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Climate change and the scientific process

The integrity of the international science system has been questioned during recent and well-publicised debates about issues such as genetic modification technologies and climate change. Bringing clarity of understanding into complex systems like biological processes and atmospheric dynamics has challenged both the scientific method and its engagement with the broader community. The explosion of information available and much wider public access to it is welcome and represents much of what is great about the modern era. But it also generates issues of its own. Science is a process based on questions leading to partial answers, in turn leading to more questions and more partial answers, and so forth. In complex systems, this rarely leads to absolute certainty, but much more often to a balance of probabilities. Science-based decisions that society has to make will always rely on weighing up the risks of acting versus those of not acting. This has long been apparent in areas of public health, such as when dealing with events such as influenza epidemics.

Putting other potential agendas aside, the fundamental issue relating to climate change remains: is there a risk of a degree of climate change sufficient to affect our capacity to continue our way of life or compromise the global ecosystem? The balance of the relevant scientific literature over the past two decades suggests that there is indeed such a risk. This research has required complex approaches looking both backwards and at the present in an attempt to predict, as well as is possible, what is likely to happen. Such science is inevitably based on a mix of disciplines and types of science and, where retrospective, on data sets of variable quality (this is common across science). The issue of different types and causes of variation (e.g. solar activity) on different time scales combined with areas of uncertainty (e.g. cloud effects) adds to the problem of reducing the level of variation in prediction models. The one kind of science not available in the climate change domain which would be used in other domains to greatly increase the certainty of prediction is empirical experiment – in this field, we can only observe, model, and evaluate iteratively.

There can be no doubt that the impact of our species on the planet continues to escalate, and the world has no choice but to confront issues arising from the extraordinarily rapid population growth and technological advancements of the past few decades: those issues include food security, water and energy supply, human health, changing demographics and changing climate. Each of these interconnected issues has geopolitical, economic and social implications, and in each the scientific community cannot stand aloof. In short, scientists and society must work together if catastrophe is to be avoided.

My own views on how science and society must work together were considerably influenced by Michael Gibbons' paper "Science's new social contract with society" published in the millennial issue of the world's leading science journal *Nature* in 1999. Gibbons argues that scientific knowledge must be "socially robust" and that society must both understand and participate in its production. Clearly this is particularly relevant to the issues now being raised around the working practices of the Intergovernmental Panel on Climate Change (IPCC), but it must be remembered that the IPCC itself is a novel way by which the scientific community is attempting to address an extraordinarily complex set of interacting questions across multiple disciplines. There is no excuse whatsoever for sloppiness or inexactitude in the work of the IPCC, but those in society who are sceptical of its conclusions should accept that their arguments must be subject to the same level of critical examination. A major part of the scientific process is to identify poor science through peer review.

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Peer review itself is not perfect, but replication, evaluation and open access to data are all components of how science advances and self-corrects. That is what distinguishes the scientific method from simple assertation. The behaviour of some scientists has also come, quite appropriately, into question. Science has always had to deal with such matters – science is, after all, a human activity. But since the IPCC report was published, more data has emerged supporting its conclusions and the few but highly publicised flaws not identified by the IPCC process do not change its view on future scenarios and thus on the basic policy decisions that have to be made.

Some of my colleagues who have roles at the interface between science and policy have also given their support to the process and conclusions of the IPCC while acknowledging that deficiencies in a small component of the Panel's data should not have occurred. The Chief Scientist for Australia, Penny Sackett, discussed the importance of the scientific peer review process for the robustness of climate change data.

In an interview with *The Times*, John Beddington, who is the Chief Scientific Adviser to the UK Government, highlighted the importance of proper societal engagement and was critical of the recently publicised sloppy and closed procedures of some climate scientists. However, to quote Professor Beddington: "Uncertainty about some aspects of climate science should not be used as an excuse for inaction. Some people ask why we should act when scientists say they are only ninety per cent certain about the problem. But would you get on a plane that had a ten per cent chance of landing?" Echoing Professor Sackett's comments, Steven Chu, President Obama's Energy Secretary, commented to the *Financial Times* that "the core of science is deeply self checking" (*registration required*). I would concur with these sentiments.

While the world has previously undergone changes both in atmospheric gases and in climate, significant events have not occurred in the last 10,000 years during which humans have transitioned from being a miniscule part of the biosystem to one of the largest components of animal biomass. At the same time, the way we live has changed drastically. The world's climate is changing faster and in a different manner to what has happened previously. There is an overwhelming view, notwithstanding the difficulties of the science, that this is related to human activity. Based on what we know, this change appears highly likely to impact on our capacity to live in the way we have come to expect.

Although the risk to our future of not acting now is real, the scientific community has had and is having difficulty communicating both its uncertainty and the absolute need for action simultaneously. In the long term, technological solutions will help us both mitigate and adapt to a changed climate, but because the nature of the prediction suggests early action is needed other approaches to incentivise a reduction in emissions are being introduced worldwide. The ensuing political and economic debate on how best to respond to climate change should not be used as an excuse to gamble the planet's future against the overwhelming evidence that humans are contributing to the world warming at an unsafe rate. The basic principle is no different to risk management in any other sphere of life.

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