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The Half-life of Facts: Why Everything We Know Has an Expiration Date

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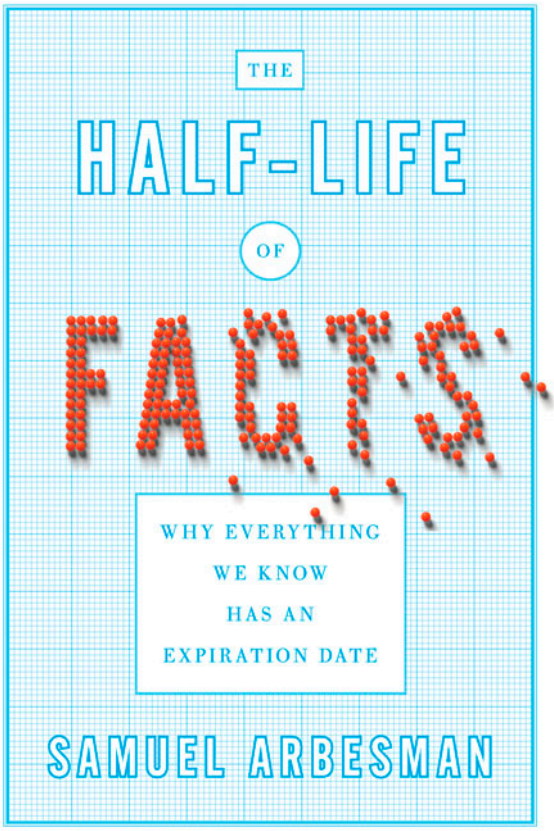
Book review



The Half-life of Facts: Why Everything We Know Has an Expiration Date, by Samuel Arbesman, Penguin Group (2012), Paperback. ISBN 978-1591844723.

> **… you need to have a lot of ideas, and then you need to throw away the bad ones.**
>
> –Two-time Nobel Laureate Linus Pauling on the secret of his success in science

Samuel Arbesman's thoroughly enjoyable book, *The Half-Life of Facts* introduces a jarring (but obvious in hindsight) feature—or bug—of human knowledge.

All facts have an expiration date:

> While there will always be an infinitesimal number of papers cited many decades, or even centuries from now, within a certain number of years, the vast number of articles will have decayed into irrelevance. Of course, some of these are not wrong, just obsolete … Facts, in the aggregate, have half-lives. We can measure the amount of time for half of a subject's knowledge to be overturned. There is a science that explores the rates at which new facts are created, new technologies are developed and even how facts spread. How knowledge changes can be understood scientifically. (Arbesman 2012, Ch 3)

At one time or another, most of us have chuckled at some anachronistic reference to outdated notions of preventative medicine and lifestyle. ('This year coffee is good for you, next year it's bad …') Such irony has become so much a part of popular culture that barbs about the naiveté of earlier generations have become a staple of period fiction. (e.g. in the 1960s period drama *Mad Men*, Roger Sterling complains: 'All these years I thought it would be the ulcer. I did everything they told me. I drank the cream, ate the butter. Then I get hit with a coronary'.)

However, it is sobering to realize that the tendency for knowledge to shift is not unique to medicine. Rather, this tendency is endemic to all branches of science and

Arbesman demonstrates this through numerous vivid examples. His dissection of the ephemeral nature of established scientific facts is both fascinating and humbling, particularly for those of us who do research.

In the first three chapters of *The Half-Life of Facts*, Arbesman guides the reader through some of the more interesting instances of how scientific knowledge evolves, enlivening the narrative with entertaining historical anecdotes and strange-but-true findings.

For example, Arbesman recounts how the study of the growth and spread of knowledge (the 'science of science') began in the late 1940s when Dereck J. de Solla Price noticed that the heights of successive stacks of the annual volumes of *Philisophical Transactions* of the Royal Society seemed to grow at an exponential rate. This suggested that scientific knowledge also grew like an exponential process, and led to the birth of the field of *scientometrics* – the quantitative study of science – which measures everything from the impact of funding on research productivity to the relationship between future success and the order in which an author is listed on joint research:

> … Nobel laureates are first authors of numerous publications early in their careers, but quickly begin to give their junior colleagues first authorship. And this happens far before they receive the Nobel Prize. (Arbesman 2012, Ch 3)

One of the most interesting discussions in the book comes in Chapter 3 in which Arbesman describes the estimation of the half-lives of facts in various disciplines. For example, two Australian surgeons found that half of the published 'facts' relating to surgical medicine become false every 45 years. (Think about that the next time you go under the knife with a surgeon boasting 46 years of professional experience …)

In the 1970s, this type of research turned out to be of great interest to librarians who were concerned about the limited (physical) space on library shelves and who were trying to determine which books could be safely retired. There is some good news here though. It turns out that books also have a predictable shelf-life that varies by discipline; however, though their content is driven by reported scientific results, the books in a given discipline tend to have a longer shelf-life than the raw findings in academic journals and papers. This is due, presumably, to the tendency of textbook authors to include mostly facts that have stood the test of time. (Ironically, of course, the original concern about physical shelf-space has itself become somewhat obsolete due to the massive digitization of libraries.)

Of course, the opposite is also true: some ideas die out more quickly than their documentation, which leaves a messy and often confusing trail. For example, Sapolsky (1997) describes the case of a mistaken finding that led to a dangerous 'preventative' irradiation treatment for SIDS. The author reports that although the original finding was eventually discredited, it was many years after that before a leading textbook reported this; and the clinical use of irradiation still persisted for years after that.

The remaining seven chapters of *The Half-Life of Facts* deal with the spread of knowledge and the ways in which new facts, which replace the old ones, are discovered, spread and, sometimes overlooked.

For example, Chapter 4 argues that Moore's Law actually represents a more general statement about the rate of advancement in knowledge. I found the research on innovation and retention of new ideas to be particularly resonant as it reinforces the important role of a dynamic and diverse 'marketplace of ideas', which can be so crucial to managing research teams.

> … Larger groups of interacting people can maintain skills and innovations, and in turn develop new ones. A small group doesn't have the benefit of specialization and idea exchange necessary for any of this to happen. (Arbesman 2012, Ch 4)

Chapter 5 explores the importance of communication technology (e.g. the movable type printing press) and personal communications in spreading and revising knowledge. Of course, this can be a bug as well as a feature: rapid dissemination of information also leads to a tendency for errors to propagate quickly. As one unsettling example of this, the author describes recent research by two engineers (Simkin and Roychowdhury 2003) that uses the propagation-rate of transcription errors in academic research references to assert that academic researchers routinely cite common literature without themselves having read it:

> … Simkin and Roychowdhury conclude, using some elegant math, that only about 20 percent of scientists who cite an article have actually read that paper. This means that four out of five scientists never take the time to track down a publication they intend to use to buttress their arguments. By examining these mutations we can trace these errors backward in time, and understand how knowledge truly spread from scientist to scientist, instead of how it appeared to spread. (Arbesman 2012, Ch 5)

Chapters 6 and 7 deal with approaches to solving very hard problems that have stood for years without solution, despite the best efforts of the scientific community. Arbesman discusses crowdsourcing and examples of how the *synthesis* of latent scientific facts (rather than the *introduction* of a new result) can lead to new solutions to such challenges. The author then goes on to analyse how long it takes for major breakthroughs to occur in science. For example, in Chapter 6, we get the author's own estimate of when $P = NP$ will be proven or disproven. (Spoiler alert: we are about 10 years away, in expectation.) Numerous examples provide entertaining reading while also highlighting useful insights.

In a flourish of integrative thinking, Abesman includes a chapter on measurement error and the impact of increasing precision on the revision of knowledge. Chapter 8 details the great advances in measurement and in the interpretation of measurement with error. Indeed a good number of advances in our knowledge are in fact due to advances in measurement.

The author pivots this discussion into one of publication bias and the tendency for researchers to overlook or classify as errors those results that contradict either their current research or established theory. This leads to a discussion of the 'decline effect' in which initial published results tend to

show greater effects than subsequent follow-up and replication studies on the same subject. This culminates in a review of John Ioannidis's series of papers on false discovery, the most well-cited of which is the descriptively titled, 'Why Most Published Research Findings are False' (Ioannidis 2005).

Having prepared the ground, Abesman's penultimate chapter deals with the behavioural aspects of knowledge discovery and revision. The author discusses topics ranging from shifting baselines to change blindness and other cognitive biases to plain old human politics and stubbornness. Those who enjoy 'gotcha' anecdotes will delight in some of this chapter's accounts. (Who could resist reading about the *NY Times's* retraction of its story on the impossibility of space flight … a day after the Apollo 11 launch.)

If I were forced to level a criticism at the book, it would be only that I would have liked to have seen more written about the behavioural aspects of the evolution of false-knowledge. While reading this chapter, I found myself thinking back to Thomas Gilovich's *How We Know What Isn't So* (1991), which deals with the mystery of why there remains a swath of 'established' knowledge that we casually accept as true, but that has no basis in fact. For example, many adults still (incorrectly) believe that infertile adopting couples tend to subsequently conceive (post-adoption) at a higher than expected rate, due to reduced stress:

> … it becomes clear that the remarkable phenomenon we need to explain is not why adoption increases a couple's fertility; clinical research has shown that it does not. What needs explanation is why so many people hold this belief when it is not true. (Gilovich 1991, p. 1)

The tendency to believe such 'nice/good/lovely' stories comes from our love of logically plausible anecdotes that sound both elegant and meaningful.

> We are predisposed to see order, pattern and meaning in the world and we find randomness, chaos and meaninglessness unsatisfying. Human nature abhors a lack of predictability and an absence of meaning. As a consequence, we tend to 'see' order where there is none and we spot meaningful patters where only the vagaries of chance are operating. (Gilovich 1991, p. 9)

Gilovich explores the darker side of our prodigious abilities to build and revise theories to explain our observations – those same abilities that Abesman catalogs in *The Half-Life of Facts*. Humans reflexively create plausible stories to explain the world around us. In fact, *we like good stories*. We revel in the surprise ending and the tried-and-true Hollywood plotline. We resist letting the facts get in the way of a great story. Therein lies the challenge. At times, our rhetorical facility is so agile that it can overwhelm our more methodological sense of reasoning. We sometimes prefer the guilty pleasure of a good story to the more refined satisfaction of empirical investigation. We can become cognitively sloppy.

Behavioural tendencies such as those discussed in Chapter 8 of Abesman's book (and Gilovich's) notwithstanding, *The Half-Life of Facts* concludes with a chapter on what is right with science. Indeed, the author asserts, science is working as designed, with old theories giving way to new ones as the old ones are tested under the bright light of the scientific method and as new insights are revealed.

Rather than despairing over the constant flux in our knowledge, Abesman suggests that our growing understanding of the way in which our knowledge evolves should be reassuring:

> Facts don't change arbitrarily. Even though knowledge changes, the astounding thing is that it changes in a regular manner; facts have a half-life and obey mathematical rules. Once we recognize this, we'll be ready to live in the rapidly changing world around us. (Arbesman 2012, Ch 10)

I have a fondness for writing that promotes thinking about thinking. *The Half-Life of Facts* delivers this resoundingly. A key component in the evolution of human knowledge is the systematic abandonment of concepts and constructs that were once thought to be inviolate as new facts and rigorous scientific inquiry render older facts obsolete. *The Half-Life of Facts* argues constructively that we should welcome this inevitable, if humbling, aspect of our understanding of what which we 'know' to be true.

This kind of self-awareness and humility is fundamental to the honest quest for knowledge:

> If it disagrees with experiment, it's wrong. In that simple statement is the key to science. It doesn't matter how beautiful your guess is, it doesn't make a difference how smart you are, who made the guess or what his name is. If it disagrees with experiment, it's wrong. That's all there is to it. (Feynman, 1965, Ch. 7)

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