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THE TREE OF KNOWLEDGE

An Experiment on a Bird in the Air Pump
Joseph Wright of Derby, 1768

Criticising Science

Martin Kusch and **Alexander Reutlinger** discuss the ways science is criticised.

Martin Kusch: In many political debates today, one can observe a curious phenomenon: while scientific knowledge seems crucially relevant for dealing with a large-scale problem, important political players go out their way to downplay and attack that very knowledge, and the science behind it. Debates regarding the climate crisis and the Covid-19 crisis are obvious cases in point, but there are many other examples as well.

Alexander Reutlinger: Yes. This raises important questions for citizens and politicians who aren't scientific experts. When and to what degree can one trust science? And, how should one adjust one's level of trust in a scientific claim when that claim is attacked or criticized?

MK: There are of course many different kinds of 'science criticism' in the media as well as in science itself. Which kinds should we distinguish, do you think?

AR: The concept of 'science criticism' covers too many different phenomena. Let me try to replace it with some more nuanced concepts and categories. First, some critics oppose science across the board: all of science, science in every form. Let's call these critics the 'anti-science brigade'. It seems to be a relatively small group of people in today's world. After all, most people rely on some aspects of science and technology. Even fierce science critics use cell phones and social media to do their critiquing.

MK: I take it that this category marks an extreme case which illuminates more common cases by way of contrast? That said, it isn't difficult to think of people inclined to reject science altogether, especially if we look at history. In Medieval times, some religious authorities, for instance, regarded all forms of science as so many attempts to meddle in God's work, and to be distractions from a life of religious devotion. There may be remnants of this attitude amongst some sects even today.

AR: The notion of the anti-science brigade opens up a conceptual space: all other types of science criticism happen *within* science, in some sense, while the anti-science brigade rejects science from a viewpoint *outside* of science...

My second concept is the criticism one finds in the context of scientific revolutions. These are episodes involving deep disagreements *among scientists*, and radical change.

MK: The Copernican Revolution is the classic example. The

'revolutionaries' criticized, amongst other things, the Aristotelian beliefs that the Earth is at the centre of the universe; that every object has a natural place towards which it strives; and also the belief that our innate perceptual organs need not be improved – by the use of telescopes or microscopes, say.

AR: Philosophers and historians of science have devoted much time and energy to analyzing the disagreements between scientific revolutionaries and the old guard. The establishment inevitably criticized the revolutionary views as 'absurd', asking questions such as, "How could the Earth be moving around its own axis and the Earth around the Sun? Is it not part of the very concept of Earth that it is immobile?" The revolutionaries in turn accused their opponents of being biased and prejudiced.

MK: Would it be correct to say that some of the sciences politically most relevant today are revolutionary? Health science and climate science, for instance?

AR: I don't think that health or climate science are currently in a state of revolution, at least not in the sense of the Copernican or Einsteinian revolutions.

MK: So why should we care about the revolutionary kind of science criticism?

AR: Because it's *indirectly* relevant for understanding current debates about the role of science. Some of today's science critics present themselves as revolutionaries. They insinuate that, say, health science or climate science are in a crisis, face insurmountable problems, and so on, and in light of this alleged crisis, call for a revolution in these sciences – a revolution led by the critics. This is not, of course, the way I see it. Generally speaking, the critics' diagnoses are wrong, and motivated by a desire to discredit the science in question.

MK: I agree that health science and climate science do not currently require revolutions on the Copernican or Einsteinian scale. Still, it appears to me that the emergence of 'climate science' as *a novel mix of sciences* – from astronomy to computer science, economics to mathematics, meteorology to oceanography, physics to political science – is something *radically new*. One expression of the novelty is perhaps the widespread *incomprehension* even within this fascinating new form of science. Climate scientists working on models in oceanography do not fully understand the relevant models in political science, or the computer scientists often do not follow the reasoning of the economists, and so on.

AR: I am certainly not against discussing the implications for knowledge of this feature of climate science, including to what extent it *is* a novel feature. However, my main emphasis would be that the relevant sciences in the context of, say, the Covid-19 crisis or the climate crisis, are not in a revolutionary phase.

MK: I agree. But there may be an interesting difference between research into Covid-19 and the climate science case. Critics of climate science sometimes refer to its enormous complexity as a reason for distrusting it – and the very real difficulty of climate science may well sometimes be a cause for why some people do distrust it. This type of criticism is not – yet – much found amongst critics of health sciences such as epidemiology and virology. In the health sciences the models and calculations are pretty complex, too, but not yet to the same extent as in climate science.

There's a further interesting connection between historical scientific revolutions and our current situation. Critics of both climate and health science often borrow the mantle of the 'revolutionary' from Galileo Galilei, that brilliant defender of the new Copernican worldview. In Austria, for instance, we have a gynaecologist fighting against mainstream medical advice on social distancing and mask-wearing who likens himself to Galileo. The *Wall Street Journal* has presented climate change deniers in a similar way (see 'Climate skepticism and the manufacture of doubt', Biddle and Leuschner, 266-267, 2015). But the analogy doesn't work. Galileo was not a lone figure fighting a consensus view. Astronomy at the time of Galileo had no such consensus. That immediately distinguishes our Austrian gynaecologist from Galileo. We also shouldn't forget that Galileo made significant research contributions in his area of criticism. The gynaecologist commenting on epidemiology has *not*.

AR: Let's move on. A third type of science criticism is quite 'ordinary'. I mean the behaviour that scientists display on a daily basis as a central part of their work. Scientists constantly criticize their own and each other's work, in order to correct mistakes and thus to improve research. One typical arena for such 'ordinary criticism', is the peer review process for publishing. But the important general point is that there are highly organized forms of quality checks *within* the scientific community.

MK: Couldn't such criticism also come from *outside of* science – or at least from outside the given scientific discipline? I'm thinking here of an anecdote I once heard from the sociologist Harry Collins. The community of physicists working on the detection of gravitational waves once received a letter from a medical doctor challenging aspects of the statistics used by the physicists to make predictions. The physicists invited the doctor for a talk, and subsequently acted on his suggestion.

AR: Absolutely. Ordinary science criticism articulated by a non-expert does occur, and sometimes it is successful. However, successful cases are probably vastly outnumbered by unconvincing laypersons' criticisms. For instance, every physicist, and many philosophers of science, regularly receive emails claiming to disprove Einstein's theory of relativity. Usually, the objections presented have already been discussed in the physics community, or they rest on misunderstandings of important parts of Einstein's theory – typically of simultaneity. Yet this kind of criticism, although unsuccessful, is sometimes done in a genuinely scientific spirit, taking science seriously.

MK: The Austrian gynaecologist attacking epidemiology is perhaps a case in point. He's a layperson when it comes to epidemiology. The same goes for one of the leading climate science skeptics, Stephen McIntyre, who is a mining consultant, not a climate scientist.

In the category of 'ordinary science critics' we thus have a mixed bag of people: scientists engaging in peer review in their own discipline; scientists challenging work in other fields; and laypersons attacking scientific work in ways that are sometimes indistinguishable from the way the scientists criticize each other. And, of course, all of these criticisms may be successful, or not. That's why it is difficult for non-scientists to apply discernment to this third kind of science criticism. It is hard to detect the critics who are not competent when they behave pretty much like the competent scientists. And even a non-expert might sometimes come up with a really good ordinary criticism of science.

AR: I'd like to propose one more form of science criticism, which I call 'strategic science skepticism'. It's widespread in current political debates. In this case, the critics claim to be very much in favor of science, and pretend to play by its rules. And yet these critics selectively contest or deny well-confirmed scientific results in order to promote their economic or political interests. In other words, they have a purely strategic attitude towards science. To use an expression mentioned by the historians of science Naomi Oreskes and Erik Conway, they 'fight science with science'. Consider one famous example. From the 1950s onwards, self-appointed 'experts' sponsored by the tobacco industry contested the causal link between smoking and lung cancer – which was already then well established in medical research – in order to serve the economic interests of the tobacco industry. Examples of this kind of science criticism have been well studied by historians of science, such as in Naomi Oreskes' and Erik Conway's *Merchants of Doubt* (2010) and Robert Proctor's *The Golden Holocaust* (2012). One can find similar instances of strategic science skepticism in many political debates – in debates on the Covid-19 crisis, and perhaps most prominently on the climate crisis.

MK: Could you make that a bit more concrete? How does strategic science skepticism actually work? What are the typical manifestations of it?

AR: Four manifestations are particularly salient. The first one consists in cherry-picking the data –

MK: – as when Trump insisted that global warming is a hoax because it was snowing in Washington in May…

AR: A second typical manifestation of strategic science criticism consists in a biased choice of experiment design.

Good news! Your cholesterol has stayed the same, but the research findings have changed!

MK: Indeed. Imagine that the public worries whether a certain pesticide makes us sick. The company producing it aims to reassure us by having its scientists expose rats to the pesticide, and the rats stay healthy and happy. So far, so good. But what if that strain of rats is not sufficiently similar to humans? And, moreover, what if that strain was chosen only because it's known not to be affected by the pesticide? We have a biased choice of experiment design.

AR: The manipulation of statistics or another biasing choice in representing empirical data is a third typical manifestation of strategic science skepticism.

MK: Yes. This can take many forms, including 'curve-fitting'. If you plot data on a graph, you can use very different principles for 'smoothing out' that data into a neat curve. Depending on how you do that, you might well conveniently make certain inconvenient patterns in the data invisible.

AR: And finally, fourthly, we have a biased choice of the concepts used to frame a research question or to interpret the data.

MK: The simplest case I can think of here, are questionnaire studies that force the subjects to self-identify as either male or female, thereby making third genders or trans people invisible.

AR: Indeed. Or think of critics of climate science who complain that the science does not produce 'certain' or 'proven' results. Concepts like 'certainty' and 'proof' are out of place in areas of science that make extensive use of probabilistic concepts and statistical methods, and so cannot be applied here.

Philosophers, historians, and sociologists of science have offered different analyses of strategic science skepticism, differing on what they take to be wrong with science scepticism. Some commentators dismiss such criticism as pseudo-science. Other analysts accuse the skeptics of lying. Still others highlight the disagreement with expert consensus. Finally, there are commentators who emphasize that the skeptics' claims are not supported by the available empirical data.

MK: Do we have to choose between these analyses? Couldn't different ones be true in different cases of science skepticism?

AR: I am confident that ultimately there is a single analysis that covers all interesting cases of strategic science skepticism, telling us what's wrong with all of them. But I might have to accept that these angles all provide useful tools for evaluating different claims of science skeptics. This is not a terrible situation to be in.

MK: Of course our list of science criticisms is incomplete. For instance, we've said nothing about forms of criticism that focus on claims such as that particular sciences or their results carry race and gender biases. Some of this kind of criticism might fit into the kinds we've discussed, other might not.

Here's an image that might sum up what we've said. Think of a line which represents different responses to scientific information. At one end, we have the extreme of total, naïve, uncritical trust: at the other, we have radical skepticism about all science. In between we have the natural, healthy, critical attitude – selective skepticism – perhaps about one particular line of research, up to a whole field of science; we also have strategic science skepticism. Our problem as ordinary citizens is not only where to place ourselves on this scale – that is, to form a view about which elements of science to believe. We also have to determine how to respond to people in the public domain, scientists or not, who tell us where we should be on the scale. This is usually hard. There are no quick fixes. Science, as well as sci-

The Attributes of Science
Jean-Baptiste-Simeon Chardin 1731

ence criticism, is a difficult business, and the more complex the question, the more difficult the assessment. Humility is called for: not to jump to quick fixes and easy solutions just because they make us feel good and successful. Think of Trump's comments about injecting disinfectant…

AR: Assessing science criticism is indeed a complex, difficult task. Still, it is not a hopeless task, and I think we can provide some positive general orientation. First and foremost, being critical of science can mean many different things in different scientific and political contexts. Think of the four kinds of criticisms we discussed, or your continuum of trust. It's often helpful to try to work out what type of criticism of science is actually at issue, and how wide-ranging it is.

MK: The more wide-ranging the criticism, the more varied and deeper should be the considerations advanced by the critic. One cannot dismiss the research done in an entire discipline, such as epidemiology, just because one of its models turned out to be inaccurate in one area. It is also a good strategy to give some weight to numbers. Say you have a certain claim criticising another claim, for instance, concerning climate change. One way to assess these claims is to see who supports the one and who supports the other. Suppose for instance that the criticism of the science comes from a single mining consultant, whereas the claims being criticised can be found in the IPCC report, underwritten by several thousand climate scientists. Then it makes sense to opt for the IPCC claims – unless, of course, you decide to dedicate your life to becoming a climate scientist so that you can make up your own mind. One should also distrust people who declare themselves revolutionaries to make their minority view more acceptable. And look carefully at any alleged expert's field of expertise. Of course, sometimes an outsider is able to help solve the problems a field of research is facing. But that's the rare exception, not the rule. Last but not least, one must draw on several sources of information – newspapers and TV and web channels with different political orientations – and compare the experts they parade before your eyes. That may be obvious, but perhaps it is worth repeating.

AR: We often find ourselves overwhelmed by too much scientific information. We all know this feeling. I certainly do. But the feeling of not being able to process a lot of information should not itself lead us to doubt or dismiss that information as being false or untrustworthy. Instead, suspending judgement is often the responsible reaction – at least for the moment, the day, or the week. It can be a form of intellectual courage to say "I can't form an opinion about this now. I need more time for this!"

A final point. As you said, one certainly should consult several sources of information. I'd like to add that amongst these resources should be the obvious outlets of scientific information, including what the relevant scientific institutions say about a particular criticism of scientific claims. For instance, suppose our topic is the Covid-19 pandemic, then – at least if you live in Germany – you ought to check out what the Robert Koch Institut says about myths concerning the transmission of the coronavirus.

Martin Kusch is professor for applied philosophy of science and epistemology at the University of Vienna. Alexander Reutlinger is Akademischer Rat (a.L.) at LMU Munich (Munich Center for Mathematical Philosophy), specialising in philosophy of science.