

III

WHY SCIENCE TOOK
SO LONG

SCIENCE'S STRATEGIC IRRATIONALITY

Why did science take so long to invent?

Because the iron rule looks like a terrible idea.

“CREDIT MUST BE GIVEN . . . to theories only if what they affirm agrees with the observed facts.” That sounds as scientific as anything said by Isaac Newton or Richard Feynman. It was written by Aristotle in the fourth century BCE. Aristotle was a systematic observer, an innovative theorist, and a first-rate intellect. He put the highest priority on a theory’s ability to explain the phenomena. What stopped him from inventing modern science two thousand years before the Scientific Revolution?

It is tempting to answer this question by writing a history of the Scientific Revolution, pointing to social, intellectual, and economic factors at work in the seventeenth century that were almost or entirely absent in Aristotle’s era: the preeminence of the mechanistic philosophy propounded by Descartes and Boyle, the application of mathematics to physical theorizing, new technologies such as the printing press and improved lens-grinding and glassblowing techniques, an emerging regard for inquiry into nature as a high-minded form of religious worship.

It makes for a fascinating story. A narrative of this sort, however,

is not very well able to distinguish what is essential to modern science from what was essential to modern science's developing in the particular way that it did in the seventeenth century. Certainly, there could have been no Galileo or Newton without mathematics, but not all scientific inquiry requires advanced math. (The development of chemistry did not.) There could have been no Boyle or Huygens without atomism, but not all science is about molecular interactions. (The theory of evolution by natural selection is not.) The telescope, in the hands of Galileo and others, rocked seventeenth-century astronomy, yet Tycho Brahe's naked-eye observations of the planets would have been sufficient on their own to sustain the new physics of gravity.

To determine why science took so long to arrive, then, I started not with a historical narrative but with a philosophical examination of modern science as a whole, seeking out its *sine qua non*: the thing or things that are decisive in explaining its powers of discovery. That *sine qua non* has turned out to be the iron rule of explanation. Aristotle and so many other natural philosophers, in many places and at many times, failed to set in motion the knowledge machine that we call modern science because, for all their concern with observation, they failed to invent the iron rule.

Compare Aristotle with Newton. Both were aiming for the same goal, a grand theory that explained the way things move and change. Their methods, however, were quite different. Aristotle but not Newton subjected his hypotheses to stringent philosophical tests. Newton but not Aristotle subjected his hypotheses to stringent quantitative tests, demanding they explain not only the qualities of motion—circular versus straight, up versus down—but also the finest details, such as the precise trajectories of the planets captured by Kepler's laws.

The quantitative tests, it turned out, were far more important. Although Aristotle carefully scrutinized all manner of natural phenomena and cared deeply about the power of his hypotheses to explain what

he saw, he was typically content with accounting for broad patterns and not matters of particular detail. It is on those small facts, however, that much of science's truth-finding power hinges.

It is extraordinarily difficult, as Kuhn saw, for human beings to maintain any kind of prolonged interest in the all-important small facts. Minutes are seldom intrinsically interesting; to transcribe them from nature is often tremendously hard work; and grand intellectual endeavors—conceptual, philosophical, systematizing—are always beckoning, luring the empirical investigator away from the lab bench or the observation post to the glittering land of ideas. Most scientific work is more like bookkeeping or long division than it is like poetic self-expression or polar exploration. Great minds are hardly likely to seek out such a life.

The iron rule solves this problem not by attempting to glamorize what's clearly menial, but through a more indirect, more devious stratagem. It sets up scientific argument, as I have explained, as a kind of game in which hypotheses are defended and attacked. In that game, only one kind of move is legitimate: the empirical move in which a hypothesis is attacked for failing to explain some observed matter of fact and defended by showing that the failure is merely apparent, due to malfunctioning equipment, unfavorable conditions, or faulty assumptions. Victory does not come through smooth rhetoric, metaphysical inquiry, moralizing, or any other sort of sweet talking or big thinking. To win, players must front up with meticulous observations.

For Aristotle to subject himself to the iron rule, he would have had to subsume his physical, chemical, biological, psychological, and astronomical investigations under the regulations of this game. Like every avid player, he would have had to put aside the search for higher harmony. The physical and intellectual energy thereby liberated would flow in the only remaining direction, toward unrelenting empirical testing. By the time of his death in 322 BCE, a classical Scientific Revolution might have been in full swing.

But Aristotle was a serious thinker; had such a game occurred to him, he would have dismissed it out of hand. He was not about to renounce philosophical reasoning.

He was no ideologue; he did not advocate philosophical reasoning as opposed to observation. Rather, he advocated philosophy *together with* observation—and when observation and philosophy clashed, Aristotle gave observation the upper hand. Criticizing some of his predecessors, he wrote:

Their explanation of the phenomena is not consistent with the phenomena. And the reason is that their ultimate principles are wrongly assumed: they had certain predetermined views, and were resolved to bring everything into line with them. . . . As though some principles did not require to be judged from their results, and particularly from their final issue! And that issue . . . in the knowledge of nature is the phenomena . . . given by perception.

The iron rule would not, then, have offered Aristotle any new sources of information or any new ways to treat it; it would merely have told him to forget the philosophy. That looks like a rotten deal: dispensing with a valuable source of information, philosophical reasoning, without offering anything in return. It would have seemed unreasonable, barbaric, simply irrational.

The same is true of the iron rule's deliberate deafness to religious, spiritual, theological reasons for belief. Throughout history, the faithful have taken their religious doctrines to have implications for the material as well as the spiritual world and certainly for the domain of living things. The implicit clash with the iron rule is well dramatized by the intellectual agonies of William Whewell, Master of Cambridge's Trinity College from 1841 to 1866. Surveying the newly discovered fossil record, Whewell saw episodes of large-scale speciation that he thought could be explained only by God's intervention. A full understanding of

the history of life would require, then, a unified treatment of geology, biology, and theology. Yet the iron rule, implanted in Whewell's mind from his undergraduate days, forbade him from providing such a synthesis in his scientific masterwork. It seemed wrong, even nonsensical, but he overrode his qualms, surrendering to the scientific method.

Take the roots of Whewell's quandary and project them back over the thousand years of history that preceded the development of modern science. Throughout the European Middle Ages and the roughly coterminous Islamic Golden Age, you find thinkers exploring the workings of the natural world by way of astronomy, optics, medicine, and more. None of these thinkers hit upon anything like the iron rule. They could not have. They were all, each in their own way, devout. It was clear to them that knowledge of God or of God's plan potentially had something to tell us about the way things were laid out in the physical world—in histories, living bodies, the system of planets. Perhaps theology would turn out to offer relatively little help to empirical inquiry, but the possibility ought to be explored.

The iron rule, however, firmly prohibits such exploration. In science, only empirical reasoning counts. Thus, to thinkers who unlike Whewell had not witnessed the rule supervise a string of stunning discoveries, scientific inquiry would have seemed a deliberately hobbled way of figuring out the world. An indiscriminate ban on theological thinking would have made no sense to these investigators, just as an indiscriminate ban on philosophical thinking would have made no sense to Aristotle. It is hardly surprising, then, that nothing like the iron rule arose in all the centuries spanned by Augustine, Avicenna, Averroes, and Aquinas.

Not even an early modern thinker like René Descartes, living on the cusp of the Scientific Revolution, would have been able to bear the iron rule's separation of empirical and theological inquiry. God's power and oversight is woven into Descartes's natural philosophy in numerous ways; it is God, for example, who ensures that our minds are stocked with

concepts well suited to thinking about his creation, and it is God who sets the matter constituting that creation into uniform circular motion. From Descartes's point of view, it would have been quite unfathomable to forbid, as does the iron rule, taking into account the supremely important fact of God's existence and attributes—omniscience, omnipotence, benevolence—when investigating the natural world. And so we find in Descartes's writing, as we find in the writing of almost all those who came before him, not the slightest inclination toward the rule's absolutist decrees. In the 1640s, despite the best efforts of Bacon and a few other radicals, science was still reluctant to be invented.

This is why it arrived so late in human history: it seemed a cockeyed pursuit, an exercise in deliberate intellectual impoverishment. There was nothing wrong with the iron rule's emphasizing that observation matters, but everything wrong with its insisting that *only* observation matters—an anti-intellectual injunction to shut down every part of the head besides the eyes.

A vicious circle, then, cut off human minds from the scientific sensibility. There was no way to grasp how useful the iron rule would be without testing it in practice, but no reason to test it without first having some inkling how useful it could be. Indeed, there was good reason *not* to test it: it ignored what were regarded as indispensable sources of knowledge. The logic of the circle entrapped the ancient Greeks; it entrapped the medieval and early modern philosophers, such as Descartes. It equally entrapped, I conjecture, thinkers in China and Korea, in India and Persia, in Central America and the Andes. Had they considered the iron rule, they would have scoffed at it; almost certainly, so preposterous an idea never entered their minds.

IN 1859, 20 years after Whewell sought to interpret the fossil record using sophisticated creationist ideas, Charles Darwin published *On*

the Origin of Species. Victorian science was electrified—and Victorian society scandalized—by the idea of evolution by natural selection. In the matter of creation, it seemed, God was being written out of the picture.

“The flood-gates of infidelity are open, and Atheism overwhelming is upon us,” wrote the anguished evolutionist George Romanes in 1878. It was by no means all Darwin’s doing. Geologists were casting doubt on the existence of a “Great Flood”; textual scholars were showing that the Bible was a compilation of texts written by many different authors at different times; French revolutionaries, English poets, and German social thinkers were imagining a world free of the strictures of organized religion. As the European nineteenth century progressed, the mantle of faith began to slip from the shoulders of the human spirit.

Today perhaps a third of American scientists believe in God. Even these believers do not for the most part think that their spiritual commitments could in any substantial way inform their research. They go along, for all practical purposes, with Stephen Jay Gould’s contention that science and religion are legitimate forms of inquiry into two entirely distinct subject matters, that they are “non-overlapping magisteria.” If you want to understand the meaning of life, by all means take up religion. To understand the movements of the planets and the origin of species, however, empirical observation is all you need. For the great majority of contemporary scientists, then, there is nothing in the least unreasonable about the iron rule’s exclusion of religious considerations from scientific argument.

The same is true of the rule’s exclusion of philosophical argument. Most physicists regard it as a waste of time, for example, to search for an understanding of quantum mechanics that renders it humanly comprehensible. Just use its mathematical machinery to make predictions and to construct shallow explanations, they say—“Shut up and calculate.” The physicist Steven Weinberg goes further:

I know of *no one* who has participated actively in the advance of physics in the postwar period whose research has been significantly helped by the work of philosophers.

Does the perceived irrelevance of religious and philosophical considerations in contemporary science mean that the iron rule has lost its semblance of logical perversity? That it no longer appears to censor sensible nonobservational reasons for belief? Then we would have a science admirable not only for its abundant successes but also as a paragon of rationality.

Yet we do not: even today the iron rule has an air of unreason. I'm not thinking of the handful of scientists who see their God working manifestly in the material world or who seek to philosophize their way to theoretical understanding. I have in mind rather a form of reasoning that a great number of contemporary scientists, including Weinberg himself, celebrate for its power to illuminate the natural world: arguing for a theory's truth on the grounds of its beauty.

The iron rule proscribes the use of all such arguments in science's official channels of communication. Consequently, any modern investigator who believes that aesthetic qualities can show us the way to truth must consider the scientific method to be willfully ignoring something of significant value. In that case the method would be, in spite of its productivity, strictly speaking in violation of the principles of reason. In the coming chapter I will examine the iron rule's war against beauty and the implications for its rationality more closely. Is it the rule that's irrational? Or those who believe in the guiding power of beauty?