June 2016

Democratizing Science in an Age of Uncertainty

An Interview with Jerome Ravetz

Uncertainty, one of the defining features of many of the challenges facing humanity in the twenty-first century, has considerable implications for scientific thought and practice. Allen White, Senior Fellow at Tellus Institute, talks with Jerome Ravetz, a pioneer of post-normal science and a leading advocate of citizen science, about why it is time to retire the doctrine of scientific certainty and why science is too important to be left to the scientists alone.

You are perhaps best known for your work on post-normal science. What drew you to the study of the philosophy of science in the first place?

I began my studies in mathematics, but I was never as passionate about it as some of my peers were. Science seemed like a relatively safe career path. Meanwhile, some seminars in philosophy piqued my interest in the philosophy of science, though I had serious misgivings. To me, philosophy's image of science had little relation to what I was studying, or even to the questions that I was beginning to have about science. In graduate school, I intended to study physics, but ended up in mathematics. After settling in England, I connected with Stephen Toulmin, a distinguished philosopher of science, who enabled me to jump from mathematics to the history and philosophy of science. I spent much of the next ten years pondering questions of where science is and where it should be going. This led to the publication *Scientific Knowledge and Its Social Problems* in 1971, in which I argued that scientific research is not a simple discovery of facts, but rather craftsmen's work on "intellectually constructed classes of things and events." The health and vitality, even the survival, of objective knowledge of the world around us depends critically on the subjective commitments to quality of the scientists themselves.

In the philosophy of science, two polar camps are the reductionist/absolutist view and the postmodern view, which recognizes the role of values, morals, politics, and power structures. Where do you fall along this spectrum?

When I entered the field, it was dominated by what one might call internalists. French philosopher Alexander Koyré, for example, believed that great science like Galileo's was purely intellectual and that experiments were not always necessary. An emphasis on social influences on scientific innovation was regarded as vulgar and communistic. As I developed my history of science course in collaboration with colleagues at the University of Leeds, we explored the social interpretation of science. We found Marxist perspectives helpful, but incomplete. They brought attention to the revival of the practice-based sciences of sixteenth-century Europe, but did not help in explaining the Great Disenchantment of the seventeenth, in which the reductionist metaphysics of modern science was born.

My personal philosophy evolved to define science as fundamentally the investigation of problems. A scientist identifies issues and associated problems that need attention, and then investigates using various tools and methods in order to ascertain a possible solution. But the process does not end there. Instead, the solution is subject to valuation and adaptation within a social milieu. Thus, I applied a historical and contextual idea of knowledge creation, recognizing that there are no simple, absolute answers and that truth is neither "internal" nor "external," but a blend of the two. Overreliance on one or the other leads to a simplistic and distorted picture.

In the 1960s, debates around the social aspects of science, particularly the issue of social responsibility, were heavily politicized. In the Soviet Union, ideologues had been interfering in science, and charlatans (like the agronomist T. D. Lysenko) caused immense harm. In the US, we saw how science and scientists had been used in an unjust and criminal war in Vietnam, further reinforcing our belief that scientists and science, rather than operating in an ivory tower, were involved in creating the social conditions of the time.

My own thinking emerged with a more nuanced view of scientific inquiry. It became clear that Descartes' belief that quantitative methods are necessary and sufficient for truth, and that numbers and formulas (and now computer programs) are the only genuine pathway to sound science, was fundamentally flawed. In fact, an exclusively quantitative view can lead to corruption and disaster instead of truth. As I see it, we choose our own ignorance, and our priorities proceed accordingly. Take, for example, pharmaceuticals. Therapies for certain less common diseases are not profitable, so we don't invest in them. In that sense, we are designing our ignorance as much as we are designing our knowledge. Even in "normal" science, fashion and prejudice influence methods, which are not so quickly corrected by experience.

Is ignorance by design more prominent in the natural than the social sciences?

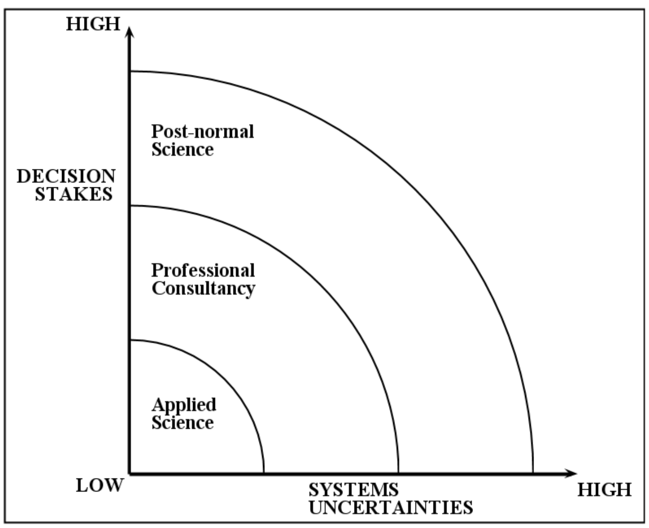
I suppose in the social and behavioral sciences there are contextual influences that are not present in the natural sciences. Social sciences are obviously more prone to direct political influence than, say, chemistry. Mainstream economics was the king of the social sciences, and its collapse after the recent financial crisis supports the view that it was little more than quantified ideology, producing sophisticated vacuity for justifying a particular institutional structure.
On the other hand, we see corporate and governmental pressure directing both the nature and methodologies of research in the natural sciences. In his book *Bad Pharma*, Ben Goldacre highlights how commercial pressures can distort the research process at every stage. In short,

resources available to scientific inquiry are not impartially decided, but instead are subject to forces beyond the control of scientists. There is no conspiracy here—this is simply the real world.

What are the core attributes of post-normal science, a concept which you pioneered and continue to advocate?

The mantra of post-normal science is that sometimes there are situations where facts are uncertain, values in dispute, stakes high, and decisions urgent. When such a situation arises and science is brought to bear in policy decisions, we say it is post-normal. If the world were always post-normal, we would be in quite a mess. Most applications of science in human affairs are relatively straightforward. Take a measurement, assess results, and make a reasonable determination, such as whether something is safe or not. And the world goes on.

Sometimes, however, the procedures of science break down and fail to provide an answer owing to other, confounding variables. This is depicted in what we call the "quadrant rainbow." Imagine a landscape with a quadrant of a circle built around two qualitative axes: the horizontal is systems uncertainties, and the vertical is decision stakes. At the bottom-left, you have what we call applied science, a zone where uncertainties are tame, values are implicit and not contested, and decisions are relatively uncontroversial. This corresponds to the "normal science" analyzed by the philosopher Thomas Kuhn in his book *The Structure of Scientific Revolutions*.



Next, we have a middle band called "professional consultancy." Take surgeons, for example. When surgeons enter the operating theater, they have a lot of background science and equipment at their disposal; however, they know that once the procedure begins, serious surprises are always possible, and that they therefore must be prepared to recognize their ignorance. That is why we say the systems uncertainties and decision stakes are intermediate—a mistake may cost the life of one individual, but still not thousands.

The third situation is one where either or both systems uncertainties and decision stakes are high. You confront a puzzle that does not lend itself to a simple solution, but instead a range of solutions. The specialized knowledge of experts, which assumes only moderate uncertainties and decision stakes, can prove inadequate here. Now comes the radical part of the theory: what we call the extended peer community, or "citizen science." The people who are being affected by the problem know about it. But they are not just victims. And, sometimes, they know more than the scientists themselves because they are living with the effects of the subject problem. For example, the people near Love Canal or in Flint, Michigan, knew that they were exposed to pollution in spite of the reassurances of the experts.

Along with the extended peer community are extended facts, another dimension of citizen science. These may take the form of housewives' epidemiology, leaked documents, or other non-traditional sources of information that do not appear in the peer-reviewed literature but could be crucial to the debate. Of course, when the debate begins, the uncertainties are great, since the experts have not deployed rigorous science in the investigation of the causes of the problem. And the stakes can be very high, such as when a whole community believes that it is being poisoned. That is when the extended peer community, sometimes using unorthodox methods, can be crucial for resolving the problem.

How does this model apply to contemporary climate debates?

There are a number of loose ends in post-normal science that we have never quite tidied up. One is what we call "wicked problems." This idea originated with planners in San Francisco who had spent the 1960s applying one federal program after another to solve one social problem after another, all with disappointing results. The paradigmatic case was "urban renewal," a model of development based on highways and gentrification—renamed "Negro removal" by its critics. Ultimately, these planners concluded that a pathological condition with deep, systemic roots does not lend itself to piecemeal, disjointed solutions.

I frequently say that if your problems are only post-normal, you are fortunate. Otherwise, your problems can be wicked. Climate change is such a case. The crucial question is not whether the climate is changing, for it has always been changing. Rather, it is whether current changes are strong evidence of the future development of dangerous conditions necessitating immediate global-scale industrial and social transformations. For many scientists and politicians, this danger is so real and urgent that any opposition borders on the criminal. Others have reservations about the dangers for a variety of reasons. They may well be wrong, but they do not lack influence. Climate action inevitably requires government action, which inevitably raises questions about the size and role of government, national and international, about which individuals hold widely divergent views. And we will not be sure whether the danger point has been reached until it is too late, although that can be some decades into the future. In light of these inherent severe uncertainties and enormous decision stakes, climate science, in my opinion, is definitely post-normal. And since the climate debates have in practice become inseparable from culture, lifestyle, and personal commitments, they might even be classed as "wicked." Of course, all that could change at any moment if there is a breakthrough in the science, but that's part of the uncertainty!

In an increasingly interdependent world comprising layers and orbits of multiple, interacting systems—information, epidemics, commerce—is uncertainty inevitably on the rise?

Such conditions make consensus difficult, which makes recognition of uncertainty all the more critical to informed decision making. When a committee of scientific experts advises on a problem, they are expected to provide *the* answer. Science is supposed to tell us that this is good, and that is bad—this is safe, and that is dangerous. But this is not the way real science works. When scientists are presented with a challenging research problem, they know that a simple answer will not come quickly—otherwise, it wouldn't be worth their time and effort. But when presented with a challenging policy problem, which is much less amenable to a neat solution, they are expected to provide just such a simple, unique answer.

An illustrative example of this deep uncertainty, arising from the complexity of the problem, is the case of bovine tuberculosis (TB) in England. This is known to be carried by badgers—no uncertainty. But do the badgers infect the cows? We know that sometimes they sneak into the cow sheds, but whether they are a primary agent of transmission is unclear. The scientific way to find out is to remove the badgers from an area and then see if the cows there become TB-free. However, getting rid of the local badgers is, to say the least, not a feasible option. Animal lovers, including some prominent celebrities, view badger culling as murder. Farmers can't simply shoot the badgers on sight because they are a protected species under European Union law. And even if they could, experiments in tracking transmission pathways yield very different conclusions among experts. So the badger problem is in danger of passing from post-normal to wicked. Meanwhile, the cattle contract TB.

The relationship between sugar and obesity is another example. Long ago, the scientist John Yudkin concluded that too much sugar makes people fat. The nutritional establishment vehemently disagreed, and over the years, they destroyed him professionally. It was decades before the link was revisited and eventually became generally accepted in the scientific community. As I noted in my 2005 book *The No-Nonsense Guide to Science*, the Quaker principle "Remember that you might be wrong" merits embrace by all scientists.

In a world filled with uncertainty and awash in information readily available to any and all interested parties, are we headed toward more paralysis and more corruption of sound science?

Centuries ago, after the rise of the printing press, people started reading the Bible for themselves. And there, they found a story about their religion that bore very little relation to what they were told by the Church. The Reformation followed, stimulated in large measure by the printing press. Religious wars ensued, but over time, the idea of multiple faiths and laypeople's questioning of Church doctrine took root.

One of the later results of the Reformation was the rise of the scientific worldview. Science rather than Scripture became the ultimate source of certainty. Scientific expertise has become the accepted source of knowledge, not just in theories but in practical subjects like child-rearing and diet. In some ways, the accredited scientific experts have become analogous to priests in the temple; they, and only they, can deliver knowledge. Recently, theories like post-normal science and wicked problems have developed to explain how science can sometimes get it wrong. None of the philosophies of science of the previous periods even mentioned such problems as error, flawed data, and corruption, which are now too serious to be ignored. And analogous to the printing press during the Reformation, the Internet has opened up the world of knowledge as never before. What the pamphlet was for the questioning of religious or secular authority, the blog is now, and the questioned authority can be scientific as well.

Is this where citizen science comes in?

Correct. What I described earlier as post-normal science comes into play. The Citizen Science Association exemplifies this movement toward democratizing scientific inquiry, providing an inclusive process for dealing with situations in which—as I noted before—facts are uncertain, values in dispute, stakes high, and decisions urgent. And they are keenly aware of the problems of quality assurance, which in mainstream science were taken for granted for too long.

In the past, there have been occasions when radical reformers tried to change science and either failed or turned corrupt. Today, it is different. There are so many people who read, know some science, are adept at handling gadgetry, and are curious, informed observers. They engage in science through a wide array of programs, ranging from counting birds for the Cornell University ornithology program, to teaming up with environmental justice advocates and producing quality-assured numbers to support claims of illegal or unacceptable pollution. "Science of the people, by the people, and for the people" has become a new mantra of the citizen science movement.

In short, you seem to be arguing that science is too important to be left to the scientists alone. If so, what are the implications of this shift for the future of higher education and, in particular, the emergence of sustainability in university curricula?

The movement toward integrating sustainability into education is expanding. For example, a colleague of mine in Luxembourg is developing a sustainability program, including a course called "Science and Citizens Meet the Challenges of Sustainability." The course is designed to help citizens be critical, self-critical, and aware. It seeks to overcome the rigidities and fractured quality of higher education that impairs the kind of nuanced, agile thinking that post-normal science and citizen science can foster.

In traditional science education, every problem has one and only one correct solution, precise to three digits. Theories are taught dogmatically. Students who ask the "wrong" questions make themselves unpopular. In contrast to a traditional arts/humanities education, one rarely sees a science exam that requires the student to critically compare and contrast theories. Those enduring the rigors of a PhD program now tend to gravitate toward a narrow topic that is well known to the thesis advisor and researchable within a restricted time period. After years of concentrating on a narrow topic and using only certain prescribed research methods, you become a "Doctor of Philosophy."

So is modern technology opening new horizons for civic engagement in scientific inquiry?

Yes, I do think technology is enabling post-normal science. Many educated citizens may know little about uncertainty except for a passing reference in a statistics course taken decades ago. Meanwhile, most scientists are averse to dealing with deep uncertainty in the belief that it may threaten their standing among colleagues and peers as well their ability to publish. Yet when we introduce them to the quadrant rainbow framework, they embrace it. It is time to retire the doctrine of scientific certainty.

We live in a world where more people are thinking for themselves about science. In the book *How the Hippies Saved Physics: Science, Counterculture, and the Quantum Revival*, David Kaiser shows how a group of deviant physicists in the 1970s helped reorient physics by asking questions that were unanswerable using conventional research methodologies. By analogy, the "deviants" today are engaged citizens whose engagement in scientific inquiry forces scientists to think outside their comfort zone of yes/no, true/false answers, and to seek more nuanced insights into pressing issues of public concern.

What are the prospects for citizen science in the face of entrenched university interests that favor disciplinary conformity and peer-reviewed publications in specialized journals?

Your question reminds me of a worrying book by the philosopher Elijah Milgram, *The Great Endarkenment: Philosophy in an Age of Hyperspecialization*. Endarkenment is the opposite of enlightenment. The thesis of the book is that scholars are becoming more narrow, self-contained, and solipsistic. In the context of science, this means they don't know and don't care about anything other than their own tiny field, reviewing each other's papers and training each other's students to behave in the same fashion. The author sees a total disintegration of learning even without the distorting effects of external corporate influence. The result is a general deterioration of creative, integrated, systemic thinking in the academic world, a slow, degenerative process of endarkenment.

Amidst this gloomy landscape are some exceptions where radical, critical thinking is practiced. There are many vigorous initiatives within science that are combating the tendencies that degrade and corrupt scientific integrity. There are also institutions in which the new awareness of science is promoted. One example is the Joint Research Centre of the European Commission, which started off as the Nuclear Energy Research Establishment and has since become the source of scientific information and advice for the Commission. And in the Directorate-General for Research, there is an active movement for developing "open science," post-normal or citizen science by another name.

The Great Transition Initiative posits normative scenarios of the global future, an exercise that accepts and integrates uncertainty. What are the implications of post-normal science for scenario design and epistemology?

Until recently, all scenarios—normative or otherwise—have taken science for granted, assuming that science will produce invention, and invention will lead to progress. In this view, science is a force unto itself and, at the same time, is controlled for human benefit. But reality is now seen to be more complex. Important issues are contested. For example, in agriculture, we have agribusinesses like Monsanto on one side and activist movements on the other, both claiming that science is on their side. The same is true for pharmaceuticals—limitless faith in scientific advancement such as genomic medicine by some, and skepticism regarding efficacy and safety by others.

So science is integral to scenario analysis. In some scenarios, it plays a positive force in achieving a Great Transition. In others, it may contribute to degeneration and collapse. Either way, it plays a pivotal role in imagining the global future. What we can say for sure is that citizen science should play a vital role in both shaping and achieving the just and resilient future that all people of good will seek to attain.

About the Interviewee

Jerome Ravetz is a founder of the discipline of post-normal science and a leading advocate of citizen engagement in science. He is Associate Fellow at the James Martin Institute for Science, Innovation and Society at Oxford University. Formerly, he was a Reader in the History & Philosophy of Science at Leeds University and co-founder and Executive Secretary (1973–76) of the Council for Science and Society. He is the author of *Scientific Knowledge and Its Social Problems* (1971) and *The No-Nonsense Guide to Science* (2005), and the co-author (with S. O. Funtowicz) of *The Merger of Knowledge with Power* (1990) and *Uncertainty and Quality in Science for Policy* (1990).

About the Publication

Published as an Interview by the Great Transition Initiative.

Cite as Jerome Ravetz, "Democratizing Science in an Age of Uncertainty," interview by Allen White, *Great Transition Initiative* (June 2016), http://www.greattransition.org/publication/democratizing-science.

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