THE ROYAL SOCIETY

Reimagining science
Core values of science

Synthesis of the event held on 6 February 2020

Introduction
Reimagining science is an ambitious Royal Society programme trying to change people's perceptions of and engagement with science. This is a synthesis of the second event in the series, looking at the core values of science and their role in meeting this challenge.

The values identified and described in this note may not always be obvious, but they underpin the entire scientific endeavour. They shed light on the science already around and within us – its beauty, messiness and accessibility to all. The values of science are truly democratic and *Reimagining science* hopes for the epistemic privilege, so often gifted to scientists, to be more widely shared.

Types of knowledge

Continuous change
From religiously motivated astronomy and the applied science of the Islamic empire to the birth of modern chemistry in the service of industry, the reasons why science is done, what science is for, and the values that underpin science continuously change throughout history. The scientific endeavour today is incredibly broad – although often narrowly framed and rewarded – and it is important to acknowledge and celebrate its many facets and motivations.

Pluralism
A straightforward, unifying narrative would say that the overarching goal of science is to produce knowledge. The traditional scientific community might side with Karl Popper in the view that science is a move to some form of more complete knowledge. However, this view may be a little too simplistic. Contemporary debates can encourage polarised views: one must either embrace a dogmatic, positivist view that there is one truth and one answer only, or go down the slippery slope of relativism, where everything is a social construct. Such a divide exacerbates, rather than bridges C.P. Snow's *Two Cultures* divide[1].

Presenting science as the ahistorical pursuit of an absolute truth is misleading. Such an absolutist view implies that complex problems have just one answer when, in fact, different sorts of explanations are needed for different sorts of problems. Science is a collective achievement and diversity and pluralism are the driving engine behind this.

Epistemic vs non-epistemic values
Philosophers of science have often drawn a distinction between epistemic values and non-epistemic values. Epistemic values are those with obvious links to the generation of knowledge such as predictive accuracy or coherence with existing theory. Non-epistemic values are those that do not have such obvious links: social values, political values, ethical values.

Whilst epistemic values might be more strongly associated with academic scientists, as a community it is important to have wider shared values. Various forms of tolerance, respect for diversity and open communication are all important ways of furthering the community goal of producing knowledge.

1. Snow CP. 1959 *The Two Cultures*. Cambridge, UK: Cambridge University.

Analogy and metaphor

Scientists rely on analogy and metaphor to make sense of scientific phenomena and communicate their findings to each other and diverse publics. Social, economic, political and cultural influences all shape how we see the world. Having a range of different perspectives is particularly useful when tackling complex problems both in science and society.

Many of the arguments Darwin used in *On the origin of species* draw on economic metaphors. Darwin was steeped in a capitalist culture and assertions about the division of labour leading to more value overall were used as a way of explaining why species diversify. Capital tinted spectacles enabled Darwin to see things that his predecessors had not.

Systems of science

The science environment

Science is shaped by its environment. The economic structure and incentives within which science and scientists function is important. This 'sociology of science' is what determines how money is allocated, where it comes from, what work or behaviour is rewarded, and what is punished. It shapes what scientists do and how they work, whatever their individual motivations.

How do you measure a scientist?

Modern systems of science operate according to a narrow definition of what 'good science' is and what a 'good scientist' looks like. This framing does not include being wrong. It does not include finding out nothing, nor does it leave room for uncertainty and doubt. It also undervalues listening to others, joining up bits of evidence from potentially very different disciplines and working to maximise the benefits to the economy, environment or society. These are all extraordinarily important parts of being a scientist and the narrow metrics against which scientists are judged crush diversity of all kinds in science.

Currently, there are two key ways scientists are judged: the work they have published in scientific journals, with the journal in which the work is published often acting as a proxy for quality, and to a lesser extent, how their work fits into the 'impact agenda'.

Journals

Whilst the prestige of a journal is technically no longer factored into how scientists are judged, the culture is slow to catch up and competition to be published in journals with the highest 'impact factor' is fierce. However, the assumption that the 'best' science gets published in the 'best' journals is flawed and it creates perverse incentives. For example, scientists may tailor their research to improve the chances of getting published in the most prestigious journals, often to the detriment of science itself.

Impact agenda

Whilst the aims of the impact agenda are admirable, it has some unintended consequences. In the rush to create or prove impact, researchers are confronted with stark moral choices relating to how they report their findings. For many, it is hard to demonstrate whether research can translate into a specific outcome and this is often not known until long after it is done, sometimes being picked up in a completely different and unexpected discipline many years later. The constant pressure to demonstrate a linear path to impact is forcing academics to reverse engineer how their work is going to have impact on the world. Often, it is not the individual project that results in the most significant impact, but the tie-ups and networks and 'glue' in the community that helps position that project within its wider context.

Economist David Galenson[2] studied what career stage people were at when they produced their most important work. Using Picasso and Cézanne as examples, he showed that some build their skills slowly over their careers, with piecemeal innovations emerging later on as part of a body of work (Cézanne). For others it happens early on in their career when they are quite young, breaking the mould and doing things completely differently (Picasso). A strong science culture should help everyone to thrive, yet the current science environment tends to reward those who satisfy a narrow set of metrics.

Education

The limits of a single approach to science education need to be recognised. In the medieval curriculum things were framed differently; for example, music was automatically set alongside geometry, arithmetic and astronomy. Nowadays, rather than an exciting journey of discovery, science is often pitched as a difficult subject where robotic geniuses succeed by memorising facts. This does not set up students well for life once their formal education is complete, where there is rarely a single, correct answer to life's questions. Those who teach

2. Galenson D. 2015. *Old Masters and Young Geniuses: The Two Life Cycles of Artistic Creativity*. Princeton, USA: Princeton University Press.

undergraduates note how often students who have completed A-levels have a different orientation towards knowledge compared to those who have studied in alternative education systems. To solve problems in a more complete and rounded way, people must take different perspectives. This means students should receive a broad, balanced and connected education, where the arts and humanities are perceived as just as important as science, and where the active connections between disciplines are evidenced.

Interdisciplinarity

When it comes to frontier research in a discipline, or getting promoted in academia, high degrees of specialisation are incredibly useful. However, strong divisions of labour in the name of thoroughness mean important, hybrid questions get overlooked. Inside the system, so much is mapped onto the individual that notions of collective responsibility and the value of deep collaboration risk being lost.

Our entire education system is geared towards greater and greater specialisation. For all but a small minority of students, education is a platform for the rest of their lives, outside specific academic disciplines. For them, the interdisciplinary habits of perspective-taking and mental complexity will have lifelong personal and instrumental value.

Some institutions are starting to embrace interdisciplinarity, despite swathes of the system being set up against it. There is a realisation that academics can be equally specialist by directing their specialism across conventional departments, rather than simply focussing on the traditional realm of their subject. This is most effective when it emerges from bottom-up initiatives, allowing everyone to create their own unique connections according to their own preferences, skills and experience.

Sceptics, rhetoric and debate

Science communication

In science communication, the ‘deficit model’ assumes that gaps between scientists and the public are the result of a lack of information or knowledge: ‘if scientists could only provide people with the right facts, everything would be ok’. This is overly simplistic. It conflates knowledge of scientific facts, with lay knowledge of how science and technology operate in people’s lives, excluding the latter. Lay knowledge is not an impoverished or quantitatively inferior version of expert knowledge; it is qualitatively different.

Language

There are several dichotomies and challenges in the ways scientists use language. On the one hand, scientists use the theological language of ‘believing in’ their findings, while on the other hand passionate, enthused and romantic language is often dismissed as unobjective and hence unscientific. Plain, simple and clear language, with the removal of the first person and active voice, can helpfully reduce subjectivity, but can also contribute to the robotic image of scientists. In addition, excessive jargon can ostracise those without the requisite education.

A source of answers

Science receives more epistemic privilege than ever before. Large numbers of people think that science surpasses other kinds of knowledge in all sorts of realms, and there is a deeply embedded notion that there are somehow magic linear unitary solutions to all of the world’s problems.

The associated triumphalist image of scientists as rational geniuses on the path to the truth is very comforting – ‘science is going to solve it, it’ll be fine’ – but also very misleading.

Being wrong

Contrary to this, there are others who are doubtful about science. Michael Gove’s (in)famous ‘experts’ quote is often cut short and should read: “people in this country have had enough of experts… saying that they know what is best and getting it consistently wrong”. The problem is that being wrong is a fundamental part of science. Scientists have an important role to play in communicating this publicly, especially when making recommendations that will impact others.

Sceptics

Scepticism is an important facet of the scientific ethos. However, it is currently being hijacked and used as a tool in the cacophony of public debate. Anyone who finds a set of results disagreeable to their ideological antecedents can simply claim scepticism and demand more conclusive evidence. This can discourage scientists from admitting any hint of doubt or uncertainty in their work, despite these being core values of science. This compounds the problems associated with “saying that they know what is best and getting it consistently wrong”.

Rhetoric

When communicating in the media, scientists rarely allow themselves to enter broader discussions beyond factually based arguments. Meanwhile, those scientists communicating data are often pitched against perfectly respectable, value-based arguments, to which the data has no answers. Recent studies suggest that if you try to provide evidence to support your view against someone who holds a different view, it causes the opposite effect and they become even more entrenched. Scientists need to be able to engage with values-based arguments just as much as others need to engage with what the data really show, and rhetoric can be a powerful starting point and common ground for such debates.

Good judgement

When is it suitable for science to move out of the laboratory and into the public realm? When is something adequately proven to be acceptably safe and effective, and when does it need more theoretical work, research or trials? Good judgment is required to answer these questions. This means setting the right evidential threshold, thinking about the costs of making various kinds of mistakes, but also potentially delaying the benefits which were originally intended.

A balancing act is required to decide which of these kinds of errors may be likely and which would have the most moral weight associated with it. It requires knowing how to listen to people and knowing how to join up bits of evidence from potentially very different disciplines. This is exceptionally difficult to do and requires a great deal of humility, intellectual generosity and interpretive charity.

Concluding remarks

There was a general sense over the day that the values discussed are widely shared, but perhaps the systems in which science sits have yet to catch up. It was also noted that the understanding and appreciation of science is an ongoing campaign, and not something that can simply be won or ticked off as ‘done’.

The following are a very subjective selection of potential ideas and questions raised to help set future agendas amongst those with an interest in the values of science, and perhaps to inform the next phase of the *Reimagining science* programme.

- Should the Royal Society rebuild the relationship between science and rhetoric?
- What can the Royal Society do to help build environments where everybody feels like they can contribute, with science as a partner and not as a dominator?
- What can be done to remove the arbitrary barriers that block or end so many science careers?
- How can the things that define the scientific method be better used and communicated in public life?
- How can science be more like music, where one does not need to know much to listen to it and feel connected to it?
- How can we educate so that everyone might be, at least a little, scientific?