SOFTENING 'HARD' SCIENCE[1] Dan Bruiger, 2023

I. Preamble

Like other human creations, science can be improved. I will argue—very informally—that the "harder" sciences could benefit by "softening." That is, they could adopt some of the self-questioning exemplified in social science and an organismic view of the world still implicit in biology. In particular, physics could improve by scrutinizing assumptions and concepts that linger from its religious and idealist heritage. First, some thoughts about modern science as it is; then, some reflections on how it could improve.

II. Present Science

The universe must be a certain way to contain living observers. Equally, creatures must be a certain way to live within it. Hence, embodied observers must view the universe in certain ways. Science is a form of human cognition that extends natural perception and compensates for some of its limitations. Humans are primates. Despite its association with realism and objectivity, their science is a primate species' adaptive survival strategy, which emphasizes mastery of its environment and facilitates technology. It is not a gods-eye perspective, a disembodied "view from nowhere," but a narrative driven by the parochial needs and nature of a particular biological organism on a solid planet. It is also a form of employment, concerned with controlling, using, and even replicating nature for human purposes, which include the goals of corporations and governments. Viewing science this way competes with a pretention to disinterested objectivity and the ideal of a complete account of nature, a final theory.

Modern Western science arose in Europe with roots in medieval Christianity as well as antiquity. Historically, science inherits many notions from monotheistic religion. Many of the early scientists were deeply religious and were literally creationists. Their prevailing attitude was that nature did not have its own inherent reality, but only the derived reality an artisan confers on made things. As a divine creation, nature was considered an *artifact*—which is essentially a product of definition. As such, the natural world should be finitely knowable and predictable. These ideas gave rise to the notions of determinism and mechanism, whose appeal reflects the need for certainty and control and the promise that knowledge could be comprehensive and definitive. The purpose of science was to discover the blueprint of the world machine—or, in modern terms, its program.

In contrast to social sciences, "hard" science traditionally excludes the epistemic subject (observer) in order to focus on the object studied. The scientific portrait of nature does not include the artist. This arrangement extends the fundamental relation of subject to object of an epistemic agent whose survival depends on tracking the external world. As Kant made clear, ignoring the situation of the observer is a mistake. The mind is in no position to grasp reality "in itself." While physical reality no doubt has inherent properties, these can only be known through the observer's intervention, who defines what knowing means and redefines nature in useful terms.

Observation necessarily involves an interaction between physical systems. For example, though basic in modern physics, the notion of *event* is ambiguous. From an ontological point of view, an event might be the collision of two billiard balls or two particles. However, to *know* about

[1] This essay won 4th prize in the 2023 fqxi.org competition, "How Could Science Be Different?"

it requires another event: in the brain of the observer (or at least occurring in a measuring device). It also requires an intervening medium—a signal—connecting them. Moreover, the observer's *embodiment* is not mere physical instantiation, but involves the epistemic agent's complex relationship to the world as an organism.

That relationship is generally ignored in scientific practice and communication. It is not the idiosyncratic personal experience of the scientist that counts in scientific reports. Instead, it is assumed that the researcher intends an "objective" description of the world. While individual and cultural idiosyncrasies may be eliminated in scientific method, the very lack of reflexivity means that characteristics common to *all* human observers may elude detection. This includes fundamental assumptions and preferences "unconsciously" built into science as a species construct.

Despite its cognitive limitations, modern Western science is a prestigious international club, without political affiliation, with both cooperative and competitive aspects. It serves as a positive model of transcultural communication, international cooperation and good will, and the potential for united human action. In large part, this owes to the central role of mathematics, which has become a universal language. Yet, research and its technological products have been pursued for individual and corporate profit, for nationalistic and military goals, even for religious, ideological, racial or gender-specific ends.

III. Future Science

I propose to unpack some of the above considerations to see how science as we know it could be better by being softer. In particular to see: (1) how physics might be freer from rigidity imposed by its religious heritage; (2) how it might benefit from being more reflexive; and (3) how science in general could play a major role in the conscious direction of our species' future.

1. The idea that nature had only a derived reality distinguished the science of the Christian Renaissance, steeped in Platonic idealism, from early Greek materialism and pagan nature-worship traditions. This idea deprived matter of any active power of self-organization. Moreover, the view of the natural world as artifact led to the idea of the world as *system* or *machine*. This becomes a concern because systems, like machines, can only be identified in accord with human definitions and purposes. The view of the world as machine, and of matter as passive, must be recognized as no more than metaphor. Since thought is unavoidably metaphorical, it should be productive for science to scrutinize its metaphors.

A different paradigm than mechanism prevailed before the machine became so culturally prominent. The world was once conceived to be an organism. This metaphor survives in biological science, where processes of self-organization, circular causation and feedback, and self-maintenance are taken for granted, despite the incursions of mechanism into genetics and despite the observer-centric biases that permeate biology as well as physics. A lesson in point: because of its view of matter as passive, inorganic chemistry could only fairly recently discover "self-organized complexity" as a physico-chemical process.

The modern notion of *theory* (a term related to *theology*) arose, perhaps, in the need to disguise propositions about reality that ran counter to religious orthodoxy in the early modern period. A theory, in that sense, was a hypothetical and self-contained fancy, whose ontological claims were not proposed to be taken seriously. This convention allowed the author to evade prosecution—successfully in some cases. It established a new category of speculation, as a free mental construct independent of empirical data and potentially superseding them. The appeal of the notion of 'theory' derives also, perhaps, from another religious trope of that period: the notion of nature as *text*, according to which scripture was one access to the mind of God and the "book of nature" was another. After all, a theory (and, for that matter, an equation) is a text: a string of symbols with syntax, to which semantic meaning can potentially be attributed.

The confluence of mechanism, textual exegesis, and the Greek heritage of deductive logic gave rise to *deductionism*, which is the belief that natural reality corresponds to theoretical formalisms such as mathematical models. If the world itself is an artifact or a text, though subject to interpretation, it could be exhaustively modelled by other artifacts or texts, such as models, equations, and deductive systems generally. Since the *theory* (as a text) is finite and completely knowable by definition, the misleading implication is that *reality* itself can be exhaustively known. Hence, there could be a final theory, even an end to science.

To rationally understand nature is to assimilate it to human goals, to give reasons for its patterns, made comprehensible in the human terms of intention, convention, and invention. Science is one expression of a general project to remove from nature and substitute for it a man-made environment. In that context, the deep significance of the ubiquitous use of mathematics is that it transcribes natural reality into humanly defined, idealized, formal terms. An equation, model or simulation is substituted for its natural counterpart because (unlike nature itself) it is exhaustible in principle and within human control to manipulate. This is effective for simple isolated systems, but nature in general is complex and there are no truly isolated systems. The very effectiveness of mathematics for treating simple systems may inhibit the investigation of more complex ones. Mathematical modeling restricts the operative factors involved to the few that can be readily treated mathematically. While useful "for all practical purposes," this creates the misleading impression that natural reality involves *only* these defined factors.

To be mathematically described at all, a natural entity or process must first be idealized and formally defined. For example, a mathematically expressible curve stands in for a scatter of data points, many of which are "outliers." Since it is assumed that the error bar is accounted for by known irrelevant processes, it is this idealization that then becomes the object of theoretical, experimental, and mathematical interest—no longer the data points themselves. Formalization involves a shift from empirical to deductive truths, with the risk that science becomes knowledge largely of its own constructs.

The concepts of isolated system, determinism, reversibility, equilibrium, and symmetry represent properties of deductive systems, not necessarily of nature itself. Deductionism not only assimilates nature to conceptual artifacts but tacitly hints that physical systems *are* such artifacts. (The very notion of *system* does not discriminate between natural reality and human construct.) Properties of equations or mathematical models can thereby be falsely ascribed to natural reality. Other properties may be excluded because they are not formally defined in the theory.

Some thinkers advocate a discrete or finite mathematics, a "digital physics." It might seem a boon to physics if math could be re-formulated to avoid non-computable numbers. Yet, such a move would eviscerate the real number continuum and would amount to treating nature as a deductive system. A digital physics would guarantee computability, but would be an idealist fiction out of tune with natural reality. The fact that one does not find integers or rational numbers at the base of physics (as physical constants, for example) is evidence that the world is *not* conveniently digital. It is not a deductive system, computer program, or simulation!

The idealism behind the philosophy of mechanism views physical laws as fundamental and transcendent, even separate from the universe they rule, just as the design principles of a machine transcend it and rule its behavior. In a different view, physical law simply describes emergent behavior and pattern that arise from the inherent ability of matter to self-organize. (To embrace such a view requires that physics outgrow its one-way relationship of subject to object, which will be discussed in the next section.) Because the *scientist's* agency is currently excluded from scientific description, *agency within nature* remains problematic and neglected. The shift from a reductive science of parts to a science of the whole would imply a shift from the notion of transcendent, eternal laws externally imposed on passive matter, to the notion of a universe that actively orders itself from within. Hard science should embrace the concept of self-organization as a fundamental principle, a counterpart to entropy and the Second Law. More than lip service would then be given to the autonomy of nature.

Many concepts, such as determinism and causal necessity, remain under the sway of the philosophy of mechanism and continue to influence scientific thought. However, it is not nature that is deterministic, but products of definition such as machines, formal models, and equations. As Hume advised, the only "necessity" is logical necessity—and even that may prove to not be absolute but a product of long evolutionary experience. Science embraces many other historically useful but now questionable basic concepts and assumptions derived ultimately from its idealist heritage. These include Occam's razor (the simpler explanation is to be preferred, even if nature is not simple); the law of excluded middle (a proposition is either true or false); the principle of sufficient reason (everything is assumed to have a knowable cause); the identity of indiscernables (things are assumed to have continuous identity and never to simultaneously occupy the same place); formalism (whereby it is assumed that nature can be effectively represented in symbols); time reversibility of processes (though it is equations that are reversible, not the world). Physics generally prefers single causes (whereas causes in the living world are multiple and circular) and causal continuity (though relations could conceivably be discontinuous). It embraces the principle of ceteris paribus ("all other things being equal," which they may not be). Principles of symmetry and invariance may overvalue abstraction and general rules. Esthetic principles of beauty in theories and elegance in mathematical treatment may reflect human preferences more than nature itself. It is assumed that presently accepted categories and ontologies reflect real structure and that nature can be carved along its true joints.

Science is mature enough now to question such assumptions, how they limit its scope, and how they affect our view of knowledge. By doing so, it could open up new avenues of research in physics and cosmology. Modern physics concepts such as entanglement, decoherence, and non-locality point to an essential wholeness even in the non-living world, to an inevitable involvement of the observer, and to limitations of our ways of seeing and conceiving the world. At observational limits, both cosmology and particle physics deal with feeble signals, statistical interpretation, and tenuous chains of inference. These are grounds for careful evaluation of the observer's epistemic involvement, especially in realms far from the human scale or ordinary experience. A "second-order" science would emphasize epistemology as inseparable from ontology. It would be a more *complete* science—more, not less, "objective."

2. While scientific cognition cannot know the world as it "truly" is, it may be more advantageous than our natural cognition for some purposes. On the other hand, science has not existed long enough to establish its long-term merit as an adaptive strategy. Physics could more fully

acknowledge the purposes for which it is presently pursued as a human activity. It could become more self-conscious, reflexive. If subject and object are co-participants in scientific cognition, as they are in ordinary cognition, then the observer's epistemic situation should be anticipated and fully taken into account. This goes against a tradition of scientific realism, initially shaken by the revolutions of the early 20th century: relativity and quantum theory, which both involved a new recognition of the active role and physical situation of the observer dependent on a medium of observation. Recognizing such epistemic contingency extends the anti-anthropocentrism of the Copernican and Darwinian revolutions, and represents a growing self-consciousness that should be deliberately cultivated.

Classical physics is the paradigm of a first-order science, in which the physical world, not physics or the physicist, is the object of study. While the natural outward orientation of mind underlies the naïve realism of science, objectivity in daily life depends upon the ability to self-consciously reflect. A science incapable of reflecting on itself cannot change itself. There is little account within science itself, as it stands, of what it is supposed to do or how scientists are supposed to do it. Except for graduate courses and advanced seminars or conferences, it is left to philosophers and sociologists to reflect on such issues (and to scientists "off duty," writing for a broader audience). It is left to writers of textbooks to define the ontology of science for the next generation.

Textbooks in physics, chemistry, and math typically approach their subject as though it were a logical rather than cultural development. They tend to present current theory as fact, an immaculate conception without historical context. This revisionism (often repeated in popular science writing or media accounts) has advantages for the transmission of knowledge; yet, it presents the current state of knowledge (or some version a decade out of date) as timeless truth. Little sense is conveyed of the scientific process, of the long intellectual struggles that ended in consensus (or not), nor of the alternative theories that ended in the dustbin. Such considerations are left to journals, books and courses on the history of science. Textbooks may fail to emphasize how tentative theory is or tell how alternative interpretations (even long past) continue to have minority adherents. Each generation's ideas are thus enshrined as definitive. While tidy, a loosely axiomatic approach to pedagogy creates the impression that nature itself can be axiomatized in some definitive theory. The laws of nature (even the laws of thought) then falsely seem foreordained. But science, and even math, are not divine revelation. Pedagogy in hard science could take a lesson from the social sciences, which tend more to discuss their own methodology and to question their assumptions as a matter of course.

While physics could profitably borrow from biology a vision of matter with inherent agency and capacity to self-organize, it could also borrow from social science an ability to reflect on its own nature. Conceptual difficulties in quantum theory, and in the standard models in particle physics and cosmology, suggest that underlying fundamental assumptions *must* be questioned if progress is to continue. These challenges include the 'measurement problem', the enormous discrepancy between predicted and observed values of the 'vacuum energy', various 'fine-tuning' problems, and the related mystery of the universe's entropic history (possibly involving 'dark energy'). The computer metaphor that dominates society underlies problems in the theory of black holes; 'information' is reified as a new ontological entity—despite the glaring fact that it is an entirely social construct. (After all, information *informs someone.*) Leaving the agents concerned out of the picture simply reinforces outmoded mechanistic thought.

Science is now positioned to grapple with grand questions, such as how the universe as a whole could have arisen. Along with mathematics, physics sets a standard of rigor, objectivity, and reliability. Yet, it is lopsided and incomplete because it has not yet included itself in its study. To answer the grand questions may require more than a new theory or ontology, framed within current terms. Such questions concern not only what exists and how we know about it, but also how we relate to it.

3. If the scientific quest can no longer be only for the truth of nature, or its uses, but must also be for humanity's right *approach* to nature, then scientific cognition should be judged not simply as true or false, but also with regard to its ultimate value for future human prospects. The dangerous social deficit of wisdom compared to technical mastery has implications for the future of science. The current scientific worldview may threaten survival because it is ultimately too parochial and short sighted. It may also restrict the scope of research and the definition of science itself. Science must shift from the traditional values of prediction and control, which focus on the world as a resource to manipulate and exploit, usually for short-term goals. It must now focus on long-term human survival, which involves adapting our attitudes and practices to nature as well as conscripting nature to our use. Science must shift its purview from the external world to reconsider its own place in that world and to consciously embrace its role as a survival strategy. That is a hard lesson for a mentality that is genetically and historically conditioned to look outward at what *is*, rather than looking at the perspective from which it looks.

The unifying potential of science positions it to deal with climate emergencies and other existential threats—indeed, to plan the human future, especially our adaptation to changing nature. If we look deeper than the myth of science as detached, objective knowledge—or as the modern creation story—we recognize a role to provide social guidance along with its commitment to technological empowerment. Then it becomes apparent that science could be more integral with the general management of society and with the political planning involved as our official interface with nature. The fact that science has kept aloof, not only from political and moral decisions, but also in ivory towers, works against its promise as the basis for a united humanity.

The risk, of course, is that it could be misused or fail to maintain its presumed objectivity in such an expanded role, which could be resisted by people suspicious of its motives. Better pedagogy and public outreach could increase public faith, which a more self-reflective science might better merit. In particular, a deeper and wider understanding of the grounding of all knowledge in our embodiment as biological creatures seems desirable. Science should be reframed as the search, not for objective truth per se, but for long-term human survival and general well-being—which, of course, depend on objective truth as well as human motives.

IV. Summary

Science should abandon the remaining vestiges of its religious heritage. These include deductionism; pretention to a god's-eye view; the assumed passive inertness of matter; and related concepts such as determinism and the isolated system. It should systematically emphasize epistemology alongside ontology. It should include agency and self-organization as basic cosmic principles. It should become reflexive.

A second-order science would acknowledge the implications of being a human construct, with inbuilt motives and goals it must be able to identify and be willing to change in the name of better serving the human future. (A high-tech or post-human future should not be presumed.) The scientist, and science itself, must be included in the picture science presents. Science must transcend commercial and parochial commitments, and step up to its role in species-level governance, reorganizing itself accordingly.