Rethinking Science

David Bensoussan
The author is a science professor at the University of Quebec

Traditionally, science has advanced through the integration of new discoveries that complemented existing knowledge. The growth of scientific understanding and technological achievement thus unfolded within a coherent intellectual framework. However, the recent breakthroughs of quantum physics challenge this model: they do not easily fit within it and compel us to reconsider the very foundations of our understanding of reality. It becomes necessary to explore new avenues of meaning, beyond those that have prevailed until now.

Classical science offers reassurance through its permanence. It is grounded in the study of physical objects accessible to our sensory experience, in abstract mathematical concepts, and in rigorous logical operations. Nature presents itself to us through continuous sensations, which we interpret through mathematical models. When a theory successfully anticipates experimental results, the union between experience and formalism seems complete.

This scientific worldview relies on the principle of causality: it explains phenomena through deterministic chains of logic. The laws it produces emerge from empirical observations and models aimed at capturing reality as closely as possible. Sensory experience, logical reasoning, and mathematical tools thus come together to offer a coherent representation of the physical universe.

Within this paradigm, a phenomenon is defined by measurable properties that are independent of the observer and the instruments used: reality is thought to exist stably, outside of and unaffected by observation. Yet this conception collapses at the microscopic level. Quantum phenomena, by their very nature, are inaccessible to direct experience and can only be grasped through instruments which, paradoxically, alter what they measure. The very act of measurement influences the observed phenomenon. This reality undermines the foundations of classical physics.

The Break Introduced by Quantum Physics

What is a physical law? It is assumed to be universal, independent of space and time, and fundamentally invariant. The scientific method presupposes that a phenomenon can be isolated from the rest of the universe in order to understand its inner workings. Yet recent discoveries demand a rethinking of this assumption.

Modern physics confronts us with unprecedented principles:

- Heisenberg's uncertainty principle stipulates that a precise measurement of a particle's position comes at the expense of knowing its speed. Only probabilities can be discussed.
- Determinism gives way to uncertainty, which becomes an intrinsic feature of reality.
- Quantum entities display dual behavior: sometimes wave, sometimes particle — two seemingly contradictory yet complementary descriptions.
- Particles may exist in multiple states simultaneously (superposition), interact instantaneously at a distance (entanglement), and possess no definite position prior to measurement.
- Any theory must account for the observer's influence on the phenomenon being observed. Observation affects the object of observation, thus challenging the classical foundations that held the properties of a phenomenon to be measurable independently of the observer or measuring apparatus.
- General relativity, for its part, overturns our intuition of time and space by rendering them relative and deformable. It also shows that matter and energy are interchangeable. And yet, despite their internal

coherence, general relativity and quantum mechanics remain incompatible.

A future “theory of everything” will need to reconcile these divergent visions of the universe. To this must be added the contribution of Kurt Gödel, who demonstrated that no consistent logical system can be both complete and self-contained: any theory, however sophisticated, will necessarily contain blind spots and unprovable truths.

Is the World Rational?

To assert that the world is rational is to believe that it obeys logical laws accessible to human reason. But is this belief justified? Are we not conditioned by mental frameworks inherited from the scientific tradition — useful, to be sure, but perhaps too narrow?

Can we truly be certain that human reason faithfully reflects reality? Is the world inherently rational, or does it only appear so because we think it must be? Are we imposing order where there is only chaos?

Should we believe that human reason uncovers a natural order — or rather that it projects a subjective structure onto what we perceive? And what if rationality were only a limited tool, useful yet incapable of encompassing the whole of reality, leaving aside what is irrational, uncertain, or paradoxical? Might we conceive of a broader form of rationality, capable of integrating what currently escapes our logic?

Classical physics enables us to predict the evolution of a phenomenon based on its initial conditions. It applies to the macroscopic scale, while quantum physics governs the infinitely small. A “macroscopic” theory does not need to account for interactions at the microscopic level. Matter is modeled there as a finite set of particles. The real challenge lies in precisely defining the respective domains of validity for classical and quantum representations of reality, as developed by classical physics and quantum physics.

Statistical physics shows that laws can emerge from chaotic microscopic behavior. The study of chaotic dynamical systems has revealed that minuscule changes in initial conditions can lead to radically different outcomes. Chaos can give rise to unexpected order.

Thinking Otherwise: Observation, Uncertainty, and Alternative Logics

We must therefore think differently: to consider that reality does not preexist observation, that it is relative to the observer, that uncertainty is not a lack of knowledge but a feature of the real. Perhaps order emerges from disorder — or perhaps every quantum possibility unfolds in a parallel universe.

This means accepting that certain facets of the world may remain inaccessible to our reason, and that reason itself may be just one prism among others. Can we conceive of an expanded logic, capable of encompassing so-called irrational phenomena — or forms of thought that can account for the indeterminate?

It may then be necessary to move beyond the binary logic of "true" or "false." Fuzzy logic, initiated by Lotfi Zadeh, allows for degrees of truth: between yes and no, there exists a gradient — useful for decision-making. But we could go further: imagine a logic that includes a third state, that of superposition — between being and non-being — reflecting reality before it is observed. This logic would be based on "state," "non-state," and "state-and-non-state," representing the coexistence of possible outcomes prior to measurement.

A more flexible logic might be better suited to a world in which structure and randomness combine to generate meaning.

Bertrand Russell wrote:

"*I think the universe is made of scraps and jumps, that there is neither unity nor continuity nor order nor coherence… Order, unity, continuity — these are human inventions… But to a large extent, we can make these inventions dominate our human world.*"

And yet, the search for physical laws that emerge from the interaction between chaos and organization remains a challenge worth confronting: how does meaning find its way through randomness? Science, far from being a fixed system, becomes an open intellectual adventure — one that continually reexamines its own foundations. It tells us not only what the world is, but also what we are capable of thinking about it.

Toward a New Scientific Imagination

In light of these epistemological, logical, and ontological ruptures, science can no longer be viewed as a linear accumulation of facts within a stable framework. Rather, it becomes an evolving endeavor, open to conceptual reversals and cognitive pluralism. The quantum revolution, by exposing the limits of classical paradigms, does not mark the failure of reason but calls for its renewal. It invites us to expand our mental architecture, to embrace uncertainty not as a deficiency but as a component of a dynamic and participatory reality.

We must therefore move beyond rigid dichotomies and adopt a more flexible rationality—one capable of encompassing ambiguity, paradox, and emergence. Scientific inquiry, far from seeking immutable truths, becomes an exploration of the conditions under which meaning, coherence, and intelligibility may arise from the fabric of the unknown.

This redefinition of knowledge is already embodied in certain recent technological advances. The rise of quantum computing offers a tangible example of a new rationality, one based not on certainty but on the exploitation of possibility. In such systems, computation is performed using qubits that do not reside in a defined state but in a superposition of states—a network of virtualities actualized by observation: reality, far from being given once and for all, is constituted in the event of observation, and computational power emerges precisely from this temporary indeterminacy.

Similarly, the quest for a theory of quantum gravity—seeking to reconcile general relativity and quantum mechanics—requires us to rethink such fundamental notions as space, time, and causality.

Artificial intelligence (AI), particularly deep learning, relies less on fixed logical rules than on the analysis of massive datasets and the extraction of patterns that are often uninterpretable. It challenges classical rationality: it provides effective answers without articulating the "reasons" behind them, blurring the boundaries between knowledge, statistical intuition, and algorithmic emergence. IA is, in fact, an imitation of human intelligence, reproducing some of its outcomes without engaging its cognitive or conscious mechanisms. Moreover, the term artificial intelligence is misleading, as it is a form of intelligence devoid of consciousness; the expression pseudo-artificial intelligence would likely be more accurate.

The boundaries between physics, logic, and philosophy fade, and where scientific imagination converges with the most profound questions about the nature of reality. Rethinking science, then, is not merely a revision of its content—it is a reimagining of its very foundations, and in doing so, a deeper understanding of the mysterious interplay between the world and our capacity to think it.