

From Impractical to Irreplaceable

By Bruce D. Rhodewalt

Review of *In Pursuit of the Unknown: 17 Equations That Changed the World*, by Ian Stewart (New York: Basic Books, 2012)

Ian Stewart has written an enjoyable book, nominally about mathematical equations but actually containing a sweeping survey of the science of the last 400 years or so. The book is organized into 17 chapters, more or less chronologically. Each chapter begins with an equation, labeled in detail, and three questions—*What does it tell us? Why is that important? What did it lead to?*—along with their respective answers. Each equation serves as an introduction to a branch or topic of mathematics or science. Chapter 6, called “Much ado about knotting (Euler’s Formula for Polyhedra),” leads to an entire chapter on topology, including knots. Chapter 8—“Good vibrations (Wave Equation)” —discusses waves and leads in some predictable directions, such as the physics of music, and in some surprising directions, such as waves in the Earth (whose study makes possible the geology that allows oil drilling and hence the internal-combustion engine).

The book covers a generous range of technical topics, including information theory, chaos theory, economics, quantum mechanics, and relativity. Although the average Instagram addict may have a vague feeling that math is somehow involved in digital photography, the curious reader will appreciate Stewart’s chapter on the Fourier transform, effortlessly evolving into a clear lesson on data compression, a technology that makes digital photography practical. A technically inclined adolescent might be prodded in any number of life-changing directions by reading this.

Rather than starting at the beginning and reading all 320 pages (plus the notes and index), you could easily approach this book randomly, as reference. Not sure what a half-life is? Go to the index and locate it; then read the chapter on logarithms to learn about half-life in the context of logarithms and exponential functions. You will be drawn into Stewart's retelling of the story of the 2011 Japanese earthquake, tsunami, and nuclear crisis. As this one does, most of the chapters stand on their own, providing plenty of context for the main topic as well as the supporting discussion that follows.

The tone is light, with occasional overt attempts at levity. Stewart really gets worked up during the last chapter, which concerns speculation in financial derivatives: "Investors are being encouraged to take ever more complex, and ever more risky, bets, using money they don't have to buy stakes in things they don't want and can't use, in pursuit of speculative profits—while the people who do want those things can no longer afford them." He tells a riveting story of this century's global money woes, culminating in the loss during the 2008-2009 banking crisis of 17 trillion dollars. Also in this chapter is a fascinating description of how the fields of economics and ecology learn from each other, typical of the many interdisciplinary connections making up the structure and style of this book.

A few specific criticisms:

- There are a few misleading choices. Stewart says, "Integral calculus—finding areas—turns out to be the inverse of differential calculus—finding slopes." True enough: in differential calculus you study the slope—i.e., *steepness*—of a line tangent to a curve. However, this is confusingly similar to—yet different from—another meaning of the word *slope*, in the sense, for example, of a *ramp*: "Galileo hit on the trick of slowing the motion down by rolling balls down an inclined slope." Stewart includes both of these statements together in the same chapter. This will not trouble readers who already understand the material, but sloppy word choices like this are an important cause of our children (and their parents) boasting, "I never got math." We present words to our students that have multiple, related meanings, and we expect them to infer from context which meaning we have in mind. A famous example is the equal sign, which begins its life in early elementary school as a prompt for the answer—"2+3 = ___"—and then surreptitiously changes into the fulcrum of a balance by around eighth grade—e.g. the problem " $2x + 3 = 17$ " and the true (but by now uninteresting) statement " $2 + 3 = 5$."

- There are editing errors of all sizes. Stewart claims, “I said at the start of this chapter that you don’t have anything chaotic in your kitchen.” (No, he didn’t say anything about kitchens.) “A guitar string playing middle C vibrates 440 times a second.” (No, that’s an A.) Cited individuals’ names are spelled wrong or inconsistently. (Is August’s name Krönig or König? Both spellings appear on the same page.)
- Besides the mechanical problems, I take issue with a few of Stewart’s sweeping generalizations. There is delicious irony in his casual analysis of how education works: “The full story is always too complicated for anyone except the experts, and they know so much that they don’t believe most of it.” Although I see what he’s getting at, this works better as a staff-lounge aphorism than as reliable axiom.
- There are one or two painfully over-simplified explanations of fundamental math, presumably for an adult audience. “A right-angled triangle has, of course, a right angle, but its other two angles are arbitrary, apart from adding to 90 degrees. Associated with any angle are three functions, that is, rules for calculating an associated number.” If the reader hated math in high school, this will not clarify things or calm him. On the other hand, if the reader liked math, why not go ahead and remind him that we’re talking about *Sine/Cosine/Tangent* and *Trigonometry*?

In *Pursuit of the Unknown* repeatedly tells one story, which occurs over and over again in different centuries and in different branches of mathematics. This is the story of an abstract, seemingly pointless (from a practical point of view) mathematical discovery becoming necessary many years later in some technological leap forward. An early example is i (the square root of -1), discovered in the sixteenth century and derided for many years by laymen and mathematicians themselves, only to emerge as a necessary ingredient in quantum mechanics, itself fundamental to understanding interactions on the smallest scale. Without it we might not have lasers, transistors, diodes, and the machines that depend on these. Indeed a discovery, if not quite an equation, that changed the world.

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