



Questioning Truth, Reality and the Role of Science

In an era when untestable ideas such as the multiverse hold sway, Michela Massimi defends science from those who think it hopelessly unmoored from physical reality.

By Philip Ball



[Kieran Dodds](#) for Quanta Magazine

It's an interesting time to be making a case for philosophy in science. On the one hand, some scientists working on ideas such as [string theory](#) or the [multiverse](#) — ideas that reach far beyond our current means to test them — are forced to make [a philosophical defense of research](#) that can't rely on traditional hypothesis testing. On the other hand, some physicists, such as Richard Feynman and [Stephen Hawking](#), were notoriously dismissive of the value of the philosophy of science.

That value is asserted with gentle but firm assurance by Michela Massimi, the recent recipient of the [Wilkins-Bernal-Medawar Medal](#), an award given annually by the U.K.'s Royal Society. [Massimi's prize speech](#), delivered earlier this week, defended both science and the philosophy of science from

accusations of irrelevance. She argues that neither enterprise should be judged in purely utilitarian terms, and asserts that they should be allies in making the case for the social and intellectual value of the open-ended exploration of the physical world.

In addition to serving as a defender of the value of science, Massimi investigates issues surrounding “realism” and “anti-realism”: how, if at all, science relates to an objective reality. Her work asks whether the process of science approaches a singular, true conception of the world, or whether it is content with simply describing physical phenomena, ignoring any sense of whether the stories it tells about the world are true. Massimi, Italian-born and currently based at the University of Edinburgh in Scotland, comes down on the side of the realists, and argues, in a position she calls “perspectival realism,” that science can make progress — a much-contested word in philosophy — despite being inevitably shaped by social and historical factors. *Quanta* caught up with Massimi as she prepared to deliver her prize lecture. An edited and condensed version of the interview follows.

Richard Feynman is often quoted as saying that the philosophy of science is of much use to scientists as ornithology is to birds. How do you defend it?

Dismissive claims by famous physicists that philosophy is either a useless intellectual exercise, or not on a par with physics because of being incapable of progress, seem to start from the false assumption that philosophy has to be of use for scientists or is of no use at all.

But all that matters is that it be of *some* use. We would not assess the intellectual value of Roman history in terms of how useful it might be to the Romans themselves. The same for archaeology and anthropology. Why should philosophy of science be any different?

What use, then, is philosophy of science if not for scientists themselves? I see the target beneficiary as humankind, broadly speaking. We philosophers build narratives about science. We scrutinize scientific methodologies and modeling practices. We engage with the theoretical foundations of science and its conceptual nuances. And we owe this intellectual investigation to humankind. It is part of our cultural heritage and scientific history. The philosopher of science who explores Bayesian [statistical] methods in cosmology, or who scrutinizes assumptions behind simplified models in high-energy physics, is no different from the archaeologist, the historian or the anthropologist in producing knowledge that is useful for us as humankind.

Many scientists in the early 20th century were deeply engaged with philosophy, including Einstein, Bohr, Mach and Born. Have we lost that engagement?

Yes, I think what we have lost is a distinctive way of thinking about science. We have lost the idea, dating back to the Renaissance and the scientific revolution, that science is part of our broader cultural history.

In the early 20th century, the founding fathers of relativity theory and quantum mechanics were trained to read philosophy. And some of the most profound debates in physics at that time had a philosophical nature. When Einstein and Bohr debated the completeness of quantum mechanics, what was at stake was the very definition of “physical reality”: how to define what is “real” in quantum physics. Can an electron be ascribed “real” position and “real” momentum in quantum mechanics even if the formalism does not allow us to capture both? This is a profound philosophical question.

It is hard to find similar debates in contemporary physics, for many reasons. Physicists these days do

not necessarily read other subjects at university or get trained in a broad range of topics at school. Large scientific collaborations enforce a more granular level of scientific expertise. More to the point, the whole ethos of scientific research — reflected in institutional practices of how scientific research is incentivized, evaluated, and research funding distributed — has changed. Today, science has to be of use to a well-identified group, or it is deemed to be of no use at all.

But just as with philosophy, we need fundamental research in science (and in the humanities) because it is part of our cultural heritage and scientific history. It is part of who we are.

One criticism made is that science moves on, but philosophy stays with the same old questions. Has science motivated new philosophical questions?

I think that again we should resist the temptation of assessing progress in philosophy in the same terms as progress in science. To start with, there are different views about how to assess progress in science. Is it defined by science getting closer and closer to the final true theory? Or in terms of increased problem-solving? Or of technological advance? These are themselves philosophical unsolved questions.

The received view up to the 1960s was that scientific progress was to be understood in terms of producing theories that were more and more likely to be true, in the sense of being better and better approximations to an ideal limit of scientific inquiry — for example, to some kind of theory of everything, if one exists. With the historical work of Thomas Kuhn in the 1960s, this view was in part replaced by an alternative that sees our ability to solve more and more problems and puzzles as the measure of our scientific success, regardless of whether or not there is an ideal limit of scientific inquiry to which we are all converging.

Philosophy of science has contributed to these debates about the nature of scientific success and progress, and as a result we have a more nuanced and historically sensitive view today.

But also the reverse is true: Science has offered to philosophers of science new questions to ponder. Take, for example, scientific models. The exponential proliferation of different modeling practices across the biomedical sciences, engineering, earth sciences and physics over the last century has prompted philosophers to ask new questions about the role and nature of scientific models and how they relate to theories and experimental evidence. Similarly, the ubiquitous use of Bayesian statistics in scientific areas has enticed philosophers to go back to Bayes' theorem and to unpack its problems and prospects. And advances in neuroscience have invited philosophers to find new accounts of how the human mind works.

Thus, progress accrues via a symbiotic relation through which philosophy and the sciences mutually develop, evolve and feed into each other.

You say there has been a debate between realist and anti-realist views of science. Can you explain this?

The debate has a long history, and it is fundamentally about philosophical stances on science. What is the overarching aim of science? Does science aim to provide us with an approximately true story about nature, as realism would have it? Or does science instead aim to save the observable phenomena without necessarily having to tell us a true story, as some antirealists would contend instead?

The distinction is crucial in the history of astronomy. Ptolemaic astronomy was for centuries able to

“save the observable phenomena” about planetary motions by assuming epicycles and deferents [elaborations of circular motions], with no pretense to give a true story about it. When Copernican astronomy was introduced, the battle that followed — between Galileo and the Roman Church, for example — was ultimately also a battle about whether Copernican astronomy was meant to give a “true story” of how the planets move as opposed to just saving the phenomena.

We can ask exactly the same questions about the objects of current scientific theories. Are colored quarks real? Or do they just save the empirical evidence we have about the strong interaction in quantum chromodynamics? Is the Higgs boson real? Dark matter?

You have argued for a new position, called perspectival realism. What is that?

I see perspectival realism as a realist position, because it claims (at least in my own version of it) that truth does matter in science. We cannot be content with just saving the observable phenomena and producing theories that account for the available evidence. Yet it acknowledges that scientists don't have a God's-eye view of nature: Our conceptual resources, theoretical approaches, methodologies and technological infrastructures are historically and culturally situated. Does that mean we can't reach true knowledge about nature? Certainly not. Does it mean we should give up on the idea that there is an overarching notion of scientific progress? Absolutely not.

You have written about the role of evidence in science. This has become a hot topic because of the efforts in some parts of physics to push into realms for which there is scant evidence that might be used to test theories. Do you think true science can be done even where empiricism is not (at this point) an option?

This is an important question because, as I mentioned, the answer to the question of how to be a realist despite the perspectival nature of our knowledge depends also on how we go about collecting, analyzing and interpreting evidence for hypothetical new entities (which might or might not be real). Not only is such evidence very difficult to gather in areas like cosmology or particle physics, but also the tools we have for interpreting the evidence are very often a matter of perspective. And so how we put those tools to the service of “finding the truth” about, say, supersymmetric particles or dark energy becomes crucial.

Take, for example, [the research program on supersymmetry](#). Here, the old philosophical ideas — that scientists start with a theoretical hypothesis, deduce empirical consequences and then run an experiment to test whether the consequences are verified or not — proves totally out of date and inadequate to capture what goes on in real scientific practice. It would be too time-consuming and inefficient for experimental physicists to test every single theoretical model produced in supersymmetry, considering also the wealth of data coming from colliders.

Instead, particle physicists have devised more efficient strategies. The goal is to rule out energy regions where no evidence has yet been found for new physics beyond the Standard Model. Our ability to survey the space of what is physically conceivable [as a guide to what is objectively possible](#) — and to fix more stringent constraints on this realm of possibilities — counts as progress, even if no particle were to be detected at the end of all those efforts.

From a philosophical point of view, what has dramatically changed is not simply old ideas about the interplay between theory and evidence, but, more importantly, our ideas of progress in science and realism. Progress here is not just about discovering a new particle. It is also — indeed, most of the

time — being able to carve out the space of what might be possible in nature with high confidence. That is progress enough. Conveying this message to the public is important to rectify misconceptions about, say, whether taxpayers' money should be spent to build more-powerful colliders if these machines don't actually discover a new particle.

At the same time, our realist commitments should be reconsidered. I personally believe that a realist viewpoint can include our ability to carve out the space of what might be objectively possible in nature, rather than in terms of mapping onto some actual states of affairs. This is what perspectival realism is driving at.

How did you start thinking about all of this?

A turning point for me happened one day in 1996 when I was browsing through dusty old issues of *Physical Review* in the basement of the physics library at the University of Rome. There I bumped into the famous [Einstein-Podolsky-Rosen paper of 1935](#) ["Can quantum-mechanical description of physical reality be considered complete," the first paper to point to the phenomenon now called quantum entanglement]. I was struck by the "criterion of physical reality" that featured on their first page — if without in any way disturbing a system, we can predict with certainty the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity. I wondered why a physics article would start by asserting a seemingly very philosophical claim about "physical reality." Anyway, I thought, what is a "criterion" of physical reality? And is this one justified? I remember then reading [Niels Bohr's response to that EPR paper](#), which chimed in my mind with more modest, knowledge-based claims about how we come to know about what there is in the world. And I decided at that point that there was a philosophical treasure trove in this area, waiting for me to explore.

Your prize address at the Royal Society is about the value of science. What do you think philosophy can bring to that discussion?

A lot! Obviously it is not the job of philosophers to do science, or to give verdicts on one theory over another, or to tell scientists how they should go about their business. I suspect that some of the bad press against philosophers originates from the perception that they try to do these things. But I believe it is our job to contribute to public discourse on the value of science and to make sure that discussions about the role of evidence, the accuracy and reliability of scientific theories, and the effectiveness of methodological approaches are properly investigated.

In this respect, I see philosophy of science as delivering on an important social function: making the general public more aware of the importance of science. I see philosophers of science as public intellectuals who speak up for science, and rectify common misconceptions or uninformed judgments that may feed into political lobbies, agendas and ultimately policy-making. Philosophy of science is an integral part of our public discourse on science, which is why I have always endeavored to communicate the value of science to society at large.