BETWEEN REALISM AND ANTIREALISM IN PHILOSOPHY OF SCIENCE

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Abstract
Although the contemporary debate between scientific realism and antirealism emerged in the twentieth-century, its root goes back to philosophical questions about the nature of reality and the possibility of human knowledge. These questions were first raised by the Milesians who sought the fundamental constituents of the universe. The concerns were subsequently developed by philosophers such as Plato, Kant, and others, who broadened the inquiry from the search for ultimate substance of reality to questions concerning the nature, limits, and scope of human knowledge. With the rise of modern science and its remarkable success, philosophical attention shifted to the aims of scientific inquiry, the status of scientific theories, and the nature of scientific progress. It is within this context that the debate between scientific realism and scientific antirealism emerged dividing philosophers into two broad schools of thought, namely; scientific realists and scientific antirealists. Scientific realists maintain that the primary aim of science is the discovery of truth and that successful scientific theories are approximately true representations of reality. Scientific antirealists, by contrast, argue that the historical replacement of once-successful scientific theories and the underdetermination of theory by evidence undermines such claims, emphasizing instead the problem-solving features of scientific theories. Using documentary sources and conceptual analysis, this paper critically examines both positions within the framework of the history of science. It argues that while scientific realism provides the most compelling explanation for the success of modern science, it does not fully account for the provisional and historically situated character of scientific knowledge. Conversely, although scientific antirealism rightly emphasizes the fallibility and revisability of scientific theories, it does not adequately explain the enduring success of scientific practice. The paper therefore defends critical realism as a *via media* that preserves the realist commitment to a mind-independent reality while incorporating the antirealist insight that scientific theories remain revisable and subject to continual empirical and critical evaluation
Keywords: Scientific Realism, Scientific Antirealism, Critical Realism, History of Science, Scientific Progress, Philosophy of Science.

Introduction

From its earliest beginnings in the ancient Ionian city of Miletus, philosophy has been driven by the quest to discover the true nature of reality. The first set of Milesian cosmologists (Thales, Anaximander, and Anaximenes) sought to uncover the fundamental stuff underlying the diversity of the natural world. Their search initiated a broader philosophical inquiry into the relationship between appearance and reality: are things exactly as they appear to our senses, or do sensible appearance conceal a deeper and more fundamental reality?

Much of the history of Western philosophy can be understood as a sustained attempt to answer this question. The Eleatic philosopher, Parmenides dismissed the world of sense perception as deceptive arguing that genuine reality is one, eternal and unchanging. In contrast, Heraclitus of Ephesus maintained that change is the very essence of reality. Plato subsequently distinguished between the changing world of appearance and the eternal world of Forms. Aristotle rejected this sharp separation by locating form within individual substances as the organizing principle of matter. Centuries later, Immanuel Kant reformulated the problem by distinguishing between *phenomena* (things as they appear to human cognition) and *noumena* or things as they are in themselves.

With the Scientific Revolution of the seventeenth century, this enduring cosmological concern acquired a new significance. Although philosophers generally agree that science has profoundly transformed humanity's understanding of the natural world, they continue to disagree about the nature and epistemic status of scientific knowledge. The central question was no longer merely whether reality exists beyond appearances, but whether science genuinely discloses the structure of a mind-independent reality, or does it merely furnish useful conceptual and mathematical instruments for organizing observable phenomena and making reliable prediction? Put differently, should scientific theories be understood as true descriptions of the world, or merely as empirically adequate tools whose value lies in their predictive success rather than their truth? It is this functional disagreement that has given rise to one of the most enduring controversies in contemporary philosophy of science: the debate between scientific realism and scientific antirealism.

In the ensuing debate, scientific realists maintain that the principal aim of science is the discovery of truth and that scientific theories provide approximately true descriptions of both the observable and unobservable aspects of the world. This claim is anchored on the extraordinary predictive and explanatory success of modern science which is seen as evidence that scientific theories represents, at least approximately, the underlying structure of reality. Hillary Putnam, one of the most ardent defender of scientific realism, famously expressed this conviction by arguing that realism is "the only philosophy that does not make the success of science a miracle."[1]

However, while acknowledging the practical success of modern science, antirealists reject the realists' claim that scientific theories are approximations of the true nature of reality. They contend that such success does not justify belief in the literal truth of those theories or in the real existence of their unobservable entitles. Foe them, the acceptance of scientific theory need not imply that it correctly describes reality, rather it is sufficient that the theory adequately accounts for observable phenomena or successfully solves scientific problems. This position has been defended in its various form by philosophers such as Bas Van Faassen, Thomas Kuhn, and Larry Laudan whose arguments challenge the realist inference from scientific success to truth.

The continuing nature of this problem raises an important philosophical problem: if the history of science contains numerous once successful theories that were eventually abandoned, can the success of current scientific theories legitimately be taken as evidence of their truth. Conversely, if science is merely an instrument for prediction and problem solving, how can its remarkable explanatory power and technological achievements be adequately explained? These competing considerations have sustained the realism-antirealism debate and continue to shape contemporary discussions concerning scientific knowledge, rationality and progress.

The paper is divided into five sections. Following this introductory section, the second section examines the nature and central claims of scientific realism. The third section explores scientific antirealism, together with its principal arguments and advocates. The fourth section presents a critical appraisal of these two opposing positions by assessing their respective strengths and weaknesses. The final section defends critical realism offers a more satisfactory account of scientific knowledge by accounting for both the remarkable success and progressive character of science, while at the same time recognizing the fallibalistic nature of scientific inquiry

Scientific Realism

Scientific realism is one of the leading schools in contemporary philosophy of science. A defining feature of this school is the conviction that the world exists independently of human perception, belief, or conceptual schemes and that the principal aim of science is to discover truths about that objective reality. Unlike instrumentalism, which regards scientific theories merely as useful tools for prediction, scientific realism maintains that successful scientific theories genuinely describe both observable and unobservable aspects of the world. Therefore, for scientific realists, entities postulated by scientific theories, such as electrons, quarks, genes, and black holes, exist independently of human mind, even though many of them cannot be directly observed.

Being one of the oldest and most dominant schools in contemporary philosophy of science, scientific realism has been articulated in different ways by different philosophers. Nevertheless, according to Stathis Psillos its central claims can be distinctly categorized into four theses. First, it affirms the existence of a mind-independent reality that is not constituted by human thought or language. Second, it maintains that scientific theories are truth-apt and should be understood as genuine attempts to describe reality rather than merely to organize observations. Third, mature scientific theories that consistently demonstrate explanatory and predictive success are regarded as approximately true descriptions of the natural world. Finally, scientific progress is understood as cumulative process through which successive theories increasingly approximate the truth, even if no scientific theory is ever considered infallible.[2]

One of the earliest and most prominent advocates of scientific realism is J. J. C. Smart who developed his version of realism in the context of his criticism of instrumentalism. Opposing the instrumentalist interpretation of scientific theories, Smart argued that the extraordinary success of science is best explained by assuming that theoretical entities are real. In his celebrated essay, "Between Science and Philosophy, he argues: Is it not clear that the success of science is evidence for the existence of entities postulated by our scientific theories? To suppose otherwise would make the predictive and explanatory achievements of science an extraordinary coincidence rather than a rational accomplishment.[3]

Smart's case in this quotation rests on the principle that the success of scientific theories demands an explanation. If scientific theories consistently explain and predict natural phenomena with remarkable accuracy,

it is more reasonable to conclude that they correspond, at least approximately, to reality than to regard their success as accidental.

Perhaps the foremost and most influential advocate of scientific realism is Hillary Putnam, whose defense realism has become one of the most widely discussed position in philosophy of science. Agreeing with Smart, Putman argues that the remarkable and predictive success of science would be inexplicable unless scientific theories were at least approximately true. He famously and indelibly summarizes this position by stating that realism is "the only philosophy that doesn't make the success of science a miracle."[4] This statement has become the cornerstone of what is known as the No-Miracles Argument. The argument maintains that the most plausible explanation for the sustained success of scientific theories is that they correctly describe significant aspects of reality. If theories that refer to atoms, electrons, DNA, and gravitational waves consistently generate accurate predictions and fruitful explanations, then it is reasonable to conclude that such theories are tracking the structure of the world rather than merely useful fictions producing

Scientific realism was further developed by Richard Boyd who emphasized the relationship between the reliability of scientific methodology and the approximate truth of scientific theories. As Boyd sees it, the success of scientific methods is best explained by the fact that they have enabled scientists to formulate theories that increasingly approximate the structure of an objective, mind-independent reality. Scientific progress is therefore neither accidental nor merely pragmatic, rather, it reflects the increasing ability of scientific inquiry to produce progressively more accurate representation of the natural world.[5]

In sum, scientific realism has been defended in different ways by philosophers such as Karl Popper, Richard Boyd, and Hilary Putnam. Among these, Putnam's No-Miracles Argument remains the most influential and widely discussed defense of the realist position. His argument proceeds from the observation that scientific theories repeatedly exhibit remarkable explanatory power, predictive accuracy, and technological success, to contend that the simplest and most convincing explanation for this success is that successful scientific theories are approximately true and that their theoretical entities genuinely exist. To deny this conclusion would require treating the repeated success of science as an extraordinary coincidence. Consequently, the realist regards scientific success not as a fortunate accident but as evidence that scientific inquiry progressively uncovers the structure of an objective, mind-independent reality.

However, in spite of its considerable explanatory appeal, scientific realism has not escaped criticism. Its confidence that the success of science warrants belief in the truth of scientific theories has been challenged by philosophers who argue that predictive success does not necessarily entail truth. These objections constitute the foundation of scientific antirealism, to which the discussion now turns.

Scientific Antirealism

As already hinted above, scientific antirealism emerged as a reaction against the realist conviction that the success of science justifies belief in the truth of scientific theories and the existence of their unobservable entities. Thus, while antirealists acknowledge the remarkable achievements of science, they reject the inference that successful theories necessarily provide true or approximately true descriptions of reality. For them, the acceptance of a scientific theory does not require belief in its literal truth but only in its usefulness, empirical adequacy, or problem-solving capacity. Consequently, the objective of science is not necessarily the discovery of truth but the development of theories capable of organizing experience, explaining observable phenomena, or solving scientific problems.

Like in realism, despite the diversity of the antirealist positions, they share several fundamental commitments. Following Alexander Rosenberg lead, these positions are summarized below. Firstly, they deny that the success of a scientific theory automatically warrants belief in the reality of its unobservable entities. Secondly, they maintain that empirical evidence underdetermines theory, making it possible for different theories to explain the same observable phenomena. Thirdly, they emphasize the provisional and historical conditioned character of scientific knowledge, arguing that scientific theories are frequently replaced despite their previous success.[6] These considerations lead antirealists to adopt a more cautious attitude toward scientific claims about reality.

Scientific antirealism is not a single doctrine but a family of related philosophical positions. To highlight the unity and variations in antirealism, some of these positions are discussed below. One of the earliest or perhaps, the earliest form of scientific antirealism is instrumentalism. This variant of antirealism regard scientific theories primarily as instruments for prediction rather than as literal descriptions of the world. From this perspective, the value of a theory lies in its practical usefulness and explanatory efficiency rather than in its truth. Under this

version of antirealism, questions concerning the actual existence of theoretical entities are therefore considered unnecessary for the practice of science.[7]

A more sophisticated version antirealism is Bas van Fraasen's constructive empiricism. The author argues that the aim of science is not truth but empirical adequacy, that is, the successful representation of observable phenomena. What this means is that a scientific theory is acceptable if what it says about observable entities is true, regardless of whether its claims concerning unobservable entities correspond to reality. He contends that "science aims to give us theories which are empirically adequate, and acceptance of a theory involves as belief only that it is empirically adequate".[8] Taking this position enables van Fraasen to acknowledge the success of science without committing himself to the existence of unobservable entities postulated by scientific theories.

Thomas Kuhn also contributed significantly to the antirealist tradition, although his classification remains a matter of scholarly debate.9 Kuhn's analysis of scientific revolutions challenges the realist conception of cumulative scientific progress by arguing that scientific development proceeds through successive paradigms shifts rather than through the steady accumulation of truths. During periods of scientific revolution, previously accepted theories were abandoned and replaced by new paradigms that embody different concepts, standards, and methods. As Kuhn famously observes, "Successive paradigms tell us different things about the population of the universe and about that population's behaviour."[10] Therefore, Kuhn's doctrine of paradigm changes and incommensurability casts doubt on the realist claim that science progressively converge upon a single, objective description of reality. If successive paradigm is not directly comparable, then scientific progress cannot simply be understood as an increasing approximation to truth.

Nevertheless, the most influential philosophical challenge of scientific realism is the Pessimistic Meta-Induction, most famously developed by Larry Laudan. The argument begins with a simple historical observation: throughout the history of science, numerous theories that were once regarded as highly successful and well confirmed were later abandoned as false. Laudan captured this point in the following passage:

> The history of science is replete with theories that were once successful and well confirmed but were eventually discarded. Such theories include the crystalline spheres model of ancient and medieval astronomy; the humoral theory of medicine; the effluvial theory of static electricity; catastrophist geology; the phlogiston theory of chemistry; the caloric theory of heat; the vibratory theory of heat; the vital force theories in psychology; the theory of electromagnetic ether; the theory of optical ether; the theory of circular inertia; and theories of spontaneous generation.[11]

Laudan's point is that the historical success of these theories did not guarantee their truth. Their eventual rejection suggests that explanatory and predictive success slone is insufficient to justify the realist claim that successful scientific theories are true or approximately true. This historical pattern provides the basis for hat later came to be known as the pessimistic meta-induction

Scientific antirealism therefore offers a powerful reminder of the historical fallibility of scientific knowledge. By emphasizing empirical adequacy, paradigm dependence, and problem-solving effectiveness rather than truth, antirealists caution against equating scientific success with an accurate representation of reality. Nevertheless, whether these considerations undermine realism remains a matter of continuing philosophical debate. The next section compares the strengths and weaknesses of both positions in order to determine which provides the more convincing account of scientific knowledge and progress.

Critical Evaluation

Determining whether scientific realism or scientific antirealism provides the more rationally satisfactory account of scientific progress requires a critical evaluation of the logical consistency and historical coherency of both positions. To begin with, scientific realism derives much of its appeal from its ability to explain the remarkable success of science. The realist contention that successful scientific theories are approximately true provides an intuitive explanation for their extraordinary explanatory power, predictive accuracy, and technological applications. The development of modern medicine, quantum physics, molecular biology, and space exploration would be difficult to explain if scientific theories bore no meaningful correspondence to reality.

The realist conception of scientific progress also accords with historical observation that later theories often preserve and improve upon the explanatory achievements of their predecessors. Moreover, realism encourages confidence in scientific inquiry by treating scientific investigation as a genuine attempt to discover the objective structure of the natural world.

However, despite these strengths, scientific realism faces several important objections. The history of science reveals numerous theories that were once considered successful but were later rejected including the phlogiston theory, the caloric theory of heat, and the luminiferous ether, all listed above by Laudan. This historical fact raises doubts about whether the success of contemporary theories guarantees their truth. In addition, because many scientific theories concern unobservable entities, critics question whether there exists any independent means of verifying that such entities actually exist.[12] Realists therefore appear to place considerable epistemic confidence in theories whose truth can never be conclusively established.

By contrast, scientific antirealist derives its strength from its epistemological modesty. Rather than equating scientific success with truth, it reminds philosophers that scientific knowledge is provisional, historically conditioned, and subject to revision. Its emphasis on empirical adequacy discourages unwarranted metaphysical commitments concerning unobservable entities and recognizes that scientific theories may remain useful even when they are eventually replaced. Antirealism also draws attention to the theory-laden character of observation and the historical discontinuities that accompany major scientific revolutions. In this respect, it provides an important corrective to overly optimistic conceptions of scientific progress.

This notwithstanding, antirealism also encounters serious difficulties. Specifically, by refusing to infer the approximate truth of successful scientific theories, it struggles to provide a convincing explanation for the extraordinary predictive and technological achievements for modern science. If theories are merely empirically adequate or instrumentally useful, it remains unclear why they should repeatedly yield accurate predictions concerning phenomena that were previously unknown or inaccessible. Likewise, reducing science to prediction or problem-solving risks overlooking its broader aspiration to understand the nature of reality, which as underscored at the introduction, is the overall inspiration behind scholarship. Therefore, while antirealism appropriately caution against dogmatism, its reluctance to acknowledge the cognitive success of science may underestimate the explanatory significance of sustained scientific achievement

These critical submissions both for and against realism and antirealism suggest that a middle position is more philosophically defensible than either extreme. As noted above, such position may be described as critical realism. Critical realism affirms the existence of an objective, mind-independent reality while recognizing that human knowledge of reality is necessarily partial, fallible, and revisable. It accepts the realist conviction that science aims at truth and that successful theories generally approximate reality, yet it also acknowledges that antirealist insight that scientific theories remain historically situated and open to correction. Consequently, scientific progress should be understood neither as the accumulation of absolute truths nor as the production of merely useful instruments, but as a continuous process of developing increasingly reliable explanations of the natural world. This, via media, enables critical realism to preserve the strengths of both traditions while avoiding their principal weaknesses.

Conclusion

Starting from the 5th century BCE, when the Milesian cosmologists set out to find the ultimate stuff of which the universe is constituted, philosophy and to a large extent scholarship has been a quest not just to unravel the nature of reality but to uncover the true nature of human knowledge. After several centuries and exceptional inroads by different philosophers including Plato, Aristotle, Kant and a host of others, modern science emerged during the seventeenth century Scientific Revolution as the dominant model of rational inquiry. Nevertheless, the remarkable success of science did not end the epistemological question of the nature of human knowledge. Rather it transformed the question from the quest for the ultimate stuff to the issue of the aim of science and how scientific progress ought to be understood. These developments eventually gave rise to the contemporary debate between scientific realists and scientific antirealists over the aims of science, the status of scientific theories, and the nature of scientific progress.

For scientific realists, the aim of science is to discover truths about a mind-independent reality. It is therefore their contention that the success of scientific theories throughout the history of modern science provides strong evidence that these theories are approximately truth, thereby reinforcing their claim that the aim of science is truth and that science makes progress by proposing theories that lead increasingly towards the truth. Antirealists, on their own, argue that the historical replacement of once-successful theories, the underdetermination of theory by evidence, and the limitations of human knowledge make confidence in science ability to discover the truth unwarranted. They therefore argue that scientific theories should be evaluated primarily in terms of their empirical adequacy, predictive success, or problem-solving effectiveness rather than their correspondence to reality.

This paper is an attempt to demonstrate that both positions offer valuable philosophical insights, though neither provides a fully satisfactory account. Scientific realism provides the most compelling explanation for the remarkable success of modern science, while scientific antirealism rightly reminds us that scientific knowledge is provisional, historically situated, and always open to revision. In other words, the strengths of one position illuminate the limitations of the other, making it difficult to defend either position in its present form.

In light of these considerations, the paper proposed a via media, critical realist position as the most satisfactory account of scientific inquiry. This is because critical realism preserves the realist commitment to an objective, mind-independent reality and the view that science progressively deepens our understanding of that reality. At the same time, it accepts the antirealist insight that scientific theories are fallible human constructions whose adequacy must continually be tested against experience and subjected to critical scrutiny. Scientific progress should therefore be understood neither as the attainment of absolute certainty nor as the production of merely useful instruments, but as the gradual development of increasingly reliable and approximately true accounts of the natural world.

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