No Failure, No Science

FAILURE: Why Science Is So Successful
Author: Stuart Firestein
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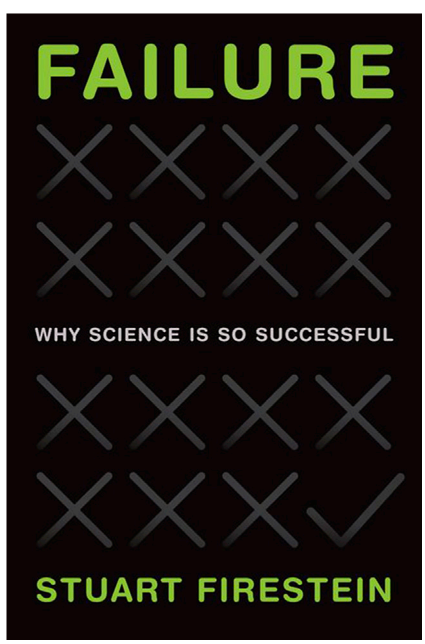
304 pp. $21.95

Just after your entire research program implodes in a catastrophic failure of unexpected results and shattered expectations, take a deep breath and read Stuart Firestein's new book on *FAILURE*. In an engaging sequel to his celebrated book *IGNORANCE: How it Drives Science* (2012), Firestein lays out the case for failure as the single most critical driver of scientific progress over centuries of human civilization. The text is structured into 15 compact chapters, and each is a free-standing essay that can be read in any order. The book first defines the particular failure that matters in science and then extolls its virtue in diverse areas: teaching, medicine, pharma, funding, scientific publishing, and more. He makes a persuasive case that science stalls without a culture of questioning the known and being willing to fail in the process. Firestein weaves together the philosophy and history of science to put his arguments into perspective. He reminds us of the dark period between the glories of Islamic science and rise of science in Europe a few centuries later, during which time little new scientific knowledge emerged. Science historians attribute this pause to the comfort of certainty that a series of knowable facts had been compiled. The implication in subsequent chapters is that we are on track for another dark age unless we confront the importance of failure in our work.

Every scientist will find a few chapters most relevant to their personal experience, and for me it was those on science education and funding. Firestein is at his funniest here, and this is important because these are the least funny problems in contemporary science and the ones that will be our undoing unless we fix them.

Let's first consider science education. Firestein's hilarious and caustic mocking of science teaching from kindergarten to college is on target. Intensive memorization and rapid forgetting of various disconnected facts is the norm, while presenting science as the exploration of the unknown is exceedingly rare. High school students are drilled to memorize $E = mc^2$ for physics, the periodic table for chemistry, and glycolysis for biology. Science as a body of knowledge is presented as a collection of immutable facts. The reality that science is a process of creative experimentation that stumbles slowly and unpredictably toward new insights, driven by failures, is never discussed. As a result, students rarely actually do anything meaningful in "lab" classes. How much is gained by sculpting an endoplasmic reticulum out of gummy bears or by dissecting an earthworm and sketching its digestive system on a photocopied handout? This approach ensures that the typical American has not even the most cursory knowledge of any branch of science or how science is done, making it impossible for him or her to be an informed citizen. The rise of the Internet means that anyone can do a search to find out that genetically modified food causes cancer, that vaccines are causal in the increase in autism diagnosis, and that fructose is poison. The "experts" who dole out this pseudoscience always seem so certain and so authoritative that the opinion of actual scientists is easily disregarded. As long as the public believes that science is a static body of knowledge, rather than a dynamic body of ideas subject to continual revision, the credibility of scientists and science will continue to erode.



"Funding failure" is the chapter that takes on the current mechanism by which government research funds are doled out. It's rare to find a working scientist these days who does not complain about the current system. Everyone is constantly writing grants, and the grants increasingly have to promise to deliver on some specific topic stipulated in a "Request for Applications." Where is the room to think and play and fail?

Firestein asserts, and I agree, that the NIH is increasingly risk averse because it operates under the tyranny of hypothesis- and project-driven science. Moreover, the imperative to earmark ever more funding for programmatically restricted projects means that there are fewer funds to support open innovation by individual investigators.

Two provocative ideas are offered to change how federal funds are distributed to make space for failure. Both involve increasing the pool of available funds and changing how they are awarded. The first is to do minimal triage and select grants by lottery for funding. As crazy as this sounds, it is not very different from the current system. When only 10% of grants are funded, the winners were likely chosen at random from a pool of the top 30% that were equally good. The second idea is to go to a market economy in which grants compete against each other on the basis of scientific merit, creativity, and the "quality of their curiosity." In the current system, grant study sections consider and score each grant sequentially, without regard to other discussed grants. Firestein's idea would be to discuss a batch of related grants simultaneously and select the top 30% for funding. Firestein emphasizes that such a system would require that we return to the higher funding success rates of 30% that were the norm 25 years ago. Funds distributed in this way would reward exploratory work that takes risks, rather than narrowly focused ideas aimed at convincing study sections of feasibility. Investments in basic science are now an acknowledged success of the 1970s Nixon-initiated War on Cancer. While we have not "cured" cancer, dramatic increases in knowledge of the underlying biology of cancer, from cell cycle to chromatin to virology to tumor immunology, have been the major driver of new life-saving therapeutics. Firestein argues that, if those funds had been narrowly restricted to purely translational goal-directed, failure-averse research, we would not be much better at saving cancer patients than we were in 1970.

What is the ideal audience for such a book? Surprisingly, it succeeds equally well with "civilians" (the non-scientist administrators, relatives, friends, shopkeepers, and lawmakers in your life) and scientists of any discipline. Although Firestein is a neuroscience professor at Columbia University, the book is not narrowly aimed at biology but manages to be all inclusive in highlighting vignettes of failure that span the entire arc of science from psychology to astrophysics. The writing style is direct and non-technical, with personable witticisms and humor to keep the narrative going, something that I attribute to Firestein's former life as a professional theater director.

One important benefit of this book is its ability to communicate what science actually is and how it advances human knowledge. The typical "civilian" has no idea what a scientist actually does day to day. We all get the same series of puzzled questions from relatives during the holidays ("Are you still in school?" "Have you solved that cancer thing yet?" "When are you going to win the Nobel Prize?"). Hand them this book. It will demystify the process of science and get them interested in thinking about the importance of failure in illuminating the unknown.

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