmenides' monism, the philosophical theory according to which the World is one and unchanging:

> Aristotle criticized Parmenides in two ways. He tried to show the mistakes in Parmenides' reasoning[,] and he pointed out that change, which Parmenides had called unreal, is important in human life. (Feyerabend 1999, 200)

Feyerabend extracts a principle behind the second strategy: "real is what plays a central role in the kind of life we identify with" (Feyerabend 1999, 201).[16] This principle is already tacitly at work in Feyerabend's work starting 1975, where he attempts to combat overconfidence in science. Feyerabend came to see scientific realism as supporting a kind of dogmatism about science and an undeserved special role for science in society, which hurt the freedom of people in our society to pursue their own values and traditional forms of like. This was the sort of work for which Feyerabend was labeled "the worst enemy of science" (Theocharis and Psimopoulos 1987). His work in that period exemplifies the negative version of Aristotle's principle—don't treat something as real if it conflicts with the life you want to live, and don't accept pictures of reality that make that life impossible or burdensome. He thus became concerned with, as the title of one provocative essay put it, "How to Defend Society from Science" (Feyerabend 1975).[17]

The positive version of Aristotle's principle treats "real" as an honorific appended to those results of inquiry that we are willing to incorporate into our worldview, as a result of endorsing their role in our practices. In other words, we are willing to treat something as real insofar as it plays a role in our valued practices and forms of life, what we care about and identify with. This is a value-laden judgment. The principle does not license an "anything goes" attitude towards what we should regard as real, but rather links it to our cherished values and practices. What "plays a role" in our practices should be understood pragmatically, as what actually plays a role in practices that we value, that are

[16] It is not important here whether this is a good interpretation of Aristotle's argument against Parmenides or whether Aristotle would accept the principle.

[17] Thus in this negative phase, Feyerabend claims: "Scientific results and the scientific ethos (if there is such a thing) are simply too thin a foundation for a life worth living. Many scientists agree with this judgement" (Feyerabend [1975] 1993, 131). Thanks to Eric Martin for reminding me of this point. I think it is an open question, whether in his more positive phase, Feyerabend might be more optimistic about the value of a scientific worldview constructed along the lines described here.

successful and unproblematic. What's more, while our decisions about what we give the honorific "real" to makes a real difference to our practices, it is a matter of the philosophical interpretation of science, not a matter of acceptance or rejection of the science itself.[18]

Between scientific worldviews and our values (and the practices and ways of life they are connected to) is a complex, two-way street. Of course, in various ways, values inform the results of scientific inquiry. (For studies of values in science, see Part III, this volume.) What's more, as Feyerabend argues, our values should play a role in the selective activities of worldview building. The worldviews we adopt are or imply complex evaluative standpoints, informing the ideals we pursue and the values we hold.

As I put the finish touches on this chapter, we continue to deal with the COVID-19 pandemic crisis, and there remains major public dissensus over the severity of the problem and the efficacy of the scientifically validated preventatives for the disease, including questions concerning the seriousness of "long COVID." We face increasingly severe and irreversible fallout from the climate crisis, but our elected representatives seem focused at best on half measures, where they acknowledge its reality at all. We have faced significant challenges to the institutions and the very values of our secular, pluralistic, democratic society. If ever there were a need for a secular worldview that could inspire natural piety and a faith in our ability to realize our ideals, now is the time. It is the religious function of science to provide such a worldview. Those of us committed to science and to humanism should bring our moral imagination to bear in order to better meet that need.

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[18]Science itself, in its plurality, would of course remain somewhat independent from any version of the scientific worldview.

References

Andersen, Holly K. 2017. "Patterns, Information, and Causation." *The Journal of Philosophy* 114 (11): 592–622. https://doi.org/10.5840/jphil20171141142.

Brown, Matthew J. 2010. "Genuine Problems and the Significance of Science." *Contemporary Pragmatism* 7 (2): 131–53.

———. 2015. "John Dewey's Pragmatist Alternative to the Belief-Acceptance Dichotomy." *Studies in History and Philosophy of Science Part A* 53: 62–70. https://doi.org/http://dx.doi.org/10.1016/j.shpsa.2015.05.012.

———. 2020. *Science and Moral Imagination: A New Ideal for Values in Science*. Pittsburgh: University of Pittsburgh Press.

Bush, Vannevar. 1945. *Science, the Endless Frontier: A Report to the President*. Washington: U.S. Govt. print. off.

Chakravartty, Anjan. 2017. "Scientific Realism." In *The Stanford Encyclopedia of Philosophy*, edited by Edward N. Zalta, Summer 2017. http://plato.stanford.edu/archives/sum2017/entries/scientific-realism/.

Churchland, Paul M. 1985. "The Ontological Status of Observables: In Praise of the Superempirical Virtues." In *Images of Science*, edited by Paul M. Churchland and Clifford A. Hooker, 35–47. Chicago: University of Chicago Press.

Descrates, René. 1677/1998. *The World and Other Writings*. Edited by Stephen Gaukroger. Cambridge, U.K.: Cambridge University Press.

Dewey, John. 1925. *Experience and Nature*. Edited by Jo Ann Boydston. Vol. 1. The Later Works of John Dewey. Southern Illinois UP, 1988.

———. 1934a. *A Common Faith*. Edited by Jo Ann Boydston. Vol. 9. The Later Works of John Dewey 1925-1953. Carbondale: Southern Illinois University Press, 1989.

———. 1934b. *Art as Experience*. Edited by Jo Ann Boydston. Vol. 10. The Later Works of John Dewey. Southern Illinois UP, 1987.

Douglas, Heather. 2009. "Reintroducing Prediction to Explanation." *Philosophy of Science* 76 (4): 444–63. http://www.jstor.org/stable/10.1086/648111.

———. 2013. "The Value of Cognitive Values." *Philosophy of Science* 80 (5): 796–806.

———. 2014. "Pure Science and the Problem of Progress." *Studies in History and Philosophy of Science A* 46: 55–63.

Dupré, John. 1993. *The Disorder of Things: Metaphysical Foundations of the Disunity of Science*. Cambridge, Mass.: Harvard University Press.

Feyerabend, Paul K. [1975] 1993. *Against Method*. 3rd ed. New York: Verso.

———. 1975. "How to Defend Society Against Science." *Radical Philosophy* 11.

———. 1999. *Conquest of Abundance: A Tale of Abstraction versus the Richness of Being*. Edited by Bert Terpstra. University Of Chicago Press.

Galison, P. L., and D. J. Stump, eds. 1996. *The Disunity of Science: Boundaries, Contexts, and Power*. Stanford University Press.

Grinnell, Frederick. 2009. *Everyday Practice of Science: Where Intuition and Passion Meet Objectivity and Logic*. Oxford: Oxford University Press.

James, William. 1902. *The Varieties of Religious Experience: A Study in Human Nature*. New York: Longmans, Green,; Co.

Kellert, Stephen H, Helen E Longino, and C. Kenneth Waters. 2006. *Scientific Pluralism*. Minneapolis, MN: University of Minnesota Press.

Kitcher, Philip. 1983. *Believing Where We Cannot Prove. Abusing Science: The Case Against Creationism.* Cambridge, Mass: MIT Press.

———. 2001. *Science, Truth, and Democracy*. Oxford University Press.

———. 2011. *Science in a Democratic Society*. Amherst, N.Y.: Prometheus Books.

———. 2015. "Pragmatism and Progress." *Transactions of the Charles S. Peirce Society* 51 (4): 475–94. http://www.jstor.org/stable/10.2979/trancharpeirsoc.51.4.06.

Kuhn, Thomas S. [1962] 1996. *The Structure of Scientific Revolutions*. 3rd ed. University Of Chicago Press.

———. 1977. "Objectivity, Value Judgment, and Theory Choice." In *The Essential Tension: Selected Studies in Scientific Tradition and Change*, 320–39. Chicago: University of Chicago Press.

Laudan, Larry. 1984. *Science and Values: The Aims of Science and Their Role in Scientific Debate*. Berkeley: University of California Press.

Miller, Boaz. 2014. "Science, Values, and Pragmatic Encroachment on Knowledge." *European Journal for Philosophy of Science* 4 (2): 253–70.

Misak, C. J. 2004. *Truth and the End of Inquiry: A Peircean Account of Truth*. Expanded paperback. Oxford: Clarendon Press.

Mishima, Kenichi. 2020. "The 'Disenchantment of the World' or Why We Can No Longer Use the Formula as Max Weber Might Have Intended." In *The Oxford Handbook of Max Weber*. Oxford: Oxford University Press. https://doi.org/10.1093/oxfordhb/9780190679545.013.20.

Mitchell, Sandra D. 1997. "Pragmatic Laws." *Philosophy of Science* 64: S468–79.

National Science Board, National Science Foundation. 2020. 2020. "Science and Technology: Public Attitudes, Knowledge, and Interest. Science and Engineering Indicators 2020." NSB-2020-7. Alexandria, VA. https://ncses.nsf.gov/pubs/nsb20207/.

Putnam, Hilary. 1981. *Reason, Truth, and History*. Cambridge: Cambridge University Press.

———. 2002. *The Collapse of the Fact/Value Dichotomy and Other Essays*. Cambridge, MA: Harvard University Press.

Quine, W. V. 1960. *Word and Object*. Studies in Communication. Technology Press of the Massachusetts Institute of Technology.

Romizi, Donata. 2012. "The Vienna Circle's 'Scientific World-Conception': Philosophy of Science in the Political Arena." *HOPOS: The Journal of the International Society for the History of Philosophy of Science* 2 (2): 205–42. https://doi.org/10.1086/666659.

Sarewitz, Daniel. 2016. "Saving Science." *The New Atlantis*, no. 49: 4–40.

Steel, Daniel. 2010. "Epistemic Values and the Argument from Inductive Risk." *Philosophy of Science* 77 (1): 14–34.

Theocharis, Theo, and Mihalis Psimopoulos. 1987. "Where Science Has Gone Wrong." *Nature* 329 (6140): 595–98.

Weber, Max. 1917/2004. "Science as a Vocation." In *The Vocation Lectures*, edited by David Owen, Tracy B. Strong, and (trans.) Rodney Livingstone, 1–31. Indianapolis: Hackett.