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ESSAY REVIEW

Assessing the assessment of five fruitful scientific faux pas

Mario Livio: Brilliant blunders: From Darwin to Einstein—colossal mistakes by great scientists that changed our understanding of life and the universe. New York: Simon & Schuster, 2013, 341pp, $26.00 HB

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The author of *Brilliant Blunders,* Mario Livio, is a man of many parts. He is an astrophysicist at the Space Telescope Science Institute, which, among other things, operates the science program for the Hubble Space Telescope. Livio is also author of an award-winning 2002 book, *The Golden Ratio: The Story of Phi, the World's Most Astonishing Number.* In addition to his research on supernova explosions, dark energy, black holes, and the formation of planetary systems around young stars, he clearly feels called both to explain to a general audience how science actually progresses and to do painstaking archival research himself to get to the bottom of certain questions in the history of science. *Brilliant Blunders* presents him with the opportunity to strut his stuff in both of these endeavors.

As Livio explains in his first chapter, "Mistakes and Blunders," his focus in the book is on "particularly serious conceptual errors that could potentially jeopardize entire theories … or could, in principle at least, hold back the progress of science." He calls these major errors "blunders," a choice of words he will explore more closely in an interesting excursus toward the end of the book. His goal is to demonstrate that the course of true science rarely if ever did run smooth; it is instead strewn with some "surprising blunders" perpetrated by even the most "genuinely towering scientists," and that, surprisingly, reactions to those blunders can result in fruitful outcomes. After some deliberation, he selected five scientists whose blunders all involve some aspect of evolution—biological, planetary, or cosmological. He makes clear that while the blunder committed by each man (and all five scientists he selects are male, a point to which I will return later) differed in nature from those of the others, "all, in one way or another, acted as catalysts for impressive breakthroughs," justifying linking them with the adjective "beautiful."

Livio begins with Darwin (1809–1882), whose name is the first one called to mind by the noun "evolution." Darwin accepted without challenge the theory of

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heredity widely believed in his day. Nicknamed the "paint-pot theory," it assumed that the traits parents passed on to their progeny were blended in their children. Darwin failed to see that this blending would, over generations, give no mutation (a term not yet in currency), no matter how favorable, a chance to survive. In other words, his own theory of natural selection—the linchpin of his evolutionary argument—would not be viable. When Darwin's blunder was pointed out by an engineer in an anonymous review of the fourth edition of *The Origin of Species,* Darwin devised a thoroughly erroneous theory of heredity called pangenesis, in which the entire body directed the development of the reproductive cells instead of the fertilized egg's directing the body's development.

Livio's second blundering genius is William Thomson (1824–1907), who later became Lord Kelvin. One of the major physicists of the day, who formulated the laws of thermodynamics and for whom a temperature scale is named, Kelvin committed a nineteenth-century version of what is sometimes called "GIGO"—Garbage In, Garbage Out—in calculating the age of the Earth, leading him to vastly underestimate it. Kelvin's math was impeccable, but the assumptions that determined the terms of his calculations, which were based on the rate at which energy escaped from the Earth as heat, were wrong. According to Livio, Kelvin's blunder was to fail to "contemplate different possibilities" regarding the Earth's heat balance, including two that were soon put forth—convection within the Earth's mantle and the radioactive decay of elements—and to cling to his erroneous calculations despite the new evidence.

Third in Livio's lineup is chemist Linus Pauling (1901–1994), who was the first to apply quantum mechanics to chemistry. His research along the boundaries between chemistry and physics shed new light on how atoms combine to form a stable molecule and also explained why atoms join together to produce certain stable substances but not others. These basic contributions earned Pauling the Nobel Prize for Chemistry in 1954. Pauling also did research along the boundaries of chemistry, biology, and medicine, helping to inaugurate the new scientific fields of biochemistry and molecular biology. In 1949 he identified the first molecular disease, sickle cell anemia, and 2 years later he published important papers on the alpha helix, whose structure he figured out by building a model based on excellent data, and which he identified as a structural feature of many proteins. In 1952, however, Pauling committed a baffling blunder. Despite his past successes and despite his authorship of an important college textbook, *General Chemistry,* in his rush to be the first to figure out the structure of deoxyribonucleic acid (DNA), he published a model, based on poor-quality data, which ignored some basic rules in chemistry. For example, an acid by definition must release positively charged hydrogen atoms when dissolved in water. The hydrogen atoms in the triple-helical model Pauling published, however, were tightly bound to the phosphates, rendering the phosphates electrically neutral, though—as Pauling's own elementary text and all others confirmed—phosphates had to be negatively charged. Around 4 months after Pauling submitted his "Proposed Structure for the Nucleic Acids," James Watson and Francis Crick submitted their double-helix model for the structure of DNA, for which they shared the 1962 Nobel Prize for Physiology or Medicine.

English astrophysicist Fred Hoyle (1915–2001) is Livio's fourth scientific blunderer. Hoyle, a major figure in his field, in 1946 was the first to establish the concept of stellar nucleosynthesis, which explained how chemical elements originate inside stars. Hoyle, however, is perhaps more famous for originating the term "Big Bang," now applied to the prevailing cosmological theory for the development of the universe. An outspoken critic of the Big Bang theory, Hoyle championed instead the steady-state theory, which tried to explain how the universe could remain essentially unchanging even though the galaxies we observe are moving away from each other. According to Hoyle, new matter formed between galaxies over time, so that even though galaxies get further apart, new mass that develops out of nothing fills the space they leave. Livio identifies Hoyle's blunder as "his apparently pigheaded, almost infuriating refusal to acknowledge the theory's demise even as it was being smothered by accumulating contradictory evidence." When the three-degree background radiation was discovered in 1964 and as further observations further undermined the steady-state theory, Hoyle came up with "increasingly contrived and implausible" explanations that made him look more and more like a crackpot.

Livio's fifth blunderer is the most famous of all, Albert Einstein (1879–1955), though Livio's spin on what the blunder actually was is original. In 1917, Einstein introduced a fudge factor, the "cosmological constant," to his 1916 general theory of relativity. Readers of biographies of Einstein are used to seeing him quoted as labeling the cosmological constant "my biggest blunder," although it is not clear he actually did so. At the time, scientists believed the size of the universe was unchanging, so when equations in the general theory led to the conclusion that the universe is expanding, Einstein corrected what he thought was his error by adding the cosmological constant to the theory. As soon as Edwin Hubble's observations confirmed previous theoretical predictions that the universe was expanding, Einstein "was delighted to rid his theory of what he now regarded as excess baggage," despite the fact that theorists, including the Belgian cleric Georges Lemaître, tried to persuade Einstein that the cosmological constant actually helped explain the age of the universe as well as other cosmic facts. According to Livio, Einstein's true blunder was not in adding the cosmological constant but rather in insisting on removing it "because of a misguided sense of what constitutes esthetic simplicity." The cosmological constant has found current use as an explanation of dark energy.

As interesting as Livio's detailed summaries of the five scientific blunders in their historical context is, I have my doubts about how successful he proves in two other goals he lays out for himself in Chapter 1: (1) "to analyze the possible causes for these blunders and, to the extent possible, to uncover the fascinating relations between those blunders and features or limitations of the human mind," and (2) "to follow the unexpected consequences of those blunders." En route to the first of these goals, Livio introduces a variety of pop psychological terms, including illusion of confidence, feeling of knowing, the framing effect, and cognitive dissonance. His attempts to use these to get to the bottom of the blunders sometimes border on the silly, as in his comparing Lord Kelvin's contrived excuses for clinging to his compromised estimates for the Earth's age in the face of evidence to the contrary to the Lubavitch community's reaction to the demise of their leader, Rabbi Menachem

Mendel Schneerson. During Schneerson's illness many of his followers had asserted that the Rebbe would be revealed as the Messiah rather than die, but once he actually did die, they insisted his death was but one step on the road to his returning as the Messiah. Livio's yoking these two reactions to Leon Festinger's theory of cognitive dissonance seems forced at best, ludicrous at worst. As for his second goal, to trace the fruitful consequences of the blunders, with the exception of Einstein and the renewed interest in the cosmological constant in the late 1990s as a way to study dark energy and the idea of the multiverse, I remain unconvinced that all the scientific developments that he attributes to the commission of the blunders would not have occurred anyway. While, for example, Watson and Crick were given the green light to speed up their efforts to uncover the correct model of the DNA molecule in the light of Pauling's astonishing blunder, not only they but also Rosalind Franklin and Maurice Wilkins were well on their way to the double helix at the time.

What impresses me most about Livio's achievement is the time he spent in archives to get to the bottom of some historical issues that troubled him. As an employee of the Space Telescope Science Institute for over two decades, he felt called upon to determine whether some ongoing efforts to tarnish the reputation of Edwin Hubble, for whom the Hubble Space Telescope was named, were valid. Over recent years, some historians of science have claimed that Georges Lemaître was cheated out of credit due him for discovering the cosmic expansion. In 1927, 2 years before Hubble's observations were published, Lemaître published in French, in the rather obscure *Annals of the Brussels Scientific Society*, a theory of cosmic expansion. In 1931, an English translation published in the *Monthly Notices of the Royal Astronomical Society* omitted the paragraphs that in the original explained how Lemaître derived a value for what was later called the Hubble constant. Some historians even went so far as to accuse Hubble of being part of a conspiracy to keep Lemaître from establishing his prior claim to the concept of expansion. Livio's painstaking work in London archives yielded a crucial letter from Lemaître to the editor of the *Monthly Notices,* making clear that it was Lemaître who personally translated the piece and who chose to leave out his tentative findings from the original paper, which had by that time been rendered outdated by Hubble's work. In a second such archival search, Livio traced the term "my biggest blunder," often cited as Einstein's own words describing his introduction of the cosmological constant, to two works by George Gamow (1904–1968), an important theoretical physicist in his own right and an early proponent of Lemaître's theory. Livio presents evidence undermining Gamow's implication that he and Einstein were close friends and combs through Einstein's "papers, books, and personal correspondence," finding no mention of "biggest blunder." Further, Gamow was known as a joker, someone who even added Hans Bethe's name to a paper by Ralph Alpher and himself so that the authors' names sounded like alpha–beta–gamma. Clearly, in any case, the alliterative Bs continue to impress Livio, leading him to settle on the book's euphonious title.

Let me end my review of this worthwhile book with a minor quibble. Earlier I alluded to the absence of women scientists in *Beautiful Blunders.* I certainly do not object to Livio's choice of an all-male cast of scientific blunderers. As a biographer of Marie Curie, however, I do object to his omission of her name in his brief section on radioactivity in Chapter 5, part of Livio's coverage of Kelvin's blunder. Instead of using the passive voice to explain that the rays emitted by a uranium ore sample that fogged a photographic plate even without exposure to light, discovered by Henri Becquerel in 1896, "became known as *radioactivity*," Livio might have mentioned that it was Marie Curie who coined the name, introducing it in a published article in spring 1898. And it borders on the offensive for Livio to mention the 1903 communication of Pierre Curie and Albert Laborde about the heat release from the decay of radio salts without even a nod in the direction of his wife's doctoral work that inspired Pierre to give up his research on crystals to participate in her search for new radioactive elements. In addition, by ignoring Marie Curie in the section on Kelvin's blunder, Livio passes up an opportunity to give another example of how the aging Kelvin increasingly "resisted new findings about atoms and about radioactivity." In 1906, Lord Kelvin wrote a "Letter to the Editor" of the *London Times*, asserting that radium—one of the two elements the Curies discovered in 1898—was not an element at all, but more likely a compound of lead and five helium atoms. Rather than respond in kind, Marie Curie set out to prove in the laboratory that radium did merit its own spot in the periodic table. Lord Kelvin, by dying in 1907, was spared the embarrassment of being proved wrong when Curie and her longtime colleague André Debierne succeeded in 1910 in isolating pure radium salts, which proved her case. In his assessment of five creative blunderers, Livio makes at least this one significant oversight.