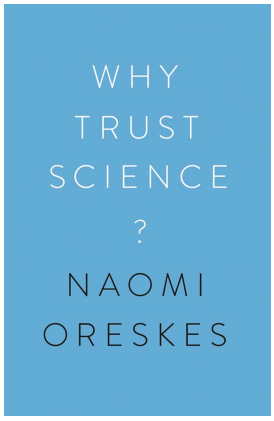
JOURNAL OF APPLIED CRYSTALLOGRAPHY
ISSN 1600-5767

Why Trust Science? By Naomi Oreskes. Princeton University Press, 2019. Pp. 376. Price USD 24.95, GBP 22.00 (hardback). ISBN 9780691179001, ebook ISBN 9780691189932.

John R. Helliwell*

Department of Chemistry, University of Manchester, Manchester M13 9PL, UK. *Correspondence e-mail: john.helliwell@manchester.ac.uk

Keywords: book reviews.



As I was reviewing this book, the National Academies of Science, Engineering and Medicine (2019) in the USA published their 2019 report on *Reproducibility and Replicability in Science*, a 256 page analysis and survey including a final chapter of 20 pages on *Confidence in Science*. Whilst naturally USA focused, it also had international participation. I found this an authoritative report with good recommendations, including for journals and societies. Data and software transparency featured prominently in the best processes for achieving as high a scientific standard as possible. With all the cogency of this report in mind, I resumed my review of the book *Why Trust Science?*

Why Trust Science? is an excellent format for a book; as well as the core argument written by Naomi Oreskes herself, it includes several chapters offering written critiques with Naomi Oreskes' responses. In chapter 1, the author reviews some recent examples of disputed science. The first is the issue of some public disquiet, fanned by President Trump, about the vaccination of schoolchildren, which she sums up by finally stating the data of the situation: the number of cases of the diseases in question have gone up as a result of vaccination avoidance. Example 2 again involves the Trump administration, this time the Vice President's belief in creationism, backed up by a poll of US churchgoers where 67% would espouse the same view. The third and final example for chapter 1 is again USA-based and concerns the American Enterprise Institute, which apparently had offered cash incentives to find errors in the International Panel on Climate Change's (IPCC's) analyses. At location 284 in my ebook copy, the author sets her metric for monitoring science as a process: there has to be a consensus. She shows no sense of immediate danger in that metric. But I would point out that, for example, the consensus among the physics community at the end of the 19th century was generally that there was nothing major left to discover, it only required details to be filled in. How wrong that consensus was! It needed piercing intellects such as Einstein, Planck and so on to radically overhaul that false consensus. The tests of their theories of relativity and a quantum world rested on experiments and in turn provided the new scientific data of the time. We will return to the topic of consensus later.

At location 676, the new section entitled *Getting Unstuck: Social Epistemology* introduces the criticism of science that it claims to be objective and yet it largely excludes half the population, females! Yes, how very true; science needs to become more representative. My efforts to do something about gender disparity I describe in my book *Skills for a Scientific Life* (Helliwell, 2016, ch. 27).

In chapter 2 at location 997 we come to an interesting point. Paraphrasing, if science progresses via a process of falsifiability *à la* Karl Popper then why should the public trust a science result now? In my own book *The Whats of a Scientific Life* (Helliwell, 2019, ch. 1) I answer that science delivers, whether it is health, wealth or comfort, modes of travel, smartphones, or the internet. Such examples I think provide answers to the author's question of how we can know which science truths will be permanent. However, we will shortly see a description seeking to separate science as a process from technology, which I evidently disagree with.

Chapter 3 is by a different author, Susan Lindee. It is intriguingly entitled *The Epistemology of Frozen Peas*. There is a subtitle, *Innocence, Violence and Everyday Trust in Twentieth-Century Science*. The author justifies the focus on everyday items like frozen

peas as resting on science (and technology) methods, and this particular example is chosen because it will be understood (in a treatise on the philosophy of science) in a country (the USA) with 'a long tradition of anti-intellectualism'. The chapter is an 'essay' and covers numerous topics, most significantly drawing a border between science and technology via the grey area of applied science. As I mention above, I see no need for such a distinction, nor did Max Perutz in his marvellous book *Is Science Necessary?* (Perutz, 1991).

Chapter 4 is entitled *What Would Reasons for Trusting Science Be?*, by Marc Lange. It is a very short chapter stating that specific areas of science can be trusted but these do not justify a wholesale trust, which one would obviously agree with.

Chapter 5 is entitled *Pascal's Wager Reframed: Towards Trustworthy Climate Policy Assessments for Risk Societies*, by Ottmar Edenhofer and Martin Kowarsch. Pascal's wager is that 'it is in one's own best interest to behave as if God does exist, since the possibility of eternal punishment in hell outweighs any advantages in believing otherwise'. I reread this title multiple times and still did not really digest it. Anyway, this chapter focuses on climate science and the consequent step of determining a policy of what to do about it. This is a very useful distinction. As I have quoted Winston Churchill before about scientists, 'they should be on tap but not on top'. I challenged that statement in my book *Skills for a Scientific Life* (Helliwell, 2016, ch. 31) by saying that a policy committee needs to include an expert scientist, not only to advise but as a voting member. Edenhofer and Kowarsch describe the spectrum of consequences of climate change, which range from the 'the Trump administration's estimate of the social cost of carbon of 1 to 6$ per additional ton of CO_2 into the atmosphere to 45$ as the estimate by the Obama Presidential administration', to which I add the Extinction Rebellion estimate of consequences if we do not achieve net zero emissions by 2025 as '6 billion deaths due to mass starvation, that is what the science is telling us' (Roger Hallam, 15th August 2019, on the BBC's *Hard Talk*; https://m.youtube.com/watch?v=9HyaxctatdA). The flaw in that BBC programme format, and many others of its type, is that they have an interviewer, Stephen Sackur, and an advocate for the science, Roger Hallam, but not a lead scientist such as the Chair of the IPCC. Overall I found that this chapter really only set the scene as it did not summarize the IPCC report, so as to dissect the contrasting policy positions of the Trump and Obama presidential administrations, which are quoted, let alone the extrapolation made by Extinction Rebellion that I cite. This chapter could have been pivotal but must await another edition of this book.

Chapter 6 is entitled *Comments on the Present and Future of Science, Inspired by Naomi Oreskes*, by Jon A. Krosnick, a practitioner of science in social psychology and cofounder of Best Practices in Science at Stanford University. This chapter has overlaps with the National Academies report on *Reproducibility and Replicability*, written with an interesting personal perspective obviously, and concludes with suggestions for remedies to avoid irreproducibilities in future. Inevitably the National Academies report recommendations are deeper, wider and authoritative. Furthermore, the latter emphasize the importance of archiving and transparency of data, as well as of software, basically following the FAIR and FACT data principles [see, respectively, Wilkinson (2016) and van der Aalst *et al.* (2017)].

Chapter 7 is a *Reply* from Naomi Oreskes to the authors of chapters 3, 4, 5 and 6. Indeed, this is a nice approach of this book. She agrees with the separation of science from technology, which I disagreed with as a position already above. She agrees with the need for consensus, which I have argued above is not the main point because it is the underpinning data that make or break a science publication. She disagrees with climate science and policy being connected on the basis that it is not only the science that determines policy. It is a controversial position, I think, that she adopts with that view. My answer is to have committees and panels determining policy to include scientists as voting members. I see that I need to make my assertion stronger still, given Naomi Oreskes' position on this; scientists need to not just be voting members and expert advisors but have a veto on policy plans if the science demands it.

On the views of the replication crisis in science by Jon A. Krosnick, Naomi Oreskes incisively states (location 2933) 'Professor Krosnick makes broad claims on limited evidence and lumps together phenomena that may be distinct.' Furthermore she correctly states (location 2954) that 'What leads to reliable scientific knowledge is the process by which claims are vetted.' To which I would add the process needs to include pre- and post-publication peer review and involve scrutiny of the words of the article with the data, and of course requires the archiving of those data for post-publication review. So, I dispute her notion (location 2954) that 'a single paper cannot be the basis for reliable scientific knowledge'. She does, however, mention the need for open reporting of data at location 3056.

There then follows a section entitled *Afterword*, followed by the chapter footnotes, which are extensive: there are 139 footnotes for chapter 1, 205 footnotes for chapter 2 (with a further 34 for the *Coda* to the chapter). At location 3987 the *References* to the chapters start. At location 4699 the career résumés of the contributors to the book are presented. They are a very distinguished group. At location 4719 the subject index starts, which is extensive; entries are accorded page numbers rather than ebook location numbers.

Princeton University Press provided a Kindle for iPad ebook for my review. This worked well until I reached the footnotes, of which there are many. I did not look at each footnote as I read the main text. Instead I read them at the end. A conventional printed volume would have made it easier to consult these. The text of the book is very well written, as one would expect of this very accomplished 'American historian of science', also previously a geochemist in the mining industry (her biography is here https://en.m.wikipedia.org/wiki/Naomi_Oreskes). There were a few typos. There are no figures.

Overall, I found this book to be a marvellous, up to date, thorough historical survey of science and its processes. The

odd thing about the book is its choice of some of the modern science topics. Naomi Oreskes describes well the improvement that we are seeing of science as a process. But we are also seeing the problems of predatory journals and conferences, a few of which can seem plausible enough, and we are also realizing the publications bias that is the reporting only of positive, not null or repeat, results. Her final remark is eminently sensible: 'confidence in science is warranted whereas the scepticism in scientists' findings in their domain of expertise is unwarranted'.

There is also a taster for the book with Naomi Oreskes' excellent TED Talk of 2014 (see a summary here https://tedsummaries.com/2014/08/03/naomi-oreskes-why-we-should-trust-scientists/).

References

Aalst, W. M. P. van der, Bichler, M. & Heinzl, A. (2017). *Bus. Inf. Syst. Eng.* **59**, 311–313.

Helliwell, J. R. (2016). Chapter 31 in *Skills for a Scientific Life*. Boca Raton: CRC Press.

Helliwell, J. R. (2019). *The Whats of a Scientific Life*. Boca Raton: CRC Press/Taylor and Francis.

National Academies of Sciences, Engineering, and Medicine (2019). *Reproducibility and Replicability in Science*. Washington, DC: The National Academies Press. https://doi.org/10.17226/25303.

Perutz, M. (1991). *Is Science Necessary? Essays on Science and Scientists*. Oxford University Press.

Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., Blomberg, N., Boiten, J.-W., da Silva Santos, L. B., Bourne, P. E., Bouwman, J., Brookes, A. J., Clark, T., Crosas, M., Dillo, I., Dumon, O., Edmunds, S., Evelo, C. T., Finkers, R., Gonzalez-Beltran, A., Gray, A., Groth, P., Goble, C., Grethe, J. S., Heringa, J., 't Hoen, P. A. C., Hooft, R., Kuhn, T., Kok, R., Kok, J., Lusher, S. J., Martone, M. E., Mons, A., Packer, A. L., Persson, B., Rocca-Serra, P., Roos, M., van Schaik, R., Sansone, S.-A., Schultes, E., Sengstag, T., Slater, T., Strawn, G., Swertz, M. A., Thompson, M., van der Lei, J., van Mulligen, E., Velterop, J., Waagmeester, A., Wittenburg, P., Wolstencroft, K., Zhao, J. & Mons, B. (2016). *Sci. Data*, **3**, 160018.