Scientific Method in Brief

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Four bold claims

This is the first of five chapters (2–6) directed mainly at this book's purpose of cultivating a humanities-rich perspective on science. The following five chapters (7–11) are directed mainly at this book's other purpose of increasing scientific productivity.

Consider a familiar scientific fact: water is composed of hydrogen and oxygen, having the chemical formula H_2O. The objective of this and the following chapter is to comprehend exactly what claims science makes for such findings. Accordingly, this chapter explicates the concepts of rationality, truth, objectivity, and realism. Mainstream science uses these four concepts incessantly, although usually implicitly, so the philosophical literature on these concepts can enrich scientists' understanding of their own craft. The next chapter explores the historical development of the concept of truth as applied to knowledge about the physical world, from Aristotle to the present. Finally, toward the end of the next chapter, additional scientific information will be presented to complete this story about science's rational, true, objective, and realistic knowledge that water is H_2O. Science worthy of the name must attend not only to facts about electrons, bacteria, humans, and galaxies but also to concepts of rationality, truth, objectivity, and realism.

Rationality

Rationality is good reasoning. The traditional concept of rationality in philosophy, which is also singularly appropriate in science, is that reason holds a double office: regulating belief and guiding action. Rational beliefs have appropriate evidence and reasons that support their truth, and rational actions promote what is good. Rational persons seek true beliefs to guide good actions. "Pieces of behaviour, beliefs, arguments, policies, and other exercises of the human mind may all be described as rational. To accept something as rational is to accept it as making sense, as appropriate, or required, or in accordance with

some acknowledged goal, such as aiming at truth or aiming at the good" (Blackburn 1994:319).

Scientific inquiry involves imagination, insight, creativity, and sometimes luck, but in no way does that negate science also involving good reasoning. "Although all sorts of imagination and thought may be used in coming up with hypotheses and theories, sooner or later scientific arguments must conform to the principles of logical reasoning—that is, to testing the validity of arguments by applying certain criteria of inference, demonstration, and common sense" (AAAS 1989:27).

Of science's four bold claims, rationality is discussed first because it is so integral to this book's topic, the scientific method. Although beliefs, persons, and other things can be the objects of a claim of rationality, the principal target here is method. Method precedes and produces results, so claims of rationality for science's conclusions are derivative from more strategic claims of rationality for science's method. Rational methods produce rational beliefs.

A claim of rational knowledge follows this formula: I hold belief *X* for reasons *R* with level of confidence *C*, where assertion of *X* is within the domain of competence of method *M* that accesses the relevant aspects of reality. The first-order belief *X* is accompanied by a second-order belief that assesses the strength of the reasons *R* and hence the appropriate level of confidence *C*, which may range from low probability to high probability to certainty. Besides supporting belief *X*, some effort may also be directed at discrediting various alternative beliefs, *Y* and *Z*. Lastly, the reasons and evidence have meaning and force from a third-order appeal to an appropriate method *M* that accesses the aspects of reality that are relevant for an inquiry into *X*. For example, the scientific method is directed at physical reality, and its domain of competence includes reaching a confident belief, based on compelling evidence, about the composition of table salt.

This business of giving reasons *R* for belief *X* must eventually stop somewhere, however, so not quite all knowledge claims can follow this formula. Rather, some must follow an alternative formula: I hold belief *X* because of presuppositions *P*. This is a story, however, that is better deferred to Chapter 5. The important story at present is just that methods underlie reasons, which in turn underlie beliefs and truth claims.

Reason's double office, of regulating belief and guiding action, means that true belief goes with good action. When belief and action do not agree, which is a moral problem rather than an intellectual problem, the result is insincerity and hypocrisy. When reason is wrongfully demoted to the single office of only regulating belief, thus severing belief from action, the inevitable consequence is sickly beliefs deliberately shielded from reality.

The traditional opponent of reason was passion, as in Plato's picture of reason as a charioteer commanding unruly passions as the horses. So a rational person

is one who sincerely intends to believe the truth, even if occasionally strong desires go against reason's dictates.

The claim to be defended here, that science is rational, should not be misconstrued as the different and imperialistic claim that only science is rational. To the contrary, science is a form of rationality applied to physical objects, and science flourishes best when integrated with additional forms of rationality, including common sense and philosophy. "The method of natural science is not the sole and universal rational way of reaching truth; it is one version of rational method, adapted to a particular set of truths" (Caldin 1949:134).

Likewise, the claim to be defended here, that science is rational, should not be conflated with the different and indefensible claim that science is always beneficial. It is unfair to deem that atomic weapons and carcinogenic insecticides count against science's rationality. Obviously, the simple truth is that knowledge of physical reality can be used for good or for ill. Science in the mind is like a stick in the hand: it increases one's ability to work one's will, regardless of whether that will is good or bad, informed or careless.

Truth

Truth is a property of a statement, namely, that the statement corresponds with reality. This correspondence theory of truth goes back to Aristotle, who wrote that "To say of what is that it is not, or of what is not that it is, is false, while to say of what is that it is, and of what is not that it is not, is true" (McKeon 1941:749). This definition has three components: a statement declaring something about the world, the actual state of the world, and the relationship of correspondence between the statement and the world. For example, if I say "This glass contains orange juice" and the state of affairs is that this glass does contain orange juice, then this statement corresponds with the world and hence it is true. But if I say that it contains orange juice when it does not, or that it does not contain orange juice when it does, then such statements are false. Truth claims may be expressed with various levels of confidence, such as "I am certain that 'Table salt is sodium chloride' is true" or "The doctors believe that 'The tumor is not malignant' with 90% confidence" or "There is a 95% probability that the sample's true mass is within the interval 1,072 $\pm$ 3 grams." Figure 2.1 depicts Aristotle's correspondence concept of truth.

The correspondence theory of truth grants reality priority over beliefs: "the facts about the world determine the truth of statements, but the converse is not true," and this asymmetry is nothing less than "a defining feature of truth about objective reality" (Irwin 1988:5). "In claiming that truth is correspondence to the facts, Aristotle accepts a biconditional; it is true that *p* if and only if *p*. But he finds the mere biconditional inadequate for the asymmetry and natural priority he finds in the relation of correspondence; this asymmetry is to be captured

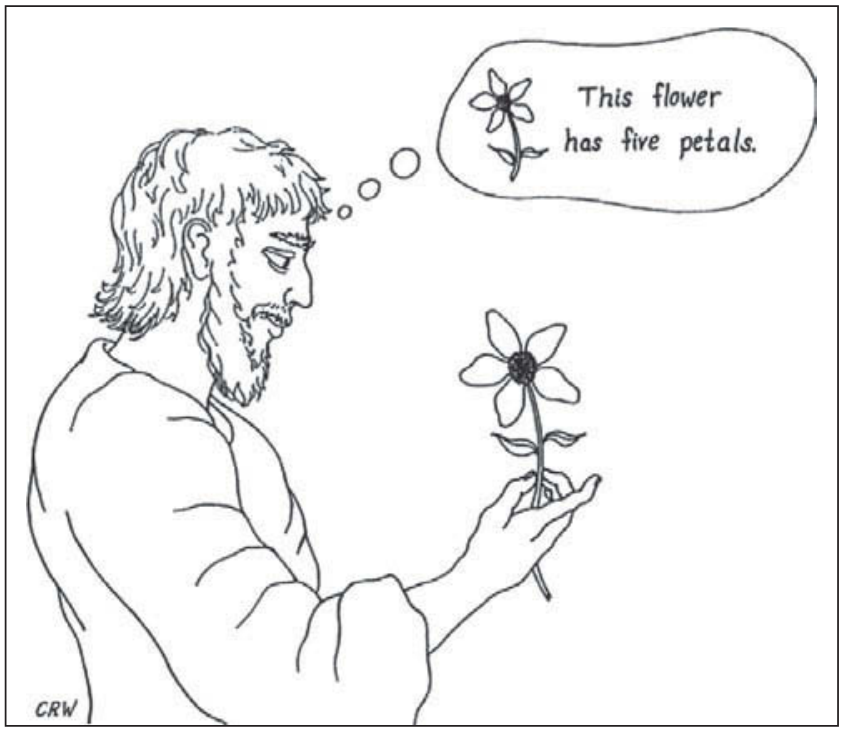

Figure 2.1 The correspondence concept of truth, with priority of nature over belief. Here the state of nature is a flower with five petals, and the person's belief is that the flower has five petals, so nature and belief correspond and, consequently this brilliant scientist's belief is true. It is the flower's petals, not the scientist's beliefs, that control the right answer. Beliefs corresponding with reality are true. (This drawing by Carl R. Whittaker is reproduced with his kind permission.)

in causal or explanatory terms" (Irwin 1988:5–6). Again, "Truth is accuracy or representation of an independent world – a world that, while it includes us and our acts of representing it, decides the accuracy of our representations of it and is not constructed by them" (Leplin 1997:29).

In the correspondence definition of truth, notice that the bearers of truth are statements, not persons. Persons are the bearers of statements, but statements are the bearers of truth. Accordingly, truth is not affected by who does or does not say it.

For better or for worse, philosophers have proposed numerous definitions of truth besides the correspondence theory advocated here. What is valid in those other definitions is best regarded as routine elaboration of the correspondence definition, which alone can serve science as the core concept of truth.

For example, the coherence theory says that truth consists in coherence (agreement) among a set of beliefs. The valid element here is that coherence is crucial. Thus, if I say that "Table salt is sodium chloride" and at the same time also blithely voice the contrary that "Table salt is not sodium chloride," then

I lose credit for this first statement because of the incoherence and insincerity caused by the second statement. Likewise, to be either true or false, a statement must at least make sense; "big it run brown" is neither true nor false, but nonsense.

For another example, the pragmatic theory of truth says that the truth is what works. The valid element here is that truth does have practical value for doing business with reality. Thus, if your doctor puts you on a low-sodium diet, then there is practical value in understanding the truth that table salt is sodium chloride. Again, reason holds the double office of regulating belief and guiding action. The danger here would be to let pragmatic actions replace true beliefs, rather than complement them, in a theory of truth.

When the correspondence, coherence, pragmatic, and other theories of truth are all considered seriously and respected equally, in practice none of them wins the day. Rather, the only winner would seem to be a "mystification theory" of truth, saying that it is beyond humans to understand or define truth. Is this *your* theory of truth? There is a simple test: your mother asks this question: "Did you eat the last cookie? Now tell the truth!" If you are capable of answering that question, then someone else may be mystified about what truth is, but you are not. The mystification theory of truth is just bad philosophy.

The definition of truth is one easy little bit of philosophy that scientists must get straight before their enterprise can make meaningful claims. A true statement corresponds with reality. A characteristic feature of antiscientific and postmodern views is to place the word "truth" in scare quotes, or else proudly to avoid this word altogether. Indeed, *every* kind and variety of antiscientific philosophy has, as an essential part of its machinery, a defective notion of truth that assists in the sad task of rendering truth elusive. Scientists must take warning from the words of Leplin (1997:28) that "All manner of truth-surrogates have been proposed" by some philosophers "as what science *really* aims for." Scientists must reject all substitutes.

The definition of truth plays the important role of making scientific hypotheses meaningful even before collecting and analyzing data to test it. For example, the hypothesis that "a carbon atom contains nine protons" is meaningful precisely because it is understood as an attempt at truth, although in this particular case, experimental data would result in rejection of that hypothesis.

Truth is guarded by science's insistent demand for evidence. "Sooner or later, the validity of scientific claims is settled by referring to observations of phenomena. . . . When faced with a claim that something is true, scientists respond by asking what evidence supports it" (AAAS 1989:26, 28).

Because true statements correspond with objective reality, a theory of truth should be complemented by theories of objectivity and realism. Accordingly, the next two sections discuss these two related concepts.

Objectivity

In its primary usage, the concept of objectivity often appears in adjectival form as objective belief, objective knowledge, or objective truth. This concept is complex and somewhat subtle, having three interrelated aspects. Objective knowledge is about an object, rather than a subject or knower; it is achievable by the exercise of ordinary endowments common to all humans, so agreement among persons is possible; and it is not subverted and undone by differences between persons in their worldview commitments, at least for nearly all worldviews.

The first of the three interrelated aspects of objectivity is that objective knowledge is about an object. The AAAS characterizes science beautifully in the simple words that "science is the art of interrogating nature" with "commitment to understanding the natural world" (AAAS 1990:17). For example, "Table salt is sodium chloride" expresses an objective claim about an object, table salt, while expressing nothing about persons who do or do not hold this belief. Because objective beliefs are about objects themselves, not the persons expressing beliefs, the truth or falsity of an objective belief is determined by the belief's object, such as table salt. This thinking reflects and respects the correspondence theory of truth and its priority of reality over beliefs.

In Aristotle's terms, an objective truth about nature is a truth "known by nature," meaning that it expresses a real feature of the physical world, not just an opinion suited to our cognitive capacities or our questionable theories (Irwin 1988:5). Indeed, "As one physicist remarked, physics is about how atoms appear to atoms," and "in science the ultimate dissenting voice is nature itself, and that is a voice which even an entrenched scientific establishment cannot silence for ever" (O'Hear 1989:229, 215). Science's goal is "observer-independent truths about a world independent of us," and "The truths science attempts to reveal about atoms and the solar system and even about microbes and bacteria would still be true even if human beings had never existed" (O'Hear 1989:231, 6).

The second aspect of objectivity is that objective knowledge is achievable by the exercise of ordinary endowments common to all humans, so agreement among persons is possible. Consequently, science's claims are public and verifiable. "Men and women of all ethnic and national backgrounds participate in science and its applications. . . . Because of the social nature of science, the dissemination of scientific information is crucial to its progress" (AAAS 1989:28–29). The link between objective truth and inter-subjective agreement is so strong that the former is difficult to defend when the latter fails.

The third and final aspect of objectivity is immunity to worldview differences. A major reason why science is respected is that it cuts across political, cultural, and religious divisions.

> The impartiality of nature to our feelings, beliefs, and desires means that the work of testing and developing scientific theories is insensitive to the ideological background of

> individual scientists. . . . [Indeed,] science does cut through political ideology, because its theories are about nature, and made true or false by a nonpartisan nature, whatever the race or beliefs of their inventor, and however they conform or fail to conform to political or religious opinion. . . . There is no such thing as British science, or Catholic science, or Communist science, though there are Britons, Catholics, and Communists who are scientists, and who should, as scientists, be able to communicate fully with each other. (O'Hear 1989:6–7, 2, 8)

There is humility, openness, and generosity of spirit in realizing that not only your own worldview supports science, but also most other worldviews allow science to make sense. But having just emphasized that science rises above worldview divisions, on balance it must also be said that this immunity to worldview differences is substantial and satisfactory, but not total. Although held by only a small minority of the world's population, there are some worldviews that are so deeply skeptical or relativistic that they do not and cannot support anything recognizable as science's ordinary claims. And those worldview commitments have a deeper role and greater influence than any and all of science's evidence. But that is a story better told in Chapter 5, on science's presuppositions. For the present, it suffices to acknowledge that science is for almost everyone, but not quite everyone.

"Objectivity" also has a secondary usage that applies to persons rather than to beliefs. When formulating their beliefs, objective persons are willing to allow facts and truth to overrule prejudices and desires. Science "forbids a man to sink into himself and his selfish claims, and shifts the centre of interest from within himself to outside" (Caldin 1949:135–136). Objective inquirers welcome truth.

Furthermore, it must be emphasized that objective knowledge is claimed or possessed by human subjects, for otherwise, unrealistic and indefensible versions of objectivity would emerge. Scientists, as human beings, "must inevitably see the universe from a centre lying within ourselves and speak about it in terms of a human language shaped by the exigencies of human intercourse. Any attempt rigorously to eliminate our human perspective from our picture of the world must lead to absurdity" (Polanyi 1962:3). Objective knowledge that is shared among numerous persons gives science a convivial social aspect, the scientific community.

> Articulate systems which foster and satisfy an intellectual passion can survive only with the support of a society which respects the values affirmed by these passions. . . . [Thus,] our adherence to the truth can be seen to imply our adherence to a society which respects the truth, and which we trust to respect it. Love of truth and of intellectual values in general will . . . reappear as the love of the kind of society which fosters these values, and submission to intellectual standards will be seen to imply participation in a society which accepts the cultural obligation to serve these standards. (Polanyi 1962:203)

But having acknowledged the subjective and social aspects of objectivity, a grave pathology develops if subjectivity supplants rather than complements

objectivity. Such elevation of the knower over the known actually demeans the personal aspect of knowing because it leaves scientists with nothing for their beliefs to be about. That outcome illustrates the principle that every excess becomes its own punishment. Any attempt to eliminate physical objects from science's picture of the world and any attempt to eliminate human persons from science's picture of the world must alike lead to absurdity.

Realism

Realism, as regards the physical world, is the philosophical theory that both human thoughts and independent physical objects exist and that human endowments render the physical world substantially intelligible and reliably known. Scientific realism embodies the claim that the scientific method provides rational access to physical reality, generating much objective knowledge. Realistic beliefs correspond with reality. Realistic persons welcome reality.

> We are trying to refer to reality whenever we say what we think exists. Some may wish to talk of God, and others may think matter is the ultimate reality. Nevertheless, we all talk about tables and chairs, cats and rabbits. They exist, and are real, and do not just depend in some way on our thought for their existence. . . . Man himself is part of reality, and causally interacts with other segments of reality. He can change things, and even sometimes control them. He does not decide what is real and what is not, but he can make up his mind what he thinks real. This is the pursuit of truth. Man's attempt to make true assertions about the self-subsistent world of which he is a part may not always be successful, and may not always prove easy or straightforward. The repudiation of it as a goal would not only destroy science, but would make human intellectual activity totally pointless. (Trigg 1980:200)

Reality does not come in degrees because something either does or does not exist. Thus, one little potato is fully as real as is the entire universe. It is not as big, not as important, and not as enduring, but it is just as real. Likewise, one little potato that exists fleetingly now is completely real regardless of whatever ultimate reality may be invoked to explain or cause or sustain its existence. Science claims to deal with reality. But, clearly, some humility is in order regarding the extent of science's reach. Scientists can agree that a little potato is real even while there is disagreement, uncertainty, or even ignorance about the deep philosophical or physical explanation of its existence.

Common-sense belief in reality is practically universal. For example, a child may say "I am patting my cat." What does this mean? Manifestly, the philosophical story, too obvious to be elaborated in ordinary discourse, is that the child feels and sees and enjoys the cat by virtue of having hands and eyes and brain in close proximity to the furry quadruped. And science's realism is the

same. "The simple and unscientific man's belief in reality is fundamentally the same as that of the scientist" (Max Born, quoted by Nash 1963:29). On the basis of numerous conversations, Rosenthal-Schneider (1980:30) summarized Einstein's view: "Correspondence to the real physical universe, to nature, was for him the essential feature, the only one which would give 'truth-value' to any theory."

The opposite of realism is antirealism, in any of its many variants. Recall from this section's opening definition that realism combines two tenets: the existence of objects and minds, and the intelligibility of objects to minds. Idealism denies the first tenet. It says that only minds exist and that "objects" are just illusions imagined by minds. Constructivism claims that the physical world is a projection of the mind, so we construct rather than discover reality. Instrumentalism denies that external physical objects should be the targets of our truth claims, substituting internal perceptions and thoughts as the material for analysis. Skepticism denies the second tenet. It does not deny that the physical world exists, but it denies that we do have or could have any reliable knowledge about the physical world. Relativism accepts personal truth-for-me but not public truth-for-everyone, so there is no objective and shared knowledge about the world such as the scientific community claims.

Ordinary science is so thoroughly tied to realism that realism's competitors seem to scientists to be somewhat like the philosophical joke expressed well in a little story by Wittgenstein: "I am sitting with a philosopher in the garden; he says again and again 'I know that that's a tree', pointing to a tree that is near us. Someone else arrives and hears this, and I tell him: 'This fellow isn't insane. We are only doing philosophy'" (Anscombe and von Wright 1969:61e). Without realism, ordinary science perishes.

The full force of science's claims results from the joint assertion of all four: rationality, truth, objectivity, and realism. Science claims to have a rational method that provides humans with objective truth about physical reality. The meanings of science's four claims are reviewed in Figure 2.2.

Science and common sense

The choice of a suitable strategy for defending science's four bold claims in subsequent chapters is greatly affected by the relationship between science and common sense. However, for better or for worse, that relationship is highly contentious. There are two basic choices. Science can be seen as a refinement of common sense, so the defense of science's four bold claims begins with an appeal to common sense. Or, science can be seen as an unnatural and counter-intuitive enterprise relative to simplistic common sense, so science's defense must locate other resources. As exemplars of these two choices, this section considers Nash (1963) and Wolpert (1993).

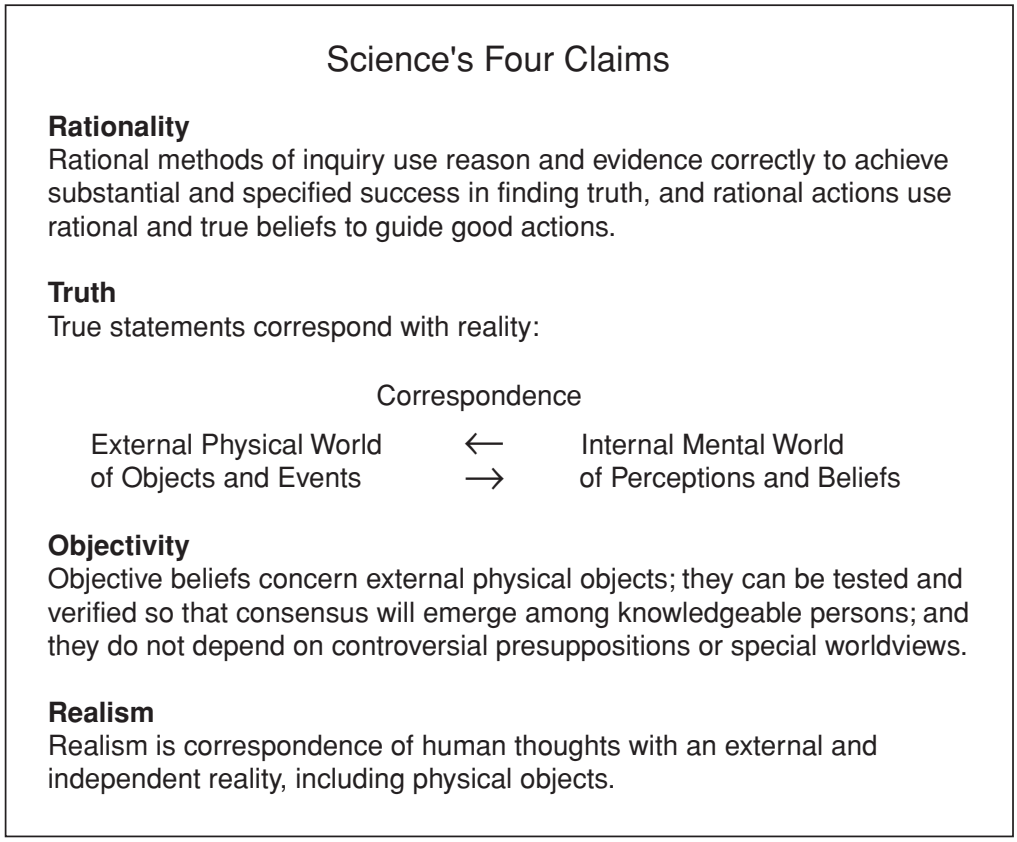

Figure 2.2 Science's claims of rationality, truth, objectivity, and realism.

The Nature of the Natural Sciences by Nash (1963) has a first chapter titled "Common Sense (and Science)" and a second chapter titled "Science (and Common Sense)." Nash began: "Science is a way of looking at the world. There are, of course, other ways. The man of common sense sees the world in his own way. So does the artist, the philosopher, the theologian. The view of the scientist, if at all unique, is characterized by its heavy involvement of elements drawn from all the others" (page 3). But, given those basic elements, the scientist then "seeks a higher unity, a deeper understanding, unknown to common sense" (page 3). He added: "Though between science and common sense there exist dissimilarities we must not (and will not) overlook, the strong similarities between them establish for us a point of departure. Seeking to understand science, we begin by trying to understand the nature of common sense" (page 4). Nash recommended that we follow Einstein, whom he quoted as saying:

> The whole of science is nothing more than a refinement of everyday thinking. It is for this reason that the critical thinking of the physicist cannot possibly be restricted to the examination of the concepts of his own specific field. He cannot proceed without considering critically a much more difficult problem, the problem of analyzing the nature of everyday thinking. (Albert Einstein, quoted in Nash 1963:4)

By contrast, *The Unnatural Nature of Science* by Wolpert (1993) has a first chapter titled "Unnatural Thoughts" that gives many examples of scientific discoveries that seem unnatural from the perspective of common sense. For instance, objects move in different paths than common sense leads most people to expect, white light is composed of a mixture of different colors, and correct probability judgments are often counter-intuitive. He expressed his perspective concisely:

> The central theme presented in this book is that many of the misunderstandings about the nature of science might be corrected once it is realized just how 'unnatural' science is. I will argue that science involves a special mode of thought and is unnatural for two main reasons. . . . Firstly, the world just is not constructed on a common-sensical basis. This means that 'natural' thinking – ordinary, day-to-day common sense – will never give an understanding about the nature of science. Scientific ideas are, with rare exceptions, counter-intuitive: they cannot be acquired by simple inspection of phenomena and are often outside everyday experience. Secondly, doing science requires a conscious awareness of the pitfalls of 'natural' thinking. For common sense is prone to error when applied to problems requiring rigorous and quantitative thinking; lay theories are highly unreliable. (Wolpert 1993:xi–xii)

Upon encountering these opposing views, the first necessity is to recognize that any two things are partly similar and partly dissimilar. For instance, a bird and a stone are similar with respect to being physical objects, but they are dissimilar with respect to being alive. The same holds for science and common sense, being similar in some respects and dissimilar in others. Given that simple insight, this book can accommodate Nash and Wolpert alike.

On the one hand, the similarity of science and common sense is asserted here with respect to two absolutely crucial matters. First, both have the same concept of truth. When a child says "I ate three cookies" and a scientist says "Table salt is NaCl," the same concept and criterion of truth is at work, correspondence of a statement with reality. The concept of truth did not originate with the emergence of science! Rather, all four of science's bold claims – rationality, truth, objectivity, and realism – have a continuity with those claims in common sense. Second, as will be elaborated in Chapter 5, science's presuppositions of a real and comprehensible world, which are indispensable for mainstream science, are best legitimated by an appeal to common sense. One might suppose that a viable or preferable alternative would be an appeal to philosophy, but philosophy is in the same position as science as regards its dependence on common sense for these presuppositions.

On the other hand, the dissimilarity of science and common sense is asserted here with respect to the more advanced and exacting methods of science and the frequently surprising and bizarre findings of science. That scientific method is demanding and sometimes even counter-intuitive is precisely why books like this are needed! And scientific findings in everything from quantum mechanics

to biology to cosmology are amazing and decidedly beyond common sense's reach.

Accordingly, a proper understanding of science must hold in tension both the similarities and dissimilarities between science and common sense. For example, consider the common-sense view that time passes at a constant rate, which has been overturned by the surprising view in Einstein's relativity theory that time passes at different rates depending on an object's speed relative to a given observer. Those different rates can actually be measured for satellites and other fast-moving objects by using extremely accurate clocks, and these measurements agree precisely with theory. Nevertheless, the strange world of relativity theory or quantum mechanics is not detached from the humdrum world of common sense because a scientist looks at a clock or measures a speed or whatever, and those appeals to empirical evidence necessarily require presuppositions about a real and comprehensible world that were best legitimated by a previous appeal to common sense. Furthermore, within the common-sense realm of ordinary speeds and ordinary clocks, relativity confirms, rather than contradicts, the common-sense perception that time always passes at a constant rate. No relativistic corrections are needed in a baseball park.

Science and common sense are partly dissimilar and partly similar. Scientific method, as compared to common-sense thinking, has complicated evidence and advanced logic supporting remarkable conclusions, but it also has identical presuppositions and shared concepts such as rationality and truth.

Summary

Science's four traditional claims are rationality, truth, objectivity, and realism. This chapter explores these four bold claims, drawing on the relevant philosophical literature that tends to be unfamiliar to scientists.

Rationality is good reasoning. Reason holds the double office of regulating belief and guiding action. Rational methods of inquiry, including scientific method, use reason and evidence correctly to achieve substantial and specified success in finding truth, and rational actions use rational and true beliefs to guide good actions.

Truth consists of correspondence between a statement and the actual state of affairs. This correspondence theory of truth presumes and subsumes the coherence theory requiring agreement among a set of beliefs, and it implies and confirms the pragmatic theory saying that truth promotes business with reality in a manner unmatched by ignorance and error. Nevertheless, the principal and essential concept is that of correspondence. The definition of truth is one very simple bit of philosophy: true statements correspond with reality. The real challenge is not the definition of truth but rather the implementation of effective methods for sorting true from false statements.

Objectivity has three interrelated aspects. Principally, objective beliefs are about objects themselves, rather than persons expressing beliefs, so the truth or falsity of an objective belief is determined by the belief's object, such as table salt. Secondly, objective knowledge is attainable by the exercise of ordinary endowments common to all humans, so agreement among persons is possible. Thirdly, objectivity involves immunity to deep worldview differences or philosophical debates, thereby allowing a worldwide scientific community to exist and flourish. A major reason why science is respected is that it cuts across political, cultural, and religious divisions.

Realism, as regards the physical world, is the philosophical theory that both human thoughts and independent physical objects exist and that human endowments render the physical world substantially intelligible and reliably known. Scientific realism embodies the claim that the scientific method provides rational access to physical reality, generating much objective knowledge.

The full force of science's claims results from the joint assertion of all four: rationality, truth, objectivity, and realism. Science claims to have a rational method that provides humans with objective truth about physical reality.

Science is both similar to and different from common sense in various respects. The concepts of rationality, truth, objectivity, and realism are rich and meaningful precisely because they are not unique to science but rather are shared by common sense, philosophy, history, law, and so on. Also, science inherits indispensable presuppositions about the world being real and comprehensible from common sense. But scientific method is more exacting and unnatural than is common-sense thinking. Also, scientific findings are often surprising and even bizarre relative to common-sense beliefs.

Study questions

(1) Define rationality. In which academic disciplines besides science is rationality also applicable and important?
(2) Define truth. How would you compare and relate the correspondence, coherence, and pragmatic theories of truth?
(3) Define objectivity. What are the three interrelated aspects of objectivity and why is objectivity important in science?
(4) Define realism. What are the two basic tenets of realism, and what philosophical positions result from denying one or the other of those tenets?
(5) How would you relate science and common sense?

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