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Trusting the scientist

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We live in a world that is often characterised as a post-trust society (1), in which the processes of societal decision-making and public reasoning have been dramatically changed by access to much more information and opinion via a variety of new media, and this content is of highly variable reliability. With this nearly boundless access to news and information, many of the claims and counterclaims about science can be conflicting and confusing, and they can be manipulated by many stakeholders, including scientists themselves, for particular goals.

Yet at the same time, there has never been a more urgent need and expectation for an active role for applying scientific knowledge and expertise in the processes of developing societal consensus, of governing, and of law-making. Indeed, virtually every major challenge a society such as ours faces today requires increasingly sophisticated scientific input, from the physical, natural, or social sciences. While it is clear that science alone cannot provide answers to societal and environmental challenges, it does provide a broader and more knowledgeable view of the various options. As such, it has truly become an essential tool of democracy.

So how do we reconcile these tensions and ensure an appropriate place for science and scientists in societal decision-making and public policy-making where they must have a critical role? First, we must acknowledge the challenges that arise when science is made a deliberate tool of public governance processes, which are inherently normative and values-rich. The methods that are designed to protect – to the extent possible – the objectivity and scepticism of science give scientifically derived knowledge a privileged place among epistemologies, but this does not mean that such knowledge will or should trump other inputs into policy decisions. There are many more dimensions to public decision-making than science alone, even if there are situations where the science is complete, which it almost never can be.

Increasingly democracies around the world are seeking ways to ensure the appropriate insertion of science-derived evidence into informing the policy process. However, as this paper will emphasise, and I have previously discussed (2), the use of science within the policy process and indeed within public decision-making is intimately related to the concept of trust.

The essence of the scientific method and the broader processes of science (peer review, publication, replication) which ultimately define it, are designed to provide relatively reliable information through validation and evaluation. In these processes a key element is the focus on objective collection and evaluation of data in an unbiased and as relatively values-free a way as possible. That is not to say that science is free of values; certainly the application of science by society must always be a values-rich judgement. But science is in a different league relative to other epistemologies because it tries to keep separate the processes of knowledge production and the values-based dimensions of knowledge use, more than any other epistemological tradition can - or would - wish to.

This is the key distinction based on which we can legitimately argue for the privileged place for science in informing decision-making. But ultimately that privilege is based on trust in the science, trust in the scientist, and trust in the communication of what science suggests we know and do not know about an issue. Thus if we are to expect science to play a more central role in societal decision-making, either informally or more formally via the policy process, we need to consider one key question: How do we ensure the scientific community can identify and address those issues that have the potential to undermine trust?

In this paper, I argue that this is best done by science reflecting on science's core processes, by adhering to those features that distinguish science from other epistemologies, and by being consistent in recognising and labelling our own limits and biases as scientists. Above all, it is by recognising that the trust – of the public, policy makers, politicians, and professional peers – in science must be earned and actively maintained.

This is not always easy in a competitive professional and funding environment which privileges independence and peer recognition. And yet, now more than ever, we must be cognisant of our public role as scientists and the public expectations that

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this carries. The social contract for science continues to change dramatically, and we scientists should be actively involved in its reshaping. Scientists must be better prepared to engage with the public, but they must also be cognisant of how they do so and the potential consequences of different approaches to that engagement.

History of the public scientist

It is instructive here to consider how the *public* role of science has evolved. For much of western history beyond the classical period, the answer is a simple one: if such a role existed at all, it was rare, informal, individualistic, and episodic. Or so it was, at least until after the Second World War, and even then it was rather limited until perhaps the late 1980s. Until then (and to some extent still today), the scientist with a media profile was too often deprecated by his or her colleagues.

In the 17th and 18th centuries, the 'professional scientist' was non-existent. Scientists were amateurs and tinkerers, often of the leisure class or having a patron who would fund their idiosyncratic hobby. To be sure, universities existed, but far from being hotbeds of scientific exploration and knowledge production that we like to see them as today, they were in fact the conservative bastions of tradition, and of faith, and generally treated scholarship as received wisdom.

It was not until the late 18th and early 19th centuries that we see the advent of the professional scientist, a term invented by William Whewell in 1833. This was the beginning of the period that, over the next fifty years, saw immense global activity in truly developing the research university in Europe and refining the accepted norms and operational standards of science as a self-regulating activity. At this point, science began developing some characteristics of a profession, although it never has established the formalised entry procedures and regulatory rules of more traditional professions. It is on the basis of these enduring norms and standards, however, that society effectively built its trust in science. This is the period so famously described by sociologist Robert Merton (3), a founding father of Science Studies, whose initial vision was of an autonomous culture of science, standing apart from the rest of society, while also instructing it. One hopes that this patronising view, which placed science on a pedestal for much of the last 100 years, is an attitude of the past. But that does not stop it from being a tempting characterisation that scientists can easily revert to.

About 100 years ago saw the start of the public funding of science as we know it today. The 1918 Haldane report (4) in the UK, while foundational to the way science has largely evolved free of political interference, also reinforced the separation between science and society in western countries. It established scientists' science-centric view about how decisions on science policy should be made – something that is now being increasingly challenged as science has entered into a different relationship with society

This new relationship only started in the mid to late 20th century. War-time and post-war science ushered in the concept of 'Big Science', which was about big public infrastructure, *technical* grand challenges (putting a man on the moon), and eventually about speeding up and globalising scientific production, with the birth of accessible computing and then the Internet. These trends changed how the public perceived science and in turn led to the kinds of funding structures by which taxpayers' resources were committed to support public scientists in universities and research institutions. The modern funding instruments for public science that we are familiar with were established over this period. As post-war science evolved, so too did an explosion of disciplines and sub-disciplines within the biological, environmental, medical and social sciences, where the relevance of the science to citizens was immediately obvious and vital. But as computational power increased, and the study of complex systems grew, particularly in areas of biological and environmental science, some fundamental changes emerged in the perception, application, and nature of science.

We are now in the age of *post-normal science* (5). This is characterised by new and unprecedented operational and methodological realities and an opening up of science to embrace uncertainties, contingencies, interdisciplinary approaches and the *co-production of knowledge* (see below). It is also characterised by science being called upon to address or contribute to issues where the societal values are often in significant dispute. But in doing all this, it has been important to protect and uphold the standards and practices that make science trustworthy in the first place, even while it is inherently embedded in larger societal processes.

So what can we learn from this woefully abridged overview of the history of science as it relates to society? Cliché though it may be, by understanding our journey, we can better see where we are and we can understand that the place of science in society is dynamic and continues to evolve. Indeed we are all actively involved in shaping it as much as it is shaping us as scientists. It is easy to forget that public science systems have not been fixed but have themselves changed dramatically in the last 50 years. As I have described elsewhere (6), public science systems are now undergoing a period of particular instability and change driven by both extrinsic and intrinsic factors. Scientists will both have to play a role in designing these changes by responding to the challenges that have emerged, but will also have to accept that significant change is inevitable.

The brief appeal to history also serves to remind us that any scientist practising today, depending on their age, either has lived through an unprecedented transition in the way that science interacts with society (including through public policy and industry), or has been professionally 'born into' this structure and therefore may take the current arrangements and relationships for granted. The older group may be indignant about the new societal demands foisted upon science, and the younger group may simply not see what is now happening for the revolution that it is. Either way, as scientists we are not prone to voluntarily unpack or research our system and truly understand its imperatives, its opportunities, and – indeed – its challenges.

Challenges to science

Two of those challenges are the evolving, highly contextual and potentially conflicting perceptions of the role of the public 'expert' on one hand and the public's attitude toward science on the other. At times there is public scepticism towards new and controversial technologies. At other times there is high public support for more science-informed decision-making in the public sphere. Sometimes these can be in overt conflict even for the same individual – some science may be accepted by an individual to address one issue but rejected to address another. Indeed this paradox has been much commented on in relation to political ideologies and reflects the challenges of pre-existing cognitive biases that filter how science is perceived. But despite this reality, the emerging public role of science means

that it is now a critical public and political resource across the ideological spectrum. It is these dynamics that complicate trust in the scientific enterprise.

I generally use the definition of science that social anthropologist Jonathan Marks (7) formulated in his book, *Why I am not a scientist.* Marks, among others, suggests that science provides the only processes by which we can gather relatively reliable information about our world. It is important to note that this definition views science as a set of processes, not facts, and accepts that science cannot provide all the answers. Protecting and promulgating the integrity of these processes is *the* key feature that legitimates the expertise of the scientist.

Yet the concept of 'expertise' is not immune to critical questioning. How do we know when scientists have attained it in sufficient measure so as to advise others? How can we ascertain its boundaries when we speak about our work to non-scientists? Jurgen Habermas (8) was the first to analyse the problematics of expertise. Curiously, much of the sociology that followed Habermas' work served to critique the role of the public expert, even calling this out as elitist and counterproductive to democracy. This is perhaps not surprising for 1960s' sociology, but this research did have the effect of ushering in a wider academic and public interest in the role of the expert. Among the influential empirical studies (9) that followed throughout the 1980s were those that began to view the legitimacy of expert advice as a combination of *authority*, built on access to specialised knowledge, and – importantly – *trust*.

In building and maintaining trust, the two concepts introduced earlier stand out and, I think, really shape the way we should think about our jobs as scientists today. These are the rise of post-normal science and the shift to knowledge co-production.

Post-normal science, first defined by Ravetz & Funtowicz (10) in the early 1990s, describes much of the public- and policy-facing science we know today, where complex and interdependent systems and feedbacks, uncertainties, and probabilistic rather than mechanistic approaches are commonplace. It is also characterised by research in areas of high public interest, disputed values, and political urgency. Social issues, climate change, and biodiversity are all examples of post-normal science. Virtually every issue of public and political contention in which science is involved fits this classification. Indeed, as science has engaged with more complex issues as a result of both analytical and computational progress, it becomes increasingly post-normal.

It is inevitably complicated and challenging to communicate legitimate expertise in the context of post-normal science. It is too easy for uncertainties to be exploited to support an ideological position or for information to be cherry-picked to support biases. And as the science of communication and decision-making becomes clearer, we understand that cognitive biases (11) are not easily overcome by simply presenting the evidence; indeed doing so can have the opposite effect. There is growing recognition that it is important to explain the processes underpinning the development of a scientific consensus and thus pull the audience into the process, rather than simply conveying results.

This brings us to the second feature of the state of our emerging understanding of science systems today – that of knowledge co-production. This is a concept originating with Science and Technology Scholars, notably Sheila Jasanoff (12), which recognises that the institutions of science and those of society are actively and inevitably shaping one another. We live in a world increasingly defined by the products of science, which offers both challenges and solutions. But science and technology are themselves influenced by social, cultural and political institutions – and so it goes on in a continual iterative cycle. The better we understand this process, the more able we are to be deliberate about the establishment and maintenance of trust in science.

This means making a space for the public voice in the scientific enterprise. Most commonly, this is done through elected public representatives involved in setting the research agenda through establishing policy for science. But experiments in more deliberative approaches, such as the consultation involved in setting the National Science Challenges in 2013, suggest other ways in which a range of voices can be incorporated. Indeed at a more grassroots level, we are seeing an increasing use of deliberative public dialogues taking place around the world engaging with controversial questions with science at their heart. Thus co-production also means working with knowledge end-users to make our science useful and listening carefully to public discourse about technology and social licences, among other things.

Thus, key to all of this work is to clearly delineate the role of science and the role of public values. In her book *Science Policy and the Values Free Ideal*, Heather Douglas (13) points out that science can never be values-free because there are some critical points where values must enter into the production of knowledge: what to ask; how to ask it; the ethics surrounding it; and the judgment needed to assess whether there is a sufficiency of evidence on which to reach a conclusion or take action. None of these steps is the domain of the scientist alone. But scientists must protect as much as possible from their own and anyone else's values the collection and analysis of data and the robust formal processes of science. Even in the context of today's post-normal science, the enduring standards of the scientific process and the checks and balances of rigorous peer review are what give science its legitimacy and secure its privileged place among epistemologies. These processes are the foundation of public trust in science.

But while the core processes of science are designed to minimise the impact of values, the acceptance and application of science by society is rightly values-rich. Indeed the issue of 'social licence' for scientific and technological innovation is enormous, yet beyond the social sciences, much of the scientific community has been insufficiently attentive to this concern. The greater public access to science-based knowledge has allowed for far better societal conversation, but the quality of that conversation is highly variable depending on how it is conducted. Too often, science can be co-opted as a proxy for a values-based debate rather than informing the public discussion on contentious topics. Such tactics render impossible any meaningful engagement about the uses and limits of technologies and the inevitable trade-offs that must be considered. In addition, the consequences of silence or misinformation are ongoing and compounded because science and technology are an ever-refining process. Thus, if discussions about the uses and limits of any technology do not involve a civil, informed and specific discussion on the technology *per se*, the capacity of a society to actively consider revisions to any position taken as the technology evolves and knowledge matures becomes more limited too.

The core theme of the 2015 NZAS annual meeting (and the impetus for this paper) was fundamentally one of the communication of science to society and the rights and responsibilities of scientists in that process. Here the very nuanced boundary between the appropriate values-free (as possible) *content* of science and the essentially values-driven *use* of science create real challenges for scientists (both as professionals and as private individuals) and the publics they ultimately serve. And this creates major issues in thinking about trust in science and scientists.

Trust is fragile. Sloppy or fraudulent science or the misapplication of science without regard for social licence increasingly gets media attention. This, combined with societal responses to the pace of technological change and the online ease of access to pseudo-science, leads to a sizable percentage of the population developing unease or frank distrust of science.

The recent public opinion survey commissioned by the Ministry of Business, Innovation and Employment (14) (and similar surveys internationally) shows that, while the majority of respondents consider science to be important, nearly half think the science they hear about is too complicated or, worse, that it is too contradictory to understand. In my role I have to address some of these issues. No matter what the science says about fluoride or vaccines or genetic technologies, for instance, some technologies will always be rejected by some in the population for a variety of philosophical and other reasons.

To be sure, society must have a right to override science in restricting the use of any technology but society is best served when rhetoric and hyperbole does not drown out either the measured and evolving scientific discussion or its ability to properly inform public debate. But the nature of the modern media and issues-based advocacy is such that the very issues that should be discussed dispassionately are often not.

This is perhaps most exemplified in the shifting use of the meaning of precaution and the precautionary principle, from the original concept of adaptive management of risks based on our growing knowledge base, to one of total inaction. The French Science Technology Studies scholar Michel Callon (15) and his colleagues first illuminated this usage shift some fifteen years ago, reminding us that the precautionary principle is a framework for measured action not abstention, while on-going science continues to reduce uncertainties. But its strategic misuse by all sides of ideological debates can entrench polarised positions in which science is co-opted in ways that both undermine public confidence in science and limit its future value to society.

The public scientist

In finding a way through this, it is helpful to recall the four types of interaction between scientist and society that Roger Pielke (16) described in *The Honest Broker*. I will focus on the two outward-facing constructs: the Issue Advocate and the Honest Broker. Although these type-constructs have been criticised for essentialising and over-simplifying very complex and contextualised roles, they remain useful heuristics in illustrating the different ways in which scientists can and do engage with the public and the policy process.

The 'Issue Advocate' is the scientist who collects and presents data with a view to servicing a cause. While it should be incumbent on such a person to apply standard scientific practice and to reflect the scientific consensus, conscious or unconscious filtering can often occur such that the scientific argument fairly or unfairly directs a particular course of action. Yet the Issue Advocate is the role that many scientists can and should play in the public arena. And it is indeed an important role in elevating issues in the public mind. For example such advocacy has been a critical element in elevating climate change and other environmental issues in the public and political consciousness. Indeed scientists, particularly academic scientists acting in their role as 'critics and consciences of society,' which is legislatively protected in New Zealand, are a critical part of the democratic process.

However, difficulty arises when the distinction is lost between presenting the scientific consensus and actively advocating by moving beyond the conveyance and contextualisation of scientific results based on the data. These lines are especially blurry when a scientist of considerable public 'mana' is seen to support one course of action over another. Similarly some advocates will deliberately use their scientist status to give greater weight to their views, even on issues outside their own area of study. This conflation can compromise the integrity of science more broadly, and undermine the possibility of its potentially privileged status as input into policy.

But the richness of a democracy is that scientists are of course also citizens with absolute rights as citizens to be active and engaged actors in issues about which they feel strongly. The challenge is to manage the tension that may arise between their private and public faces as both citizens and scientists. This is a matter that a number of bodies concerned with the integrity of science have recently turned their attention to and is discussed below.

The Honest Broker, as defined by Pielke, tries to identify and overcome biases to present what is known, what is not known, what is the scientific consensus, what are the implications for policy and action, and the trade-offs of various options. This is the role that science advisors to governments are expected to take, whether they are committees or individuals.

Distinctions such as that between the Issue Advocate and the Honest Broker are not new. What is new, perhaps, is how important they have become to the wider public discourse. One measure of their public salience is the recent cover story by the American popular magazine, the *National Geographic* , dealing with public mistrust of science. In this piece *Washington Post* science writer Joel Achenbach (17) highlights the thoughts of noted science communicator, Liz Neeley:

> *Some environmental activists want scientists to emerge from their ivory towers and get more involved in policy battles. Any scientist going that route needs to do so carefully. That line between science communication and advocacy is very hard to step back from. In the debate over climate change the central allegation of the skeptics is that the science saying it's real and a serious threat is politically tinged, driven by environmental activism and not hard data. That is not true and it slanders honest scientists. But it becomes more likely to be seen as plausible if scientists go beyond their professional expertise and begin advocating specific policies.*

The New Zealand situation

So with this in mind let us reflect on the various types of scientist/societal interactions that are operating within the New Zealand science community. In this, it is important to recognise

the multiple roles of scientists and their relative positioning within the public science system.

For those such as myself and the growing number of departmental science advisors, our roles and obligations as Honest Brokers are clear whether we operate alone, within committees, or by establishing working groups to address particular questions more deliberatively. The latter is a model that we have adopted recently with the Royal Society of New Zealand, for example in our report on water fluoridation. I will not comment on those roles further as they are well described elsewhere (18) except to note here that the primary role of my Office is to improve the use of evidence in policy formation and the use of science to benefit New Zealand's interests rather than to advance the interests of the science community *per se*. This is a distinction that is not always fully appreciated.

Then there are the many scientists employed within government departments and Crown agencies – primarily in entities such as the Department of Conservation, the Environmental Protection Authority, and the Ministry for Primary Industries – who deal with policy and regulatory science and may also conduct or commission research. By virtue of their employment, such individuals are bound by the rules of the State Services that generally require the consent of management to communicate as employees outside of their workplace. This has some implications as to how their research can be communicated to the public, but provided they are acting as Honest Brokers, such communication is to be encouraged. There appears to be a worrisome trend in some countries in the opposite direction, but codifying the honest brokerage approach should be sufficient protection in virtually all cases other than those of national security. Of course, in releasing such information, the sensitivities of the policy process must be respected. Indeed, some agencies such as Department of Conservation encourage their staff to be part of the scientific community and promote openly their scientific conservation efforts. Fundamentally, however, no civil service gives employees the right to be free agents outside their employment on the very matters they are employed to deal with. This is normative in the operation of a public service.

University academics, for their part, are in quite a different position. While members of the wider State sector, they operate under the principle of academic freedom that is enshrined in New Zealand law within the role of the university. However, this principle has its own parameters. The notion of academic freedom is the pursuit of a line of intellectual enquiry and comment unfettered except by the provisions of research ethics and scientific integrity. Yet the function of peer review ensures that even academic freedom has (indeed must have) its own bounds; it is a privilege extended on the basis of individual expertise. Society treasures that academic freedom and in general university staff have neither abused it nor ignored it. As a result the excellent profile of many academics in the media is well deserved. The only caveat I would make is the growing evidence that university press offices tend to over-hype research success stories to benefit the institution, which can undermine confidence in the science and the scientist.

Academics are also increasingly being engaged by governments in advisory processes and clearly this is highly desirable for a well-functioning democracy. But it is important that any academics speaking out to government or the public delineate the limits of their expertise. When I am asked to advise on specific issues, I identify the subject-matter experts and serve as a conduit for translating the relevant information to the government. But importantly there needs to be consistency between what individual academics say in public and when part of an advisory process. Where there is inconsistency, distrust rapidly arises, particularly for the policy audience.

Perhaps the biggest emergent issue for the academic, however, is that of real or perceived conflicts of interest. These exist everywhere, but are particularly apparent in small countries. Most can be easily handled in a transparent manner. But the conflicts that create most difficulty are those that arise because of sources of funding – whether from the private sector or from civil society organisations. Transparency is critical but there is no doubt that the increasing drive worldwide to engage the private sector with universities is creating tensions. Arguably, less attention has been paid to scientists who are supported by issues-based NGOs (non-governmental organisations). But this too gives rise to conflicts, and increasingly journals are expecting such interests to also be declared.

This whole area is complex and the increasing dependence of all academics on co-funding means that these issues provide an easy target for criticism which is sometimes justified and sometimes not. Parts of the academic community remain suspicious about the quality of science produced in partnership with the private sector. This is a mistaken generalisation. Indeed, such research has long been shown to consistently be among the most highly cited in peer-reviewed journals (19). It will require on-going discussion within the community of scholars and with civil society to get beyond kneejerk reactions and find pragmatic and transparent realistic solutions.

For instance, many university-based researchers also have partnerships with the private sector supported by contracts. Many such academics have shown that it is possible to be open communicators without compromising these contracts, which may establish some parameters for limiting public communication until patents are filed. But university technology transfer offices generally are very good at minimising those clauses that limit communication, and beyond this, universities leave decisions over public communication of science to individual academics.

New Zealand is unusual in that half of its publically funded scientists operate in government-owned research institutes (Crown research institutes) outside the tertiary education sector. Excluding defence-related activities, equivalent arrangements in many democracies are generally far more modest, though there are exceptions within Europe. Here again, history is instructive: New Zealand science largely occurred within the Department of Scientific and Industrial Research (DSIR) until our universities in the 1960s and 70s started to offer research-based degrees. DSIR and then its offspring, the CRIs, were designed to prioritise the research effort in areas where the universities were not seen to have a primary role. But what was and remains unusual was that in 1992, when the DSIR was replaced by the CRIs, the CRIs were set up as state-owned *companies* but with the multiple missions of conducting public good research, supporting and assisting private sector research, and making a return on investment. This range of roles can create on-going tensions and angst.

It is understandable that some CRI employees would prefer to operate under the same rules as academic staff, but the mission

and operational modalities of CRIs and universities are quite different. As company employees, CRI staff have different roles from those within the Universities Act for they do not operate under the umbrella of enshrined academic freedom. Amongst other considerations this means in effect less autonomy over public communication by scientists in CRIs. But whether these restrictions are necessary to the extent that some managers and boards require is another matter. Again the honest brokerage approach should give some guidance particularly for those areas of research not encompassed within private sector contracts. Indeed the environmentally focused CRIs have tended to be more open in their communications approach overall. Given that many of our scientists are employed in CRIs and in areas of high public interest, this matter of open communication is an issue that really merits reflection. But in so doing, let us also remember that the practices governing the conduct of CRI scientists were adopted directly from predecessor agencies. The rules have not changed. What has changed is the nature of the relationship between science and society and the societal context in which CRIs operate.

Have some CRI managers become too risk-averse in managing the public role of CRIs? Should they encourage their staff to engage more in public communication, particularly in the role of honest broker? As I understand it, the issue seems to be an assumption that enhanced public communication could harm the ability to win commercial contracts or contracts from the Crown. Yet there is no fundamental reason why this should be the case provided that sensitivities are appropriately handled and contextualised, as has been done by University Technology Transfer Offices.

Thus, while CRI management would likely take issue with a staff member acting as an advocate from within their professional position, there is real merit in a constructive dialogue with CRI management over enhancing the public sharing of expertise in an honest brokerage model. I have started a discussion with Science New Zealand, the organisation which represents the CRIs (20), on how we might make progress on this matter.

Crises and emergencies

Crises and emergencies are a special case, and here the responsibilities and obligations of science to society become particularly acute. As UK Science Adviser Sir Mark Walport pointed out in his address to the global meeting on science advice to governments held in Auckland last August (21), during crises the scientists close to government (local or central) effectively have much more influence on decision makers than simply acting as advisors. Scientists with these roles thus have particular responsibilities in how they package their advice.

These issues spill over into the public domain for other scientists who engage with the public in such crisis situations. Where possible, there is a strong need for constructive alignment. I find that non-specialist policy advisors are often influenced by their reading of science in the media, and this will often flow into the totality of their policy advice. Thus, it is paramount to ensure that the consensual scientific message carried through the media in times of crisis is appropriate to the situation.

It is thus not surprising that events such as L'Aquila and Fukushima have exposed issues about scientific trust and advice in times of crises and have led to a lot of soul searching by the scientific policy community. Many august bodies, including the Global Science Forum of the OECD, have been reviewing their guidelines relating to trust and integrity in crises as a result of such events (22). This conversation has overlaps with that of a broader consideration of the responsibilities of scientists in public communication.

Perhaps the most important declaration of this type is the Singapore Statement on Scientific Integrity (23) published in 2010. This statement was the result of the second World Conference on Research Integrity that involved more than 50 countries and included researchers, funders, representatives of universities and research institutes, and research publishers. Article 10 on public communication is particularly relevant to the present discussion and states:

> *Researchers should limit professional comments to their recognized expertise when engaged in public discussions about the application and importance of research findings and clearly distinguish professional comments from opinions based on personal views.*

Of course such a statement is open to multiple interpretations especially by the researcher, who may well have a series of unconscious or conscious biases that conflate what this declaration tries to separate, namely professional comments from personal views. There is also the issue of the contested meanings of 'recognised expertise.'

While this declaration does not expect or require all scientists to act as honest brokers, it suggests the need to separate discussion based on expertise from that based on values, biases, and issues advocacy. This is a very nuanced and poorly discussed boundary but one that has real implications for trust in science and for effective science/societal engagement. In effect, the clause is suggesting that while all scientists must be able to exercise their rights as citizens to comment on any issue, when invoking their status as a scientist to give weight to their pronouncements, they should do so based on their recognised scientific expertise, whether this expertise is sector-specific or relates to structural matters such as science policy.

However, this distinction is not an easy one in today's inherent post-normal contexts. The development and promulgation of guidelines encourages scientists to speak – indeed they must – but also asks that scientists be specific about the basis on which they are speaking. Doing so can only enhance respect for the communicator and trust in science.

Similar statements to that launched in Singapore appear in many guidelines produced by academies. The most recent perhaps is the revised statement of the Science Council of Japan (24). Our own Royal Society of New Zealand has a Code of Professional Standards and Ethics with very similar sentiments within it, and it is currently under review. However, one does wonder just how many scientists or trainees are aware of such codes and their implications for communication, and whether the codes can adequately account for – by way of example – new methods of communication and public engagement now at our disposal.

Clearly the relationship between science and society is changing and the compact between them must be reinforced. It is in the context of this progressive change that the National Science Challenges Panel recommended to the Government the Science in Society initiative that culminated in the release of the strategy entitled *A Nation of Curious Minds* (25), which is designed to encourage and assist the science community to reach out more to society in many different ways. Indeed the drive behind this report was to encourage more scientific engagement with multiple publics. Within this initiative was a simple recommendation that the Royal Society of NZ Council

be asked to consider whether its Code is up-to-date or might need revision for the ever-changing contexts that this essay has just described.

Surely asking the New Zealand science community through its national academy to independently review its own code, which may or may not need any change, is a healthy thing. The very request undoubtedly brought the code to the attention of many scientists for the first time and that in itself has been a benefit. However, it was somewhat perplexing that this recommendation could be (and still is being) misinterpreted by some as having the opposite intent when it is clearly meant to promote and enhance the quality of science/societal interactions and is part of a major attempt to enhance science capital in our country.

The culture and structures of science are designed for, and thrive on, sceptical and constructive debate, but it does us no good to confuse that internal culture with our obligations to the public. In the media this confusion is often manifested in the drive to find a contrarian view in order to present a false 'balance' in a putative debate, completely disregarding any overarching scientific consensus and emphasising instead the uncertainties. Here, the media are seeking controversy and have been rightly called out on this practice.

In my address last year to the opening of the Congress of the International Council of Science in Auckland (26), I suggested that we needed to give much more attention to the issues of Civics within science training. Science is embedded in society, and all scientists – but particularly emerging scientists – need a greater awareness of the way science is engaged with society and the obligations it places on them.

Final remarks

I have argued that science ultimately depends on trust and integrity. As the scientific enterprise has grown and as it has engaged in more post-normal challenges so, too, have its interactions with issues of public controversy. Science communication (as opposed to scientific journalism) is an inherent part of the science enterprise and it, too, needs integrity if the reliability of science is to be protected. It is easy to blur boundaries – when does scientific debate over complex matters stop being a scientific debate and become a values debate? And scientists can and should take different roles in such debates. They can be acting as knowledge brokers, or they can be acting as advocates. In both cases, do they make clear the limits of their expertise and in the latter case are they clear as to what role they are taking? Are they simply transmitting rigorous and reliable information or is their communication affected by virtue of organisation, employment or deeply held belief?

There are no easy answers and no absolute rules: the solutions will always be nuanced and depend on individual integrity. As scientists, we must be active and more engaged members of society. But when we use our privileged position to speak to governments or to the public, we have two basic choices. We can try and be honest brokers of knowledge or alternatively we must make clear and understood our expertise, biases and vested interests (if any) if we choose to take on the role of issues advocates. And for those among us who wish to advance a cause that extends well beyond the limits of our expertise, this is our right as citizens, but as scientists we have a responsibility to the public to position our comments appropriately.

Trust and integrity will remain central to our contribution to the advancement of knowledge and its application to create better environments, societies and a healthier economy and planet.

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