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EDITORIAL

The Trouble With Science

The title of this column is adapted from a book that came my way a few days ago: *The Trouble With Physics*, by Lee Smolin (Houghton Mifflin Co., USA, 2006; Penguin, 2008). My attention was immediately drawn to the Penguin edition, because the title was printed upside-down; undoubtedly a marketing strategy thought up by the publishers. My physics is weak, at best, but the subtitle 'The Rise of String Theory, the Fall of a Science and What Comes Next' seemed irresistible. The very first page did not disappoint. 'There may or may not be a God. Yet there is something ennobling about our search for the divine. And also something humanizing which is reflected in each of the paths people have discovered to take us to deeper levels of truth. Some seek transcendence in meditation or prayer; others seek it in service to their fellow human beings; still others, the ones lucky enough to have talent, seek transcendence in the practice of art. Another way of engaging life's deepest questions is science. Not that every scientist is a seeker; most are not. But within every scientific discipline there are those driven by a passion to know what is most essentially true about their subject. If they are mathematicians, they want to know what numbers are, or what kind of truth mathematics describes. If they are biologists, they want to know what life is, and how it started. If they are physicists, they want to know about space and time, and what brought the world into existence. These fundamental questions are the hardest to answer and progress is seldom direct. Only a handful of scientists have the patience for this kind of work. It is the riskiest kind of work, but the most rewarding: When someone answers a question about the foundations of a subject, it can change everything we know.' Smolin's book is an exceptionally engaging discourse on subjects that require a deep understanding of physics and which have been illuminated in the past by some of the most penetrating insights in human history.

For readers, generally interested in science, Smolin's style is bound to be attractive; although professional theoretical physicists may be less than enthusiastic about his effort to present a strong critique of the way the discipline has moved in the last quarter of a century. He begins by noting: 'The most cherished goal in physics, as in bad romance novels, is unification. To bring together two things previously understood to be different and recognize them as aspects of a single entity – when we can do it – is the biggest thrill in science' (p. 18). He cites two examples. The first is Giordano Bruno's recognition that 'the sun is just another star – and the stars are just suns that happen to be very far away', which led to his burning at the stake as a heretic. The second is Charles Darwin's idea of natural selection which points inexorably towards a common ancestry of living organisms. Smolin notes: 'Biology before Darwin and biology afterward are hardly the same science'. In setting the stage for his survey of the unified theories that have for so long been a goal of physics, Smolin reminds us: 'Great unifications become the founding ideas on which whole new sciences are erected. Sometimes the consequences so threaten our worldview that surprise is quickly followed by disbelief' (p. 19). How do new theories gain acceptance? There must, of course, be 'new insights and hypotheses' which then act as 'the engine that drives progress in understanding'. Most importantly a new unifying theory in science must make firm predictions which must be confirmed by experiment. While observations, both in the natural world and the laboratory, provide the basis for formulating theories, these in turn must point the way towards new experiments that advance our understanding and provide a test of the predictive power of a theory.

Smolin illustrates the power of unification beginning with what he terms as 'the greatest unification in all of science: the *unification of motion and rest*'. The beginnings of modern science are indeed traceable to the revolution, begun by Copernicus and Galileo and decisively completed by Newton, in which our basic Aristotelian instincts are suppressed. Newton's first law, drilled into generations of students, implicitly advances the notion 'that whether a body is moving or not has no absolute meaning. Motion is defined only with respect to an observer, who can be moving or not'. Smolin's assessment is engaging: 'Galileo and Newton achieved here a beautiful intellectual triumph. To others, it was obvious that motion and rest were completely different phenomena, easily distinguished. But the principle of inertia unifies them. To explain how it is that they seem different, Galileo invented the *principle of relativity*.' It is the emphasis on the insights that come from thought alone that is at the core of Smolin's writing. In developing his theme of the foundational role of unification he notes: 'In the history of physics there is one unification that serves more than any other as a model for what physicists have been trying to do for the last thirty years. This is the unification of electricity and magnetism achieved by James

Clerk Maxwell in the 1860s.' Those who are confronted by the concepts of forces and fields, in their brushes with science, may find some reassurance in Smolin's words: 'Thus a field can carry a force from one body to another. There is no need to believe in ghostly action at a distance.' Michael Faraday's work on electricity, magnetism and their interrelatedness stands as one of the major triumphs of the 19th century. Maxwell's unification was the stepping stone to Einstein's special theory of relativity, 'born, as a joining of Galileo's unification of rest and motion with Maxwell's unification of electricity and magnetism'. This achievement in 1905 happened at a time when 'the mechanists had the right equations, they just had the wrong interpretations' (p. 37).

In a short and beautifully written chapter entitled 'The world as geometry', Smolin outlines the remarkable road that Einstein took in unifying 'gravity with relativity' reiterating the importance of the unification of motion and rest traceable to Galileo. At the heart of this remarkable feat of thought that led to general relativity lay other unifications: 'So Einstein succeeded in unifying all kinds of motion. Uniform motion is indistinguishable from rest. And acceleration is no different from being at rest with a gravitational field turned on.' The unification of the gravitational field with the geometry of space and time, the realization that 'the presence of matter affects the geometry of space' was to be one of the defining events of 20th century physics. Smolin turns to the gap between gravity and electromagnetism, a subject that had already begun to attract many physicists in the second decade of the 20th century. He describes Einstein's reaction to a theoretical construct of Herman Weyl: 'Apart from the [lack of] agreement with reality it is in any case a superb intellectual performance'. This is a situation that often surfaces in Smolin's account; mathematically elegant, often compellingly beautiful theories, which seem to be imperfectly grounded in the prevailing view of reality. The unification of quantum mechanics and electromagnetism, a mid-20th century triumph and the construction of a theory to unify electromagnetic and weak nuclear forces are in Smolin's account landmarks in the development of 'unification as a science'. It is here in the years that followed the 'standard model of particle physics' that Smolin introduces us to one of the predictions that 'grand unification' approaches made – that protons must fall 'apart into simpler things'. As Smolin tells the story: 'Funds were raised, and huge tanks were built in mines deep underground. The results were impatiently awaited. After twenty five years we are still waiting. No protons have decayed . . . . It's a beautiful idea, but one that nature seems not to have adopted' (p. 64).

In a chapter titled 'Preparing for a revolution' Smolin is reflective: 'Sometimes scientific progress stalls when we encounter a problem that just cannot be solved in the way we understand it. There is a missing element, a different sort of trick involved. No matter how hard we work, we won't find the answer until someone somehow stumbles on this missing link'. These simple words seem to capture the romance and adventure of science in a way that almost seems at odds with the frenetic and apparently purposeful march of modern science. He illustrates the 'missing link' using the explanation of eclipses. He goes on to add: 'The idea that elementary particles are not pointlike particles but vibrations of strings may be another of these rare insights. If right, it is as profound a realization as the ancient discovery that the circles the planets travel on are themselves moving' (p. 102). He traces the origins of string theory in the late 1960s and early 1970s and its relatively slow acceptance until the mid 1980s. In his words: 'Few of us realized that we were living in the last days of physics as we had always known it'. To the average reader this may seem an overstatement of his case. But for Smolin it is the foundational aspects of the discipline that are of concern; not the more mundane areas where physics has made deep inroads, primarily in areas that border chemistry and biology. He describes two string theory revolutions, noting that 'string theory initially proposed to unify all the particles and forces in nature'. It is here that he begins a forceful critique: 'But as it was studied in the decade following the 1984 revolution something unexpected happened. The alleged unified theory fractured into many different theories: the five consistent superstring theories in ten-dimensional spacetime, plus millions of variants . . . . As time went on, it became clear that string theory itself was in need of unification.' The attempts to provide the unifying frameworks are 'conjectures' not 'theories' for Smolin. As he describes it, the acceptance by a community of 'the existence of a landscape containing a vast number of theories based on much less evidence than we needed twenty years ago to convince ourselves that a single theory existed' (p. 160), is a matter that merits discussion. The development of string theory, in Smolin's analysis, seems to have led to a situation where theories that make no falsifiable predictions are legitimate. Its most visible proponents, Steven Weinberg among them, argue that 'we may be at a new turning point, a radical change in what we accept as a legitimate foundation for a physical theory' (p. 168).

Smolin describes recent theoretical and experimental work which he believes has 'already inaugurated the post-string era in fundamental physics. In all the frontier fields – quantum gravity, foundations of quantum mechanics, elementary-particle physics and cosmology – bold new ideas are evolving in tandem with experiments. These initiatives have to be nourished or they'll die on the vine, but they show great promise'. It is in his final section that Smolin draws attention to the growing stranglehold of string theorists over academic theoretical physics in a chapter titled 'How do you fight sociology?'. Smolin raises questions relevant for many other fields of science, where communities in specialized areas grow to exercise a disproportionate influence on a broad discipline. Fashions can sometimes dominate the development of science. That, indeed, may be the trouble with modern science.

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