Philosophy of Physics

A new introduction

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Contents

Foreword

Like many other philosophers, I am constantly confronted with the challenge of explaining the meaning and value of philosophy of science to skeptical practitioners. Also like other philosophers, I have been confronted with the challenge of explaining certain approaches to philosophy of science to skeptical colleagues with who adopt different ones. Philosophers of science can talk, not just past scientists, but also past each other. To overcome this, I finally realized that I'd have to begin by explaining the different approaches. This book is the result.

Preface

Scientists are sometimes stymied by puzzles created, but not solved, by their own activities. What does quantum mechanics mean? What makes string theory scientific? Is there a fundamental branch of science? Are atoms 'parts' or 'moments' of molecules? How to define 'species', 'race', 'disease', 'biodiversity', 'element', 'discovery', 'theory', and other terms?

Left to their own devices, researchers can either ignore such puzzles or sweep them under the rug with rough and ready answers. But when the usual scientific theorizing and data-collecting is applied, the answers can contain ambiguities, contradictions, mysteries, or implausible verdicts. If you want to find philosophical issues in science, look here.

'Philosophy', like 'science', may refer to several different things. It may refer to a group of topics, such as beauty, truth, the good; to a set of discoveries; or to ways of inquiry. This book is about the latter. What are the ways that philosophers inquire, what happens when that inquiry is directed to science, and how can philosophy help resolve questions such as the above?

Two kinds of challenges

Being a scientist means inheriting a set of concepts, practices, and ways of thinking. Generally this inheritance works smoothly, but puzzles may arise when scientists find that their knowledge or expectations collide. When such puzzles are resolvable with more research they are *scientific* challenges; otherwise they may involve *philosophical* challenges.

Most scientific research does not generate philosophical challenges. Either that, or practitioners are confident that more experimental and theoretical work will clear things up—say, the fine details of superconductivity or of protein folding. Other areas of research are bedeviled by philosophical issues. No amount of physics seems able to solve the problem of how to interpret quantum mechanics in a satisfactory way—though one might say 'Not yet' and await future research.

The conviction that scientific inquiry, via the usual theorizing and data-collecting, will be able to resolve all such questions, and that it provides the only reliable way to settle any important question, is called *scientism*. But scientism is not a part of science; it is a story *about* science, one that claims to purge it of philosophical issues. This creates a set of problems and dangers, to be discussed in this book.

Philosophy has plenty to deal with. It inquires into the origin of scientism, into puzzles arising from collisions between features of science that science cannot repair, and into how scientific model-building springs from and illuminates our experience.

Coherence

Scientists and philosophers demand different kinds of coherence. Scientists demand the coherence of nature. If the energy of the $2s_{1/2}$ electron orbital in atomic hydrogen is not where quantum electrodynamics says it should be, if two ways of measuring the fine structure constant reach different values, or if the way tau and theta particles

decay means that they can and cannot be the same particle, physicists must find explanations. Otherwise it threatens the foundations of the scientific enterprise itself.

Philosophers demand a different kind of coherence, the coherence of experience. What happens when we desire, savor, appreciate, remember, imagine, hallucinate, wonder, inquire, and are curious? How do these experiences relate to the theoretical, knowledge-seeking attitude of scientists in a laboratory? Who are we, we humans, that we can have all these experiences?

In telling the story that the usual theorizing and data-collecting is able to answer all those questions, scientism maintains that the first kind of coherence effectively absorbs the second, rendering philosophical activity unnecessary—something that mystifies rather than clarifies.

According to scientism, for instance, humans don't *really* see sunsets and sunrises but the earth spinning, we don't observe rainbows but reflections and refractions, what looks to be stars in the sky are only left-over glimmers of faraway objects that ceased to exist billions of years ago, the human body is 60% water, and so on.

No doubt such storytelling, which delegitimizes human experience, is meant to foster appreciation for science. But it can have the opposite effect.

Two tables

Almost a century ago, the English astronomer Arthur Eddington began his book *The Nature of the Physical World* with a famous image involving two tables. One is a familiar commonplace object of experience that is extended, colored, and motionless. Another table is the one as dissected by science, consisting mainly of tiny electrical charges swarming in empty space.

Physicists, Eddington said, may claim that the scientific table is 'the only one which is really there'—but they will 'never succeed in exorcizing' the table of ordinary experience. Eddington admitted that he was unsure how the two tables are related, saying that the question lies outside the scope of physics. Many of his colleagues, though, are sure, and say the scientific table is real and the ordinary one is just in our heads. There is no need to relate them.

It's fortunate that Eddington didn't ditch his ordinary, experienceable table. For even as he was writing his book, Werner Heisenberg and others were developing quantum mechanics, forcing Eddington to revise some of his manuscript. Evidently, even 'scientific' tables can be defective and swapped out for newer models.

Eddington was wise to say that ordinary experience can't be exorcised, for it's the precondition for any knowledge at all. Even when we've been mislead—say, in optical illusions where straight lines appear bowed—it's not that something outside me drops into a hole to replace the knowledge that the lines are angled by the fact that they are straight. I have to be curious, play around, and recognize that what I find integrates with what I already know, in an ongoing, temporally spread-out experiential process. It's not that somebody tells me, 'Don't believe your eyes, the lines *are* straight!' That's an opinion that I may or may not believe, and anyway I still *see* the lines as bowed. It's by using a ruler and maybe some explanation that I realize how I see the lines as bowed. I don't suspend my experience in realizing that something's an illusion, but enrich it.

Towards the end of his life, the German philosopher Edmund Husserl began an essay that he called 'The original Ark, Earth, does not move'. The editors of his posthumous works thought this sounded too absurd in a post-Copernican world, and retitled it 'Foundational Investigations of the Phenomenological Origin of the Spatiality of Nature'. But the point of the essay was exact. Experiencing a non-moving background environment is not a mistake, Husserl argued, but a precondition for humans to be able to develop a sense of movement and to model oneself as being on a moving Earth.

Philosophy of science involves examining the relation between such background environments and the scientific activities that arise in and thanks to them.

Scientific and philosophical stances

Near the beginning of his *Lectures on Physics* Richard Feynman captured his conception of physics in a dramatic image:

> We can imagine that this complicated array of moving things which constitutes 'the world' is something like a great chess game being played by the gods, and we are observers of the game. We do not know what the rules of the game are; all we are allowed to do is to *watch* the playing. Of course, if we watch long enough, we may eventually catch on to a few of the rules. *The rules of the game* are what we mean by *fundamental physics* (Feynman *et al* 1963, section 2-1).

To continue Feynman's metaphor, if scientists watch the playing to figure out the rules of the game, philosophers watch how scientists watch the game. Philosophers can ask many different questions about the process. How do scientists judge that they are watching a game, and decide what a 'rule of the game' is? How do they find those rules, make mistakes about them, know when they are mistaken, and correct those mistakes? What built-in assumptions about such things as material, motion, identity, time, and space have the scientists made in dividing up the game into pieces, the board, and the 'gods' (the 'movers'). What is involved in scientists narrowing their experience to the theoretical task of figuring out the game at all? What philosophers of science investigate is not so much the objects that scientists investigate but how scientists investigate them.

Philosophers of science and scientists investigate different things and are standing in different places. The philosophical and scientific stances involve different approaches, methods, concepts, standards, interests, vocabularies, and literatures. The scientific stance objectifies what is under investigation, treating it as something independent of mental activity, while the philosophical stance is aware of, informed by, and cannot leave out the human world to which philosophers, scientists, and the subject of inquiry all belong. A first task of philosophy of science is to convey the difference between the naturalist and philosophical stances.

The fact that philosophers and scientists have different stances means that it can be difficult for the latter to appreciate the former. It can lead scientists to assume that

any difficulty they have in grasping what philosophers say must be due to the failure of philosophers to properly understand the subject-matter. If one makes that assumption, the natural response is either to break down the subject for the philosophers as if explaining it to novices, or to dismiss philosophers and philosophy altogether as irrelevant, wrongheaded, or obsolete.

This has been the case since the dawn of modern science. In 1604 Galileo published a pamphlet ridiculing philosophers who could not figure out whether a new star that had appeared the previous year was near Earth, as Aristotelians insisted, or at a remote distance like the other stars, as per astronomers. It is easy to find the answer, Galileo knew, if you understand the mathematics of parallax, or how from the perspective of a moving observer an object changes position against the background. Galileo had fun skewering philosophers who arrogantly regarded themselves wise in the ways of the world but were clueless about how to use a simple tool that might help them find out.

Galileo's fictional philosophers were indeed arrogant if they tried to use a scientific tool such as parallax to address philosophical issues. But Galileo was displaying his own arrogance if he assumed that those philosophers were essentially looking for the same thing that the scientists were. That assumption has persisted ever since. As Nobel laureate Steven Weinberg wrote in a 1977 *American Scientist* article:

> I have considerable difficulty in understanding the philosophical content that many people seem to find in discoveries in physics. It is true, of course, that many of the subjects of physics—space and time, causality, ultimate particles—have been the concern of philosophers since the earliest times. But in my view, when physicists make discoveries in these areas, they do not so much confirm or refute the speculations of philosophers as show that philosophers were out of their jurisdiction in speculating about these phenomena (Weinberg 1977, p 175).

Or, as physicist Murray Gell-Mann commented a few years later,

> In my opinion, worrying about philosophy is often bad for the fundamental theorist. It muddies the waters and obscures his principal task, which is to find a coherent structure that works. Moreover, a philosophical bias may easily cause him to reject a good idea (quoted in Crease 1983, p 9).

But philosophy is not a set of speculations, positions, or set of theories, and it definitely does not aim at solving scientific problems.

Philosophy can often be difficult to explain to scientists. Its language, like the discourse of science itself, frequently takes a narrow focus and is preoccupied with special topics and technical issues whose value understandably may not be obvious to outsiders. Scientists, meanwhile, may adopt the attitude that only the measurable is meaningful. That makes the phenomenal, qualitative world that philosophers typically address—the human world in which people actually *live*—appear less tangible, concrete, and interesting than the grandeur of things like Newtonian physics or the intricate beauty of quantum mechanics. Yet science and its

'magnificent structures' (as Francis Bacon put it) arise out of that human world and would be impossible without it.

Science without philosophy

The scientists' pursuit of the coherence of nature assumes a sharp boundary between that domain and ordinary experience. Adherents of scientism take that as a natural, and hard, boundary. They make a sharp distinction between experience and what scientists say that experience is of. The motive is educational and benign—to encourage an appreciation for the wonders of science.

But that sharp distinction is a problem. It encourages in outsiders the sense that there is a class of elite influencers (i.e. scientists) who think that only they possess the truth and that the rest of the population (i.e. non-scientists) is confused and misled, which makes it easier for people to ignore the claims of the elites as untrustworthy. Maybe sea levels are not rising, glaciers not melting. Maybe vaccines cause autism, and rising amounts of human-produced CO_2 in the atmosphere—if that's even true—is not responsible for global warming. Who knows? Why trust those influencers? Scientism can foster backlash—skepticism that only scientists have a true grip on the world and that the rest of us ordinary humans have only illusion or ignorance.

The philosophers' pursuit of the coherence of various types of human experience does not contain such a boundary, for it includes how the theoretical attitude arises and is related to other ways of experiencing. Education is not 'having the right information', given to us by experts who have mined the information from a special place to which only they have access. One task of philosophy of science is to develop a robust account of how scientific conclusions are generated from and only within human experience. That's not in the scope of science. It doesn't take a whole lot more humanities research to understand this, just a greater appreciation for it.

Philosophy of science is as alive, relevant, and as full of active questions as science itself. It is easiest to begin to present what it does, to physicists who may be interested in philosophy but know little about it, by outlining the aims and approaches of philosophy of science using the metaphor of science as a workshop, and then to exhibit the different approaches that can be taken to understanding that workshop and what goes on in it. The aim of this book is not to contribute to any one of these approaches, but to show how they fit together in the philosophy of science.

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I struggled mightily and long with this manuscript, and was on the verge of giving up when I realized that the first step had to be to indicate the different approaches of philosophers to inquiring into what it's all about. Unless one understands and appreciates the value of these different approaches one cannot understand and appreciate philosophy of science. I hope that I have done enough to convert the cynical physicist, and to survive scharffing, to show the first steps as to how this is done.

Author biography

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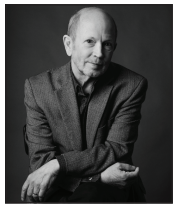

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Robert P Crease is a Professor in, and the former Chair of, the Department of Philosophy at Stony Brook University. He has written numerous books and articles on the philosophy and history of science, and specializes in the history of post-War scientific institutions. For 23 years he has written a monthly column for *Physics World*, called 'Critical point', on the philosophical, historical, and social dimensions of science. From 2014 to 2021 he was co-Editor in Chief of *Physics in Perspective*. In 2021 he was awarded the William Thomson, Lord Kelvin Medal and Prize (Institute of Physics) for 'describing key humanities concepts for scientists, and explaining the significance of key scientific ideas for humanists'. Crease is a Fellow of both the American Physical Society (APS) and the Institute of Physics (IOP). His last book is *The Leak: Politics, Activism, and Loss of Trust at Brookhaven National Laboratory*, with Peter Bond (2022, MIT Press).