Electricity and Magnetism FREE

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Noteworthy errors viewed in hindsight

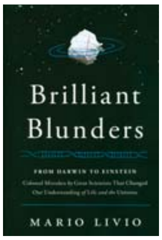
Brilliant Blunders

From Darwin to Einstein—Colossal Mistakes by Great Scientists That Changed Our Understanding of Life and the Universe

Mario Livio
Simon and Schuster, New York, 2013.
$26.00 (352 pp.).
ISBN 978-1-4391-9236-8

Reviewed by Donald Simanek

Typical textbooks and popular science books often sweep historical mistakes of science under the rug. Only successes are mentioned, which gives the misleading impression that scientific progress results from the work of a few geniuses with uncanny insights.



At last we have a book specifically devoted to scientific mistakes: *Brilliant Blunders: From Darwin to Einstein—Colossal Mistakes by Great Scientists That Changed Our Understanding of Life and the Universe*. Its author, astrophysicist Mario Livio, chooses only five from the many available classic "blunders": mistakes made by Charles Darwin, William Thomson (Lord Kelvin), Linus Pauling, Fred Hoyle, and Albert Einstein.

Livio's title and subtitle are worth pondering. Are the mistakes he writes about truly "brilliant"? Isn't "colossal" a bit over the top? Are they even "blunders," or are they justifiable and well-motivated ideas that just happened to turn out wrong? Concentrating on five examples gives Livio the opportunity to explore them and their scientific importance in detail. His extensive, 21-page bibliography is evidence of his thorough research.

The reader might assume that Pauling's mistake was his advocacy of vitamin C as a remedy for the common cold. That isn't mentioned here. It is an earlier mistake—his triple helix DNA model—that qualifies as a major blooper. Livio retells the history of James Watson, Francis Crick, and the double helix. I had the feeling I was rereading Watson's *The Double Helix* and wondering how Pauling would figure into Livio's account.

The account of Kelvin's calculation of Earth's age corrected the impression I had long held about why his estimate was wrong. I thought that he knew nothing of the contribution of radioactive materials in Earth's crust to the thermodynamic cooling problem. Livio concludes that the main reason his calculation was so far off was Kelvin's willful neglect of the possibility of convective currents within Earth's mantle. Many other books mislead by treating that subject too superficially.

Darwin's mistake was his failure to recognize that his assumed mechanism for heredity (blending of inheritable traits) was at odds with his hypothesis of natural selection. It appears that he had not read or heard of Gregor Mendel's experiments—work that had languished for three decades in an obscure journal.

Hoyle's defense of his steady-state universe, even after contrary evidence had convinced others to abandon it, was a case of a common human failing. We place special weight on our own original ideas and may defend our intellectual brainchildren even in the face of overwhelming evidence and arguments against them.

Livio corrects another common historical misconception. Despite going to great lengths, he found no document or account of Einstein ever calling the cosmological constant "his biggest blunder." The quote appears to have been invented by George Gamow. Yet it has become widely circulated as a genuine Einstein quote. The introduction of the constant itself seems not to have been a serious mistake at all.

One strength of Livio's book is its argument that, despite the title, scientific mistakes are seldom blunders at all. They are complex manifestations of human psychology in the context of the prevailing scientific knowledge of the time. Livio concludes each essay with speculations about the mistakes from the perspective of our present knowledge of how the brain works. Some readers may consider those ruminations pop psychology. In any case, skipping them won't diminish the value of the rest of the book.

Livio often tells you more than you thought you wanted to know: the background, the context, the subtle nuances, and the aftermath. His is not a book for the casual reader looking for a pleasant and entertaining diversion from serious work. When Livio tells a story, he leaves no pebble unturned. He habitually puts asides in the text, resulting in lengthy and complex sentences with parenthetical insertions. There are 271 numbered endnotes, but no reference numbers appear in the text. And every so often there's a "Huh?" sentence that forces you to reread it to unravel its meaning.

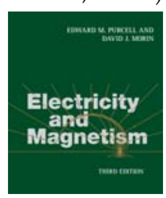
Such quibbles shouldn't deter a serious reader from savoring the book's episodes from the recent history of science. For someone who wants the whole story, Livio's book is a page turner.

Donald Simanek is an emeritus professor of physics at Lock Haven University in Pennsylvania. His research has included cosmic-ray physics, optics, and condensed-matter physics. His web pages on physics, pseudoscience, science humor, and textbook mistakes are at http://www.lhup.edu/~dsimanek.

Electricity and Magnetism

Edward M. Purcell and David J. Morin
Cambridge U. Press, New York, 2013.
$80.00 (853 pp.).
ISBN 978-1-107-01402-2

The third edition of *Electricity and Magnetism* by Edward Mills Purcell and David Morin is a welcome update to the original (McGraw-Hill, 1963) and second-edition (McGraw-Hill, 1985) texts by Purcell. The previous editions were a product of a series known as the Berkeley Physics Course. The series was influenced by MIT's Physical Science Study Committee, which was formed in 1956, shortly before *Sputnik* was sent into space. The satellite's passages, their times published by the Boston newspapers, were watched from the rooftops at MIT. The *Sputnik* affair shook up the US scientific establishment and led policymakers and academics to take a new look at science education in the US.



Prior to the 1960s, students at MIT and elsewhere were brought up on MIT professor Nathaniel Frank's terse *Introduction to Electricity and Optics* (McGraw-Hill, 1940). The first in the less terse and widely adopted *Physics* textbooks by David Halliday and Robert Resnick was published in 1960 by John Wiley and Sons. Publisher Addison-Wesley later celebrated the one-millionth sale of Francis Sears's *Electricity and Magnetism* (1951) at a meeting of the American Physical Society. The APS celebration may have been the inspiration for authors to start catering to the physics textbook market. Sears was joined by Mark Zemansky and Hugh Young in *University Physics* (Addison-Wesley, 1975), another successful textbook that has been frequently updated. The above texts, and many others, are excellent, but I think students, who are generally financially strapped, would welcome less frequent new editions, and only when substantive revision is warranted.

In 1973 Purcell—who shared the 1952 Nobel Prize in Physics with Felix Bloch for "development of new methods for nuclear magnetic precision measurements"—came to New York University to present the endowed Stanley H. Klosk lectures. At that occasion, I asked him about the possibility of a new edition of his book. He replied that the publishers wanted a rewrite, but in the meter-kilogram-second (mks) system, which he adamantly refused to do—he was more interested in devoting his time to the magnetic properties of bird navigation systems than in converting from cgs.

Now, a half-century after the original publication of Purcell's *Electricity and Magnetism*, and 16 years after his death in 1997, we have this update by Morin, associate director of undergraduate studies in Harvard University's department of physics and author of *Introduction to Classical Mechanics* (Cambridge University Press, 2008). The new *Electricity and Magnetism* sticks closely to Purcell's original book, but it uses mks units, and in many places it amplifies and clarifies the previous editions. For example, Purcell covered electromagnetic induction and Maxwell's equations in a single chapter; in Morin's update, the topics are split into two chapters and Maxwell's equations are more extensively discussed. A particularly interesting discussion in both the early and the new text includes an expression of electric and magnetic fields purely in terms of velocity-transformed magnetic and electric fields. That unification, based on principles of special relativity and the invariance of electric charge, is of fundamental interest.

In the time between the first edition and the latest, several experiments concerning fundamental-particle properties have been conducted. They include demonstrations of the equality of proton and electron charge, experiments showing that protons and neutrons are made up of quarks, investigations of the nucleons' internal structure, and many observations of specific particle and antiparticle properties. Although the basic physics remains largely unchanged, the Purcell and Morin book has many clarifying discussions based on those experimental results, and most chapters end with current applications and a summary. Solutions to the problems represent roughly one-quarter of the text—they are a most welcome addition, particularly for self-study. (Purcell wrote out a solution manual by hand—mainly for instructors!—to accompany his first edition.) Five of eleven appendices deal with units and corresponding formulae; one each with curvilinear coordinates, radiation by accelerated charges, superconductivity, magnetic resonance, and fundamental constants; the final appendix is a mathematical summary.

The book assumes the reader's knowledge or concurrent study of vector calculus. The physics and problems, as in the original text, are challenging and presented in stimulating ways. I believe Morin did a careful job in taking the edges off some of the rougher passages. Some years ago, one of my daughters took an Electricity and Magnetism course at Harvard that used the second edition of Purcell's book. The text was a challenge for her, and despite Morin's smoothing, the book remains a challenge.

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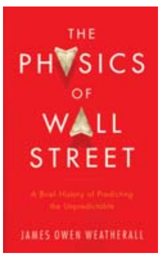
The Physics of Wall Street
A Brief History of Predicting the Unpredictable

James Owen Weatherall
Houghton Mifflin Harcourt, Boston, 2013. $27.00 (286 pp.).
ISBN 978-0-547-31727-4

If you're looking for stories of physicists and mathematicians who made important contributions to understanding and modeling financial markets, you'll find several in *The Physics of Wall Street: A Brief History of Predicting the Unpredictable*. Its author is James Weatherall, a PhD physicist and assistant professor of logic and philosophy of science at the University of California, Irvine. He presents interesting personal details and broad context on how certain econophysicists got involved in rather unconventional studies, seemingly distant from their disciplines' traditional domains. Most of his subjects appear in the book as brilliant, maverick minds, determined to study what they find interesting no matter where they find it.



Having been in econophysics since the late 1990s, when the subject was emerging as an academic field, I knew the main narratives and many of the people personally, but I found many new and interesting details in *The Physics of Wall Street*. I also found the book engaging, well written, and well researched, with detailed notes and references. Avoiding heavy math, it explains the main concepts with clever analogies. I highly recommend it to anyone who is interested in economics and finance. Other books covering similar ground include Jeremy Bernstein's *Physicists on Wall Street and Other Essays on Science and Society* (Springer, 2010) and Scott Patterson's *The Quants: How a New Breed of Math Whizzes Conquered Wall Street and Nearly Destroyed It* (Crown Business, 2010).

This book's first chapter introduces Louis Bachelier, Henri Poincaré's graduate student, who worked at the stock market in Paris and whose 1900 PhD thesis, "The theory of speculation," was the first to propose a mathematical theory of option pricing based on the random walk—five years before Einstein's theory of Brownian motion was published. Following in successive chapters are introductions to Matthew F. Maury Osborne, a Naval Research Laboratory (NRL) physicist who independently applied random-walk theory to the stock market; Benoit Mandelbrot, whose famous 1963 paper shows that a power-law distribution better describes cotton-price data than the lognormal one proposed by Osborne; and mathematician Edward Thorp, who invented and published a winning strategy for blackjack and teamed up with Claude Shannon to design a wearable, concealed computer that could help them beat a roulette game in Las Vegas.

Other scientists appearing in the book include mathematical physicist James Simons, the poster child for physicists on Wall Street and a benefactor of the mathematical sciences; applied mathematician Fischer Black, of the famous Black–Scholes equation for option pricing; physicists J. Doyne Farmer and Norman Packard, cofounders of a company that uses chaos theory to predict and profit from stock markets; and physicists Didier Sornette and Jean-Philippe Bouchaud, cofounders of what is now the largest hedge fund company in France. In a departure from coverage of financial markets and stock profiting, the eighth and final chapter focuses on an optimal design of the Consumer Price Index for measuring inflation. For that purpose, mathematical physicist Eric Weinstein and economist Pia Malaney have proposed the use of curved-space geometry and gauge theories inspired by Hermann Weyl.

The main sentiment in the book is Weatherall's admiration of how mathematical models that were developed in physics and related disciplines found useful and relevant applications to financial markets—human-based systems that seemingly have nothing to do with conventional physics. I share that admiration. But one cannot escape thinking that the strategists who win when they play the financial markets do so at the expense of the rest of us.

As evidence, my analysis with economist J. Barkley Rosser Jr on the statistical mechanics of money, wealth, and income (*Reviews of Modern Physics* **81**, 1703, 2009) shows that the US has two distinct classes based on income distribution: The lower class, about 97% of the population, has an exponential distribution, reminiscent of the Boltzmann–Gibbs energy distribution; the upper class, about 3% of the population, has a power-law distribution. When financial innovations invented by physicists and mathematicians—called "financial weapons of mass destruction" by Warren Buffett—were rapidly proliferating, the upper-class share of total income doubled, which resulted in a sharp increase in overall income inequality.

Weinstein, the mathematical physicist and now hedge fund manager, has called for a "New Manhattan Project" to reform the world of finance in the wake of the 2008 global financial crisis. Other similar initiatives, including the Institute for New Economic Thinking (INET), established in 2009, are not mentioned in *The Physics of Wall Street*. INET invites grant applications from economists and explicitly from people in the physical sciences. As a recent INET grantee, I was pleasantly surprised to see many fellow econophysicists at the 2013 INET conference. That was a promising sign of budding constructive collaboration between economists and physicists in addressing the urgent problems of the world.

In the 1950s a dissertation by the NRL's Osborne was rejected by the University of Maryland physics department (where I work) because "it wasn't physics." But attitudes are changing. Now, physics departments are beginning to embrace econophysics and other broader applications of physics methods—and rightfully so. The economy is too important to be left to the economists.

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An Introduction to Statistical Mechanics and Thermodynamics

Robert H. Swendsen
Oxford U. Press, New York, 2012.
$81.00 (416 pp.).
ISBN 978-0-19-964694-4

The development of statistical mechanics—understanding a macroscopic system through a statistical analysis of its