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The problem of future knowledge

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Abstract The paper argues that future knowledge will in substantial measure be inscrutable for us today, with the principal exception of facts about the past. The paper considers the reasons for this circumstance and examines its wider implications for the condition of human knowledge.

Keywords Future knowledge · Prediction · Innovation · Perfectability (of knowledge) · Scientific realism · Knowability

1 Predicting future knowledge

Philosophers since Aristotle have stressed that knowledge about the future poses drastic problems.[1] And the issue of knowing the future of knowledge itself is particularly challenging. No-one can possibly predict the details of tomorrow's discoveries today. To be sure, there is no inherent problem about predicting *that* a certain discovery will be made. But its nature is bound to be unfathomable. After all, if we could solve tomorrow's problems today they simply would not be tomorrow's problems.

We may assume—or suppose—that man will continue to exist and to do so in a form that will enable him to pursue the prospect of inquiry into the nature of things. With this supposed, we do actually know some important facts about the body of knowledge that will be available to the knowers of the future. One of these relates to retrospective knowledge: knowledge of particular facts regarding the past. That Caesar crossed the Rubicon, that Napoleon lost at Waterloo, that Hitler led Germany

[1] That contingent future developments are by nature cognitively intractable, even for God, was a favored theme among the medieval scholastics. On this issue see Adams (1987), chap. 27.

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to invade Poland in 1939, that there were 48 states in the continental US in the year 2000—these and their like are parts of our currently available body of knowledge that will continue in place in the future. And another of these preserved kinds of knowledge relates to various trans-temporal facts: the speed of sound, the specific gravity of lead, the molecular structure of water, the evolutionary history of man. Such facts will continue in place—at least in a rough and approximate formulation.

However, that aspect of the future which is most evidently unknowable is the future of invention, of discovery, of innovation—and particularly in the case of science itself. As Immanuel Kant insisted long ago that every new discovery opens the way to others, every question that is answered gives rise to yet further questions to be investigated.[2] And the fruits of future science are not yet ripe for present picking.

The landscape of natural science is ever-changing: innovation is the very name of the game. Not only do the theses and themes of science change but so do the very questions. Scientific inquiry is a creative process of theoretical and conceptual innovation; it is not a matter of pinpointing the most attractive alternative within the presently specifiable range, but one of enhancing and enlarging the range of envisageable alternatives. Such issues pose genuinely open-ended questions of original research: they do not call for the resolution of problems within a preexisting framework but for a rebuilding and enhancement of the framework itself. Most of the questions with which present-day science grapples could not even have been raised in the state-of-the-art that prevailed a generation ago. It is in principle infeasible for us to tell now not only how future science will answer present questions but even what questions will figure on the question agenda of the future, let alone what answers they will engender. In this regard, as in others, it lies in the inevitable realities of our condition that the details of our ignorance are—for us at least—hidden away in an impenetrable fog of obscurity.

The contrast between present knowledge and future knowledge is clearly one that we cannot characterize in detail. It would be utterly unreasonable to expect prognostications of the particular *content* of scientific discoveries. It may be possible in some cases to speculate that science will solve a certain problem, but *how* it will do so lies beyond the ken of those who antedate the discovery itself. If we could *predict* discoveries in detail in advance, then we could *make* them in advance.[3] In matters of scientific importance, then, we must be prepared for surprises. Commenting shortly after the publication of Frederick Soddy's speculations about atomic bombs in his 1950 book *Science and Life*, Robert A. Millikan, a Nobel laureate in physics, wrote that "the new evidence born of further scientific study is to the effect that it is highly improbable that there is any appreciable amount of available subatomic energy to tap."[4] In science forecasting, the record of even the most qualified practitioners is poor. For people may well not even be able to

[2] On this theme see Rescher (2000).

[3] As one commentator has wisely written: "But prediction in the field of pure science is another matter. The scientist sets forth over an uncharted sea and the scribe, left behind on the dock is asked what he may find at the other side of the waters. If the scribe knew, the scientist would not have to make his voyage" (Anonymous [1920]).

[4] Quoted in *Daedalus*, vol. 107 (1978), p. 24.

conceive the explanatory mechanisms of which future science will make routine use.

In inquiry as in other areas of human affairs, major upheavals can come about in a manner that is sudden, unanticipated, and often unwelcome. Major scientific breakthroughs often result from research projects that have very different ends in view. Louis Pasteur's discovery of the protective efficacy of inoculation with weakened disease strains affords a striking example. While studying chicken cholera, Pasteur accidentally inoculated a group of chickens with a weak culture. The chickens became ill, but, instead of dying, recovered. Pasteur later reinoculated these chickens with fresh culture—one strong enough to kill an ordinary chicken. To Pasteur's surprise, the chickens remained healthy. Pasteur then shifted his attention to this interesting phenomenon, and a productive new line of investigation opened up. In empirical inquiry, we generally cannot tell in advance what further questions will be engendered by our endeavors to answer those on hand. New scientific questions arise from answers we give to previous ones, and thus the issues of future science simply lie beyond our present horizons.

It is a key fact of life that ongoing progress in scientific inquiry is a process of *conceptual* innovation that always places certain developments outside the cognitive horizons of earlier workers because the very concepts operative in their characterization become available only in the course of scientific discovery itself. (Short of learning our science from the ground up, Aristotle could have made nothing of modern genetics, nor Newton of quantum physics.) The major discoveries of later stages are ones which the workers of a substantially earlier period (however clever) not only have failed to make but which they could not even have *understood*, because the requisite concepts were simply not available to them. Thus, it is effectively impossible to predict not only the answers but even the questions that lie on the agenda of future science. Detailed prediction is outside the realm of reasonable aspiration in those domains where innovation is preeminently conceptual.

2 Detail versus generality

Forecasts of scientific developments must conform to the vexatious general principle that, other things being equal, *the more informative a forecast it*, *the less secure it is*, *and conversely*, *the less informative*, *the more secure it is*. It is a basic principle of epistemology that increased confidence in the correctness of our estimates can always be secured at the price of decreased accuracy. For in general an inverse relationship obtains between the definiteness or precision of our information and its substantiation: detail and security stand in a competing relationship. We estimate the height of the tree at *around* 25 feet. We are *quite sure* that the tree is 25 ± 5 feet high. We are *virtually certain* that its height is 25 ± 10 feet. But we can be *completely and absolutely sure* that its height is between 1 inch and 100 yards. Of this we are "completely sure" in the sense that we are “absolutely certain”, “certain beyond the shadow of a doubt”, “as certain as we can be of anything in the world”, “so sure that we would be willing to stake your life on it,” and the like. For any sort of estimate whatsoever there is always a characteristic trade-off relationship between the evidential *security* of the estimate, on the one hand (as determinable on the basis of its probability or degree of acceptability), and on the other hand its contentual *detail* (definiteness, exactness, precision, etc.).

An ironic but critically important feature of scientific inquiry is that the unforeseeable tends to be of special significance just because of its unpredictability. *The more important the innovation*, *the less predictable it is*, *because its very unpredictability is a key component of importance*. Science forecasting is beset by a pervasive *normality bias*, because the really novel often seems so bizarre. A. N. Whitehead has wisely remarked:

> If you have had your attention directed to the novelties in thought in your own lifetime, you will have observed that almost all really new ideas have a certain aspect of foolishness when they are first produced.[5]

Before the event, revolutionary scientific innovations will, if imaginable at all, generally be deemed outlandishly wild speculation—mere science fiction, or perhaps just plain craziness.[6]

With respect to the major substantive issues of future natural science, we must be prepared for the unexpected. We can confidently say of future science *that* it will do its job of prediction and control better than ours; but we do not—and in the very nature of things cannot-know *how* it will go about this.

3 Is future knowledge convergent?

Some theorists have maintained that as science progresses the *magnitude of the issues* grows ever smaller and smaller. Later questions, so they hold, are always lower questions, so that later science is always lesser science. Successive innovation becomes a matter of increasing refinement in detail, and furnishes new materials whose inherent significance decreases continually—exactly as with the decimal expansion of π or $\sqrt{2}$.

Scientific inquiry would thus be conceived of as analogous to terrestrial exploration, whose product—geography—yields results of continually smaller significance which fill in ever more minute gaps in our information. In such a view, the later investigations yield findings of ever smaller importance, with each successive accretion making a relatively smaller contribution to what has already come to hand. The advance of science leads, step by diminished step, toward a fixed and final view of things.

This general position is central to Charles Sanders Peirce’s vision of ultimate convergence in scientific inquiry:

5 Whitehead (1969).

6 See Kuhn (1970), for an interesting development of the normal/revolutionary distinction.

> As the investigation goes on, additions to our knowledge…are of less and less worth. Thus, when Chemistry sprang into being, Dr. Wollaston, with a few test tubes and phials on a tea-tray, was able to make new discoveries of the greatest moment. In our day, a thousand chemists, with the most elaborate appliances, are not able to reach results which are comparable in interest with those early ones. All the sciences exhibit the same phenomenon….[7]

But such a theory encounters deep difficulties. For any such picture of convergence, however carefully crafted, will shatter against the *conceptual innovation* that continually brings entirely new, radically different scientific concepts to the fore and brings in its wake an ongoing wholesale revision of "established fact." Consider how many facts about a simple object—a sword, for example—were unknown to the ancients. They did not know that it contained carbon or that it conducted electricity. The very concepts at issue ("carbon," "electricity-conduction") were outside their cognitive range. There are key facts (or presumptive facts) even about the most familiar things—trees and animals, bricks and mortar—that were unknown a 100 years ago. This ignorance arises because the required *concepts* have not been formulated. It is not just that the scientists of antiquity did not know what the half-life of californium is but that they couldn't have *understood* this fact if someone had told them about it.

Ongoing scientific progress is emphatically not simply a matter of increasing accuracy by extending the numbers in our otherwise stable descriptions of nature out to a few more decimal places. It will not serve to take the preservationist stance that the old theories are generally acceptable as far as they go and merely need supplementation; significant scientific progress is genuinely revolutionary in that there is *a fundamental change of mind* as to how things happen in the world. Progress of this caliber is generally a matter not of adding further facts—on the order of filling in a crossword puzzle—but of changing the framework itself. The fact is that in natural science small innovations with respect to data can constrain large changes in theoretical systematization so as to render future science presently inscrutable.

4 Is future knowledge perfectible?

How far can the scientific enterprise advance toward a definitive understanding of reality? Might science attain a point of recognizable completion?

But is the achievement of perfected science actually a genuine possibility, even in theory when all of the "merely practical" obstacles are put aside as somehow incidental? After all, what would *perfected science* be like? What sort of standards would it have to meet? Clearly, it would have to complete in full the discharge of natural science's mandate or mission.

It thus appears that if we are to claim that our science has attained a perfected condition, it would have to satisfy (at least) the four following conditions:

[7] Peirce (1934), sect. 7.144. See also Peirce's important 1898 paper on "Methods for Attaining Truth," in ibid., sects. 5.574 ff.

1. *Erotetic completeness*: It must answer, in principle at any rate, all those descriptive and explanatory questions that it itself countenances as legitimately raisable, and must accordingly explain everything it deems explicable.
2. *Predictive completeness*: It must provide the cognitive basis for accurately predicting those eventuations that are in principle predictable (that is, those which it itself recognizes as such).
3. *Pragmatic completeness*: It must provide the requisite cognitive means for doing whatever is feasible for beings like ourselves to do in the circumstances in which we labor.
4. *Temporal finality* (the omega-condition): It must leave no room for expecting further substantial changes that destabilize the existing state of scientific knowledge.

Each of these modes of substantive completeness deserves detailed consideration. First, however, one brief preliminary remark. It is clear that any condition of science that might qualify as "perfected" would have to meet certain formal requirements of systemic unity. If, for example, there are different routes to one and the same question (for instance, if both astronomy and geology can inform us about the age of the earth), then these answers will certainly have to be consistent. Perfected science will have to meet certain requirements of structural systematicity in the manner of its articulation: it must be coherent, consistent, consonant, uniform, harmonious, and so on. Such requirements represent purely formal cognitive demands upon the architectonic of articulation of a body of science that could lay any claim to perfection. Interesting and important though they are, we shall not, however, engage these *formal* requirements here, our present concern being with those four just-mentioned *substantive* issues.[8]

5 Theoretical adequacy: issues of erotetic completeness

Could we ever actually achieve erotetic completeness—the condition of being able to resolve, in principle, all of our (legitimately posable) questions about the world? Could we ever find ourselves in this position?[9]

In theory, yes. A body of science certainly could be such as to provide answers to all those questions it allows to arise. But just how meaningful would this mode of completeness be?

The reality is this erotetic completeness is an unattainable mirage. We can never exhaust the range of open questions.

For the world's furnishings are cognitively opaque; we cannot see to the bottom of them. Knowledge can become more extensive without thereby becoming more complete. And this view of the situation is rather supported than impeded if we

[8] Rescher (1979a) deals with these matters.

[9] Note that this is independent of the question "Would we ever want to do so?" Do we ever want to answer all those predictive questions about ourselves and our environment, or are we more comfortable in the condition in which "ignorance is bliss"?

abandon a cumulativist/preservationist view of knowledge or purported knowledge for the view that new discoveries need not supplement but can displace old ones.

It is sobering to realize that the erotetic completeness of a state of science *S* does not necessarily betoken its comprehensiveness or sufficiency. It might reflect the paucity of the range of questions we are prepared to contemplate—a deficiency of imagination, so to speak. When the range of our knowledge is sufficiently restricted, then its erotetic completeness will merely reflect this impoverishment rather than its intrinsic adequacy. Conceivably, if improbably, science might reach a purely fortuitous equilibrium between problems and solutions. It could eventually be "completed" in the narrow erotetic sense—providing an answer to every question one can also in the then-existing (albeit still imperfect) state of knowledge—without thereby being completed in the larger sense of answering the questions that would arise if only one could probe nature just a bit more deeply. And so, our corpus of scientific knowledge could be erotetically complete and yet fundamentally inadequate. Thus, even if realized, this erotetic mode of completeness would not be particularly meaningful. (To be sure, this discussion proceeds at the level of supposition contrary to fact. The exfoliation of new questions from old in the course of scientific inquiry that is at issue in Kant's Principle of question-propagation spells the infeasibility of ever attaining erotetic completeness.)

After all, any judgment we can make about the laws of nature—any model we can contrive regarding how things work in the world—is a matter of theoretical triangulation from the data at our disposal. And we should never have unalloyed confidence in the definitiveness of our data base or in the adequacy of our exploitation of it. Observation can never settle decisively just what the laws of nature are. In principle, different law-systems can always yield the same observational output: as philosophers of science are wont to insist, observations *underdetermine* laws. To be sure, this worries working scientists less than philosophers, because they deploy powerful regulative principles—simplicity, economy, uniformity, homogeneity, and so on—to constrain uniqueness. But neither these principles themselves nor the uses to which they are put are unproblematic. No matter how comprehensive our data or how great our confidence in the inductions we base upon them, the potential reversatility of our claims cannot be dismissed.

We can reliably estimate the amount of gold or oil yet to be discovered, because we know the earth's extent and can thus establish a proportion between what we know and what we do not. But we cannot comparably estimate the amount of knowledge yet to be discovered, because we have and can have no way of relating what we know to what we do not. But (to hark back to Hegel), with respect to the realm of knowledge, we are not in a position to draw a line between what lies inside and what lies outside—seeing that, *ex hypothesi* we have no cognitive access to that latter. One cannot make a survey of the relative extent of knowledge or ignorance about nature except by basing it on some picture of nature that is already in hand—that is, unless one is prepared to take at face value the deliverances of existing science. This process of judging the adequacy of our science on its own telling is the best we can do, but it remains an essentially circular and consequently inconclusive way of proceeding. The long and short of it is that there is no cognitively adequate basis for maintaining the completeness of science in a rationally satisfactory way.

6 Pragmatic completeness

The arbitrament of praxis over our scientific contentions—not then theoretical merit but practical applicability—affords the best standard of adequacy. But could we ever be in a position to claim that science has been completed on the basis of the success of its practical applications? On this basis, the perfection of science would have to manifest itself in the perfecting of control—in achieving a perfected technology. But just how are we to proceed here? Could our natural science achieve manifest perfection on the side of control over nature? Could it ever underwrite a recognizably perfected technology?

The issue of "control over nature" involves much more complexity than may appear on first view. For just how is this conception to be understood? Clearly, in terms of bending the course of events to our will, of attaining our ends within nature. But this involvement of "*our ends*" brings to light the prominence of our own contribution. For example, if we are inordinately modest in our demands (or very unimaginative), we may even achieve "complete control over nature" in the sense of being in a position to do *whatever we want* to do, but yet attain this happy condition in a way that betokens very little real capability.

One might, to be sure, involve the idea of omnipotence, and construe a "perfected" technology as one that would enable us to do literally *anything*. But this approach would at once run into the old difficulties already familiar to the medieval scholastics. They were faced with the challenge: "If God is omnipotent, can he annihilate himself (contra his nature as a *necessary* being), or can he do evil deeds (contra his nature as a *perfect* being), or can he make triangles have four angles (contrary to *their* definitive nature)?" Sensibly enough, the scholastics inclined to solve these difficulties by maintaining that an omnipotent God need not be in a position to do literally anything but rather simply anything that it *is possible* for him to do. Similarly, we cannot explicate the idea of technological omnipotence in terms of a capacity to produce any result whatsoever, wholly without qualification. We cannot ask for the production of a *perpetuum mobile*, for spaceships with "hyperdrive" enabling them to attain transluminar velocities, for devices that predict essentially stochastic processes such as the disintegrations of transuranic atoms, or for piston devices that enable us to set *independently* the values for the pressure, temperature, and volume of a body of gas. We cannot, in sum, ask of a "perfected" technology that it should enable us to do *anything* that we might take it into our heads to do, no matter how "unrealistic" this might be.

All that we can reasonably ask of it is that perfected technology should enable us to do anything *that it is possible for us to do*—and not just what we might *think* we can do but what we really and truly can do. A perfected technology would be one that enabled us to do anything that *can possibly* be done by creatures circumstanced as we are. But how can we deal with the pivotal conception of "can" that is at issue here? Clearly, only science—real, true, correct, *perfected* science—could tell us what indeed is realistically possible and what circumstances are indeed inescapable. Whenever our "knowledge" falls short of this, we may well "ask the impossible" by way of accomplishment (for example, spaceships in "hyperdrive"), and thus complain of incapacity to achieve control in ways that put unfair burdens on this conception.

Power is a matter of the "effecting of things possible"—of achieving control—and it is clearly cognitive state-of-the-art in science which, in teaching us about the limits of the possible, is itself the agent that must shape our conception of this issue. *Every* law of nature serves to set the boundary between what is genuinely possible and what is not, between what can be done and what cannot, between which questions we can properly ask and which we cannot. We cannot satisfactorily monitor the adequacy and completeness of our science by its ability to effect "all things possible," because science alone can inform us about what is possible. As science grows and develops, it poses new issues of power and control, reformulating and reshaping those demands whose realization represents "control over nature." For science itself brings new possibilities to light. (At a suitable stage, the idea of "splitting the atom" will no longer seem a contradiction in terms.) To see if a given state of technology meets the condition of perfection, we must *already* have a body of perfected science in hand to tell us what is indeed possible. To validate the claim that our technology is perfected, we need to *preestablish* the completeness of our science. The idea works in such a way that claims to perfected control can rest only on perfected science.

In the final analysis, then, we cannot regard the *realization* of "completed science" as a meaningful prospect—because we cannot really say science-independently what it is that we are asking for. And this consideration decisively substantiates the idea that we must always presume out knowledge to be incomplete in the domain of natural science.

7 Predictive completeness

The difficulties encountered in using physical control as a standard of "perfection" in science will also hold with respect to *prediction*, which, after all, is simply a mode of *cognitive* control.

Suppose someone asks: "Are you really still going to persist in plaints regarding the incompleteness of scientific knowledge when science can predict *everything*?" The reply is simply that science will *never* be able to predict literally everything: the very idea of predicting *everything* is simply unworkable. For then, whenever we predict something, we would have to predict also the effects of making those predictions, and then the ramification of *those* predictions, and so on *ad indefinitum*. The very most that can be asked is that science put us into a position to predict, not *everything*, but rather *anything* that we might choose to be interested in and to inquire about. And here it must be recognized that our imaginative perception of the possibilities might be much too narrow. We can only make predictions about matters that lie, at least broadly speaking, within our cognitive horizons. Newton could not have predicted findings in quantum theory any more than he could have predicted the outcome of American presidential elections. One can only make predictions about what one is cognizant of, takes note of, deems worthy of consideration. In this regard, one can be myopic either by not noting or by losing sight of significant sectors of natural phenomena.

In the end it is science itself that determines the limits to predictability—insisting that some phenomena (the stochastic processes encountered in quantum physics, for example) are inherently unpredictable. And this is always to some degree problematic. After all, the most that science can reasonably be asked to do is to predict what is predictable. But this will have to be what it itself sees as in principle predictable. No more can be expected of science than answering every predictive question that it itself countenances as proper. And not only is this problematically circular, but we must once more recognize that any given state of science might have gotten matters quite wrong.

With regard to predictions, we are thus in the same position that obtains with regard to actually interventionist (rather than "merely cognitive") control. Here, too, we can unproblematically apply the idea of improvement—of *progress*. But it makes no sense to contemplate the achievement of *perfection*. For its realization is something we could never establish by any practicable means.

8 Temporal finality

And now on to temporal finality. Scientists from time to time indulge in eschatological musings and tell us that the scientific venture is approaching its end.[10] And it is, of course, entirely *conceivable* that natural science will come to a stop, and will do so not in consequence of a cessation of intelligent life but in C. S. Peirce's more interesting sense of completion of the project: of eventually reaching a condition after which even indefinitely ongoing inquiry will not—and indeed in the very nature of things *cannot*—produce any significant change, because inquiry has come to "the end of the road." The situation would be analogous to that envisaged in the apocryphal story in vogue during the middle 1800s regarding the Commissioner of the United States Patents who resigned his post because there was nothing left to invent.[11]

Such a position is in theory possible. But here, too, we can never effectively determine that it is actual.

There is no practicable way in which the claim that science has achieved temporal finality can be validated. The question "Is the current state of science, *S*, final?" is one for which we can never legitimate an affirmative answer. For the prospect of future changes of *S* can never be precluded. After all, one cannot plausibly move beyond "We have (in *S*) no good reason to think that *S* will ever change" to obtain "We have (in *S*) good reason to think that *S* will never change."

Moreover, just as the appearance of erotetic and pragmatic equilibrium can be a product of narrowness and weakness, so can temporal finality. We may think that science is unchangeable simply because we have been unable to change it. But that's just not good enough. Were science ever to come to a seeming stop, we could

[10] This sentiment was abroad among physicists of the *fin de siècle* era of 1890–1900 (see Badash [1972]). And such sentiments are coming back into fashion today. See Feynmann (1965), p. 172. See also Stent (1969); and Hawkins (1981), pp. 15–17.

[11] See Jeffrey (1940).

never be sure that it had done so not because it is at "the end of the road" but because we are at the end of our tether. We can never ascertain that science has attained the *X*-condition of final completion, since from our point of view the possibility of further change lying "just around the corner" can never be ruled out finally and decisively. No matter how final a position we *appear* to have reached, the prospects of its coming unstuck cannot be precluded. As we have seen, future science is inscrutable. We can never claim with assurance that the position we espouse is immune to change under the impact of further data—that the oscillations are dying out and we are approaching a final limit. In its very nature, science "in the limit" relates to what happens in the long run, and this is something about which we *in principle* cannot gather information: any information we can actually gather inevitably pertains to the short run and not the long run. We can never achieve adequate assurance that *apparent* definitiveness is *real*. We can never consolidate the claim that science has settled into a frozen, changeless pattern. The situation in natural science is such that our knowledge of nature must ever be presumed to be incomplete—and thereby inadequate overall.

One is thus led back to the stance of the idealistic tradition from Plato to Royce that human knowledge inevitably falls short of recognizably "perfected science" (the Ideas, the Absolute), and must accordingly be looked upon as deficient. Our knowledge of the real is something we can certainly improve upon—but not something we can perfect. As best we can judge, science is destined to remain incomplete.

9 The problem of future science in its relation to reality

How then are we to relate present-day science to the science of the future? The preceding considerations must inevitably constrain and condition our attitude toward the natural mechanisms envisaged in the science of the day. We certainly do not—or should not—want to reify (hypostasize) the "theoretical entities" of our *current* science as current science sees them—to say flatly and unqualifiedly that the contrivances of *our* present-day science correctly depict the furniture of the real world. We do not—or at any rate, given the realities of the case, should not—want to adopt categorically the ontological implications of scientific theorizing in just exactly the state-of-the-art configurations presently in hand. An unacceptable fallibilism precludes the claim that what we purport to be scientific knowledge is in fact *real* knowledge, and accordingly blocks the path to a scientific realism that maintains that the furnishings of the real world are exactly as our science states them to be. Scientific theorizing is always inconclusive.

If the future is anything like the past, if historical experience affords any sort of guidance in these matters, then we know that *all* of our scientific theses and theories at the present scientific frontier will ultimately require revision in some (presently altogether indiscernible) details. All the experience we can muster indicates that there is no justification for viewing our science as more than an inherently imperfect stage within an ongoing development. The ineliminable prospect of far-reaching future changes of mind in scientific matters destroys any prospect of claiming that the world is as our science claims it to be—that science's view of nature's constituents and laws is correct.

Our prized "scientific knowledge" is no more than our "current best estimate" of the matter. The step of reification is always to be taken provisionally, subject to a mental reservation of presumptive revisability. We cannot but acknowledge the prospect that we shall ultimately recognize many or most of our frontier scientific theories to need revision and that what we proudly vaunt as scientific knowledge is a tissue of hypotheses—of tentatively adopted contentions of many or most of which we will ultimately come to regard as requiring serious revision or perhaps even abandonment.

And so a clear distinction must be maintained between "*our conception of* reality" and "reality *as it really is*." We must—and do—realize that there is precious little justification for holding that present-day natural science describes reality and depicts the world as it really is. And this constitutes a decisive impediment to any straightforward realism. It must inevitably constrain and condition our attitude towards the natural mechanisms envisioned in contemporary science. We certainly do not—or should not—want to reify (hypostatize) flat-out the "theoretical entities" of present-day science, to say flatly and without qualification that the contrivances of *our* present-day science correctly depicts the nature of things as they actually and ultimately are.

This situation blocks the option of scientific realism of any straightforward sort. Not only are we not in a position to claim that our knowledge of reality is *complete* (that we have gotten at the *whole* truth of things), but we are not even in a position to claim that our "knowledge" of reality is *correct* (that we have gotten at the *real* truth of things). Such a position calls for the humbling view that just as we think our predecessors of a century ago had a fundamentally inadequate grasp on the "furniture of the world," so our successors of a millennium hence will take a similar view or our purported knowledge of things.

We do not—or at any rate, given the realities of the case, should not—want to adopt categorically the ontological implications of scientific theorizing in just exactly the state-of-the-art configuration presently in hand. A realistic acknowledgment of scientific fallibilism precludes the claim that the furnishings of the real world are exactly as our science states them to be—that electrons actually are just exactly as the latest *Handbook of Physics* claims them to be.

In relation to what is to come, our present thought about nature is no more than our inadequate anticipation—an estimate rather than a specification. And the fact of it is that we shall never be able to make claims about realty that go beyond what we presently think to be the case: reality as we can deal with it will always have to be *our* reality—reality as we presently conceive it to be.

10 Epistemic vistas

Thought about nature is a complex issue: if only because nature's make-up can be known with different degrees of adequacy. The scale at issue in Display 1 is significant and instructive in this regard.

Display 1 Steps towards objectivity

Subjective	(1) I think that…	[Self-impression]
	(2) We (nowadays) think that…	[Group-impression]
	(3) They will then think that…	[Future impression]
	(4) They will eventually or ultimately think that…	[Long-run ultimacy]
Objective	(5) It is to be thought (because actually true) that…	[Ideality]

It seems incontestably sure that when X is a large scale and complex fact regarding nature, then as one moves down that list one is soon out of one's depth, since in substantial matters of scientific inquiry we can seldom get beyond (2). And the fact of it is that we do and cannot but realize that there is a potential gap between (3) and (4) and that no matter when that future date may fall there is room for error.

Moreover, the instruction "Tell me what X is actually like, over and above and apart from what you think it to be" is an instruction that we cannot obey. The progressiveness of science means that the *merely seems/actually is* distinction is one we cannot operate with respect to matters of exact detail.

After all, who must X be in order for the following equivalence to hold:

$$X \text{ thinks } p \text{ to be the case } \equiv p \text{ is actually the case}$$

Pretty well nobody maintains that "X = the scientific community of the present day" will do the job. But for a time C. S. Peirce thought that the following would work out

$$X = \text{the scientific community of the long-run future}$$

Only gradually did he abandon this idea and move on to:

$$X = \text{the scientific community in its } \textit{ideal} \text{ formation}$$

And this puts Peirce into proximity with the later Josiah Royce who thought that

$$X = \text{the Absolute (in its communal form)}$$

wouldwork out. But of course the problem is that we actually live in the real and not the ideal world. For those confined to the mundane idealistic of the actual, those idealizations do not afford much help.

It has to be acknowledged that with many matters—those of scientific futurity emphatically included—an assured knowledge of the truth (the whole truth and nothing but the truth) is inaccessible to finite minds. Those who—like Euro-Idealists (German and British alike)—were to equate truth and knowledge have no alternative to following Josiah Royce into postulating an Absolute or Ideal Mind able to go where finite minds cannot reach. Granted, the idea of "naturalizing" the Absolute by reconceptualizing it as the work of finite minds in their aggregate totality is ingenious. But its visionary and unrealizable nature makes it an ultimately impracticable and futile expedient. We simply have to concede that Table I's ladder of objectivity cannot be descended as deep as we might like. The faith we lack in the present is not unavailable for the future either.

11 Science and reality

We are now in a position to place into clearer relief one of the really big questions of philosophy: How close a relationship can we reasonably claim to exist between the answers we give to our factual questions at the level of scientific generality and precision and the reality they purport to depict?

Scientific realism is the doctrine that *science describes the real world*: that the world actually is as science takes it to be, and that its furnishings are as science envisages them to be.[12] But is such a "scientific realism" a tenable position?

It is quite clear that it is not. There is clearly insufficient warrant for and little plausibility to the claim that the world indeed is as our science claims it to be and that *our* science is *correct* science and offers the definitive "last word" on the issues. We really cannot reasonably suppose that science as it now stands affords the real truth as regards its creatures-of-theory.

One of the clearest lessons of the history of science is that where scientific knowledge is concerned, further discovery does not just *supplement* but generally *emends* the bearing of our prior information. Accordingly, we have little alternative but to take the humbling view that the incompleteness of our purported knowledge about the world entails its potential incorrectness as well. It is now a matter not simply of *gaps* in the structure of our knowledge, or errors of omission. There is no realistic alternative but to suppose that we face a situation of real *flaws* as well, of errors of commission. This aspect of the matter endows incompleteness with an import far graver than meets the eye on first view.[13]

Realism equates the paraphernalia of natural science with the domain of what actually exists. But this equation would work only if science, as it stands, has actually "got it right." And this is something we are surely not inclined—and certainly no *entitled*—to claim. We must recognize that the deliverances of science are bound to a methodology of theoretical triangulations from the data which binds them inseparably to the "state -of-the-art" of technological sophistication in data acquisition and handling.

As far as the actual condition of nature is concerned, science merely purports but does not achieve: it may provide us with the very best achievable estimate, but all the same this is still an estimate. The step of reification is always to be taken qualifiedly, subject to a mental reservation of presumptive revisability. We do and must recognize that we cannot blithely equate *our* frontier scientific theories with *the* truth. We do and must realize that the declarations of science are inherently fallible and that we can only "accept" them provisionally subject to a clear realization that they may need to be corrected or even abandoned.

12 Ramifications of impredictability

One further implication of these deliberations deserves comment. Man (homo sapiens) is an intelligent being whose actions in the world are guided by his

[12] For some classical discussions of scientific realism, see Sellars (1963); McKinnon (1972); Harré (1970); and Suppe (1977).

[13] Some of the issues of this discussion are developed at greater length in Rescher (1977, 1979a, b).

beliefs—by what he takes to be knowledge. But insofar as the future development of human knowledge is impredictable, so this will also be the case with respect to human doings and dealings, so that human actions and affairs will also be in substantial measure impredictable. And thus insofar as man is an integral and interactive part of nature so there will be a section of the natural world that will be impredictable as well. In relation to the cultivation of knowledge, the chance and contingency that afflicts human affairs is bound to involve some part of nature as well. To be sure, man and his dealings are small potatoes in the cosmic scheme of things. But nevertheless we are a part of the overall picture and the role of our thought cannot simply be set at naught. And to this extent idealism, too, must be conceded its place.

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