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Commentary

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Book and Media Recommendations: Mathematical Insights, the Seventh Flavia de Luce Novel, and Scientific Ideas We May Be Able To Give Up

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ABSTRACT: Three books are reviewed: Insightful observations about the mathematics of everyday life; the latest Flavia de Luce novel; and the opinions of "experts" about outmoded scientific ideas.

KEYWORDS: *General Public, Elementary/Middle School Science, High School/Introductory Chemistry, First-Year Undergraduate/General, Second-Year Undergraduate, Upper-Division Undergraduate, Interdisciplinary/Multidisciplinary*

At least half the battle in teaching and learning science is the instillation of habits of mind that bring to bear quantitative tools of mathematics and probability to the classroom. Mathematics professor Jordan Ellenberg may not really be able to make us always "not wrong" (he concedes this to be so a couple of hundred pages into his new book), but he edifies and entertains us with examples from life that demonstrate that math is neither dull nor irrelevant. Meanwhile, Alan Bradley presents another episode of chemistry prodigy Flavia de Luce, whose exile to Canada provides a new landscape for a new murder investigation. Maybe it would be better if scientists could meet periodically to decide which ideas should be thrown into the trash bin. While I am glad that is not the way real science progresses, it is interesting to read the candidates for ignominy that are proposed by the bunch of "experts" that John Brockman has invited to nominate.

HOW NOT TO BE WRONG: THE POWER OF MATHEMATICAL THINKING

Jordan Ellenberg has the high-powered credentials that one would expect of a mathematician working at the frontier of his field and directing graduate research that nobody understands. One would not be astonished to learn that he earned a perfect score on the math part of the SAT at age 12 (and nearly perfect on the verbal), but there are not many advanced mathematicians who also have an MFA and an award-winning novel on their résumé. Of interest to us is his talent for combining his writing ability with his wit to show how much math underlies ordinary life experiences.

One such story in *How Not To Be Wrong*[1] (Figure 1) resonated with me because I had used our state "Powerball" lottery with my physical chemistry students to illustrate "expectation values" (the statistically expected return of a ticket). It was a practical example of probabilities in action and had the bonus of dissuading students from wasting their money on lottery tickets. Math graduate students at MIT were also calculating the expectation value of the Massachusetts lottery game "Cash WinFall" back in 2005. The state had introduced new rules that applied in drawings that occurred after no jackpot winner had been chosen in a given week. The extra cash was rolled into the subsequent lottery and the payoffs were changed to encourage more players. When the "rollover" was really large, the expectation value of a ticket became bigger than its price, and consortia of players, including the MIT students, began buying tickets by the thousands. Profits were guaranteed by the statistics, but maximum profits require buying patterns that minimize the variance in the payoffs of prizes for matching the state's numbers. Ellenberg deftly describes how the expectation values were calculated, the strategy for maximizing profits, and the competition between different consortia of buyers against one another.

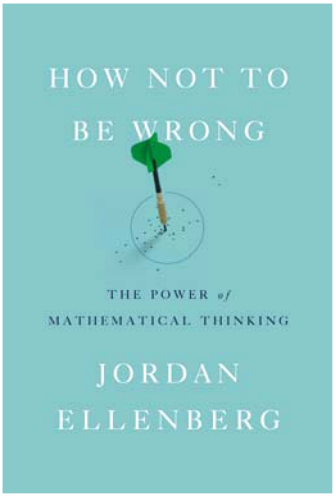

Figure 1. *How Not To Be Wrong: The Power of Mathematical Thinking*[1] cover image provided by Penguin Group and reproduced with permission.

Another topic that I found particularly informative was about error-detecting and error-correcting codes for digital information. If an important document is to be sent by computer, its accuracy can be checked and even corrected using different methods. Remarkable to me was that there is an intimate connection between these two problems: the best choice of tickets in the lottery and a method to detect and correct digital

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data. The key is a seven-point "geometry" invented by Gino Fano in 1892. The numbered intersections of lines that constitute a circle inscribed in a triangle are all of the points in this geometry, and the three-digit numbers generated by traversing the seven possible straight lines are those that intersect each pair of the seven numbers exactly once. Choosing those numbers guarantees a minimum payoff in a lottery in which three balls are chosen from a universe of seven and the number of matches above two are rewarded with prizes. It turns out that the same geometry allows the encoding of data without errors. Three-bit representations (octal) of numbers are translated into a seven-bit code (the "Hamming code"), whose representation of each octal character corresponds to one of the allowed numbers in the Fano geometry. Anything transmitted that does not correspond to an allowed code word is sure to be an error.

What does "statistically significant" mean? The usual standard is that the "*p*-value" which says that if the null hypothesis is true (usually the thing that the investigator is trying to prove incorrect), then the probability that the measured value is nevertheless interpreted as significant is less than the *p*-value that has been adopted. The usual standard is that p be less than 0.05, which means that only about 1 experiment in 20 is erroneously interpreted as significant. To show how this can lead us astray, Ellenberg introduces us to the *International Journal of Haruspicy*, in which predictions about the future based on the examination of sheep organs (dead sheep, that is) are published. If lots of experiments are performed, and even though nearly all of them (95% or so) have negative results, there are still plenty of articles accepted by the editors of the journal, based on the scientific principle that they show a *p*-value of 0.05 or lower. If the negative results are not published, as most negative results are not, then the literature becomes clogged and confused with erroneous results that are never confronted by their far more numerous but unpublished negative results.

How Not To Be Wrong: The Power of Mathematical Thinking is illustrated by whimsical, hand-drawn graphs and pictures by the author that perfectly match the lighthearted spirit of the text. I really enjoyed this book, which was recommended (and lent) to me by a colleague and which I have recommended to many others. I rather hope he will forget to ask me to return it.

AS CHIMNEY SWEEPERS COME TO DUST: A FLAVIA DE LUCE NOVEL

This is the seventh novel in the series by Alan Bradley that feature the 11-year-old chemistry prodigy Flavia de Luce, who solves mysteries using science, and especially chemistry. In *As Chimney Sweepers Come to Dust*,[2] (Figure 2) Flavia has been sent from her comfortable if decaying estate in rural England to Miss Bodycote's Female Academy in Toronto, the school that had been attended by Flavia's deceased mother, a spy−aviatrix whose history has been slowly disclosed through the novels. Flavia is barely an hour in her new school when she is confronted by a murder, when a body falls out of the chimney at her feet, and she must undertake solution of the mystery while also trying to understand the arcane relationships between the students and the staff of the school, which has even more intrigue than your average school for girls. Flavia is homesick for her family, Buckshaw—her old home in the little town of Bishop's Lacey—and Gladys, her trusty bicycle. I have to admit that I missed them, too. While Flavia is a charming character, the details of her life in Bishop's Lacey in the early 1950s also add greatly to the appeal of these books. I also found this novel to have a lower concentration of chemistry than any of the previous ones. {Spoiler alert} One of the sparse chemical references is a key to the resolution of the mystery. It is the Marsh Test, and you know what that means! This should probably not be your first novel in this series.

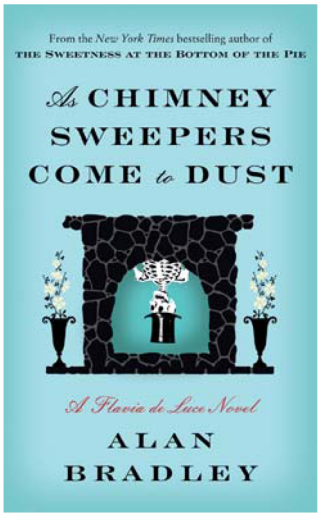

Figure 2. *As Chimney Sweepers Come To Dust: A Flavia de Luce Novel*[2] cover image provided by Delacorte Press, an imprint of The Random House Publishing Group, and reproduced with permission.

THIS IDEA MUST DIE: SCIENTIFIC THEORIES THAT ARE BLOCKING PROGRESS (EDGE QUESTION SERIES)

This book is a compilation of brief essays by 175 supposed scientific experts who were invited by John Brockman, the originator of the wonderful TED conferences, to rant about their favorite outmoded scientific ideas by engaging the 2015 Edge Question: What Scientific Idea Is Ready for Retirement? The result is, to my mind, both unscientific and unsuccessful. It is not scientific because this is not the way science advances. There are no conferences at which scientists get together to vote out outworn or unsuccessful ideas. Old theories and practices die because they are first replaced by better ones, or are abandoned in light of contradicting evidence. Each contributor to *This Idea Must Die*[3] (Figure 3) is given only a few pages in which to write a précis of his or her argument. Some of the short pieces (all are less than four pages or so) are recognizable summaries of works that are worth reading in a longer form, such as Nassim Nicholas Taleb's thesis that the normal probability distribution is over-used (read *The Black Swan*[4]), or Scott Atran's that IQ is meaningless and destructive (read Stephen Jay Gould's *The Mismeasure of Man*[5]), but some of them can be dismissed out of hand, such as the question about entropy by oceanographer Bruce Parker "[S]hould we maybe rethink it?" Azra Raza of the Columbia University School of Medicine argues that we should abandon "mouse models" of disease, without offering alternatives. The articles by Gerd Gigerenzer and Charles Seife plow the same ground: the abuse of $p = 0.05$ as the arbiter of statistical significance. All in all, this collection should not be taken very seriously. It was clearly published to sell books and to generate discussion, not to really advance science.

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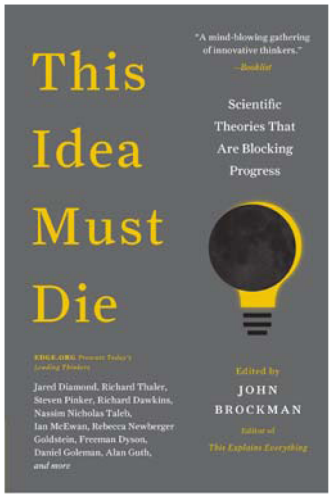

Figure 3. *This Idea Must Die: Scientific Theories That Are Blocking Progress*[3] cover image provided by Harper Perennial and reproduced with permission.

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Notes

The authors declare no competing financial interest.

REFERENCES

(1) Ellenberg, J. *How Not To Be Wrong: The Power of Mathematical Thinking*; Penguin Group: New York, 2014.
(2) Bradley, A. *As Chimney Sweepers Come To Dust: A Flavia de Luce Novel*; Delacorte Press: New York, 2015.
(3) Brockman, J. *This Idea Must Die: Scientific Theories That Are Blocking Progress*, Edge Question Series; Harper Perennial: New York, 2015.
(4) Taleb, N. N. *The Black Swan*, 2nd ed.; Random House: New York, 2010.
(5) Gould, S. J. *The Mismeasure of Man*; W. W. Norton: New York, 1996.

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