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Scientific Citizenship and good governance: implications for biotechnology

Keith G. Davies[1] and Jonathan Wolf-Phillips[2]

[1]Nematode Interactions Unit, Rothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, UK
[2]New Leadership Ltd, Bridge House, River Side North, Bewdley, Worcestershire, DY12 1AB, UK

In the wake of public distrust regarding biotechnology, it has been suggested that the debate should be moved 'upstream', whereby the public help to set research priorities. Although many scientists see this as an illogical reaction to a loss of faith in science, we argue that the boundaries between science and its technological applications have become blurred and this produces conflicts of interests that have led to this crisis of trust. Furthermore, this distrust is also a crisis in governance that calls for a new open and democratic approach to scientific research. We propose that the concept of Scientific Citizenship, based on good governance, will help to restore public trust and bridge the gap between science and the society that it serves. Integral to this is the suggestion that the governance of science forms part of the training for scientists.

Introduction

Our present day society is a scientific one, which means that scientific knowledge, and its integrity, is crucial. This fact underpins the everyday technology on which we depend; however there is an increasing concern that scientific integrity is being undermined [1,2]. Ethical considerations have led to the development of regulatory frameworks within which biotechnology can be developed in socially acceptable ways [3], but is this sufficient to assuage public opinion?

Today, the level of distrust of applied science, and its resulting technologies, in the general public is at an all time high, and public anxiety is heightened by the constant back and forth debates about global warming, genetically modified organisms, mobile telephones and, now, nanotechnology [4]. Part of the underlying problem is that a distinction needs to be made between science – the exploration of the external world for its own sake – and its application in technologies that are implemented to solve problems. It is the opinion of some scientists that sociologists might be partly responsible for the public-relations problems that beset science [5], particularly in light of the recent suggestion to move the public debate 'upstream' and allow the public to set research priorities [6]. In applying lessons learnt from the GM debate, the British Government appears to be sympathetic to this approach by stating that, 'We have learnt that it is necessary with major technologies to ensure that the debate takes place "upstream", as new areas emerge in the scientific and technological development process' [7]. However, in light of recent findings that show it is not risk *per se* that concerns the public [8], many researchers feel that this sounds too much like a case of the tail wagging the dog, and fear their roles will be relegated to purely technical ones.

Arguably, it is difficult to draw a clear boundary between science and technology because they are inextricably entwined. Historically, science earned its legitimacy and public acceptance through a division of labor between the various organizations that actively undertook its practice – universities, institutes and commercial companies – and these institutions were, in turn, monitored and regulated by government. In the period after the Second World War, scientists commanded a high degree of respect from the public and were, in the main, allowed to experiment in their laboratories unhindered, and quality control was maintained by a peer-review process. However, since then, several crises of confidence regarding science and its applications have arisen, most notably around the nuclear industry when, following the deployment of nuclear weapons, physicists moved into the life sciences, many for ethical reasons.

Today, we see ethical dilemmas arising again but this time in the life-sciences and their applications to biotechnology. The debates surrounding GM technologies have led many scientists to despair over what they see as an illogical loss of public confidence in science and technology, and they perceive the 'tyranny of the majority' to have taken hold [9]. This is also a growing concern for political leaders because governments have placed increased emphasis on science and innovation as a foundation of their economic strategies.

Crisis of trust and the need for good governance

From the perspective of a publicly funded research establishment, it is our contention that this loss of faith in science is a crisis of trust, which is caused by a blurring of the boundaries between science and its applications through the actions of commercial companies and

Corresponding author: Davies, K.G. (keith.davies@bbsrc.ac.uk).
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governments. Indeed, it has been argued recently that commercial interests prejudice the whole university system at the expense of disinterested knowledge [2], thereby undermining the peer-review process. Although it can be asserted that this crisis of trust is more perceived than real [10], for professional scientists it is a real part of the public perception of science and runs through all institutions. If the results of *Eurobarometer* surveys investigating trust and confidence in scientific and technological institutions are accurate, there might be little need for concern; however, when asked, 'Which of the following sources, if any, would you trust to tell the truth about modern biotechnology?' the respondents show that trust is a scarce resource [8,11]. If this is accepted, O'Neill [10] has shown a way forward by reasoning '…we need to think less about accountability through micro-management and central control, and more about good governance'. Therefore, the crisis of trust in science is, in fact, a crisis of governance, and a new approach to the governance of science is needed. As the old boundaries between academic scientists, commercial companies and government have eroded, there has been a simultaneous focus on the commercialization of publicly funded science through intellectual property, together with a change in the gatekeepers to knowledge.

According to Graham [12], the 'gatekeepers to knowledge' used to be the editors of journals, and a scientist wishing to publish had to convince them, and the referees, that they had made an original contribution to scientific knowledge, placing the emphasis on completed research. It could be argued that the gatekeepers to knowledge have now changed. Modern laboratories are headed by a Chief Executive Officer, and the new gatekeepers to knowledge are the committees and referees that review the grant proposals, and what matters to them is proposed future research [12]. These grant-awarding bodies also have members with industrial and commercial interests; therefore, the potential for conflicts of interest to arise within the grant awarding process itself is increasing. As Sheila Jasanoff [13] has pointed out, 'Far-reaching alternations in the nature and distribution of resources and the roles of science, industry and the state could hardly occur without wrenching political conflicts'. Clearly, it is the huge potential for conflicts of interest that leaves the public increasingly distrustful of pronouncements made in the name of science and drives a wedge between science and society.

Wilsdon and Willis [14] have rightly identified that fundamental questions around ownership have been ignored, together with '…deeper questions about values, visions and vested interest that motivate scientific endeavor often remain[ing] unasked'. If these motivational aspects of science are not articulated, science will become increasingly seen as tyrannical, and mutual understanding and trust will be impossible. In the UK, the GM Nation debate highlighted the fact that it was not GM technology *per se* that was the cause of concern but rather the threat lies with the power of the multinational companies that promote this technology. Corporate science was seen to have huge internal conflicts of interest and it is these that are the cause for genuine public concern along with the need for answers to questions such as: who owns this technology? who benefits from this technology? to what end is the technology directed? The key question that needs a convincing answer regards the extent to which publicly funded science should address questions with commercial interests. We should also remember that private companies are answerable only to their shareholders. This question was thrown into sharp focus in the wake of the sequencing of the human genome, which clearly demonstrated the conflict of values between public and private ownership and public and private benefit [15]. The challenge now is how to address this. There is a definite need, we would argue, to create a climate for science and its application to thrive and to accomplish this, a new approach for the governance of science is required. As the late Jacob Bronowski observed [16]:

> Let us stop pretending. There is no cure in high moral precepts. We have preached them too long to men who are forced to live how they can: that makes a strain which they have not been able to bear. We need an ethic which is moral and which works.

A case for a renewal of professional ethics

The public needs to understand that scientists are fallible, and mistakes are made; however, at the same time, scientists need to rebuild public trust by demonstrating a high degree of professional integrity that amounts to more than a gesture. As Lord Phillips of Sudbury has suggested [17], what is required is a widespread debate that can '…lay the essential foundation for enlivening that holistic sense of professionalism which would both reassure the public and enhance the work fulfillment of professionals'.

There is some evidence of a change in the approach to professional integrity, and the late Karl Popper suggested that old professional '…ethics was based upon the ideas of personal knowledge and of the possibility of reaching certainty; and therefore the idea of authority' [18]. Popper sees that the expansion of our scientific knowledge is so large that it is now more than one individual can master and, therefore, it is clear that there can no longer be such a thing as a single authority. 'The new ethics, by contrast,' argues Popper, 'is based upon the ideas of objective knowledge and of uncertain knowledge.' This, he claimed, would require a fundamental change in professional ethics: from being closed and intolerant, where the focus is based on being the authority and where mistakes are not permitted, to a more open and tolerant set of ethics. Although some philosophers of science would argue against this rational methodological approach to scientific knowledge, suggesting that anarchic and irrational elements are, and should be, important [19,20], most scientists would maintain that the process of conjecture and refutation outlined by Popper [21] has a role, and that ethics and integrity are key.

Ethics since Aristotle has relied on essentialism and the idea of a final end (or teleos), which, in turn, is related to the idea of the supreme good that is final. This reflects a system that is closed; therefore Aristotelian essentialism

will not do [4,22], rather it is a Popperian approach that is required, which is open and democratic. For openness to thrive, intellectual doubt must be placed at the heart of moral reflection, a duty that Socrates believed was the responsibility of every conscientious citizen [23]. The new professional approach of Popper also requires a self-critical and reflective attitude to be the duty of everyone [18]. The solution is to have individuals that are authoritative in their own area (an authority but not the authority) who can then interact with others in an open and respectful manner; this openness and mutual respect would naturally lead to an atmosphere of tolerance.

Creative innovation is fundamental in a knowledge-based economy. According to May [24], '…the best management strategy is to create institutional cultures in which the best young people are free to express their creativity and set their own agendas, not being entrained in hierarchies of deference to their seniors…'. Such ageism highlights the fact that the management of innovation is difficult, if not impossible, because creative thought can occur anywhere and at anytime within an organization, and funds are finite. Therefore, in the knowledge-based economy, the relationship between individuals and their management needs revision. According to Lynda Gratton [25], the role of the traditional supervisor is obsolete, 'as each of us can choose to give or withhold our knowledge and it is virtually impossible to detect when we are doing so'. Gratton suggests that enterprises need to become more democratic by developing an organizational culture of trust and reciprocity in which employees actively choose to share their knowledge (Box 1).

Although some regard the approach of Gratton as highly idealistic and controversial, the sentiment expressed behind these tenets is ethically sound and would be recognized readily, and endorsed, in the scientifically professional republic described by Polanyi [26]. Today, scientists need to rearticulate their professional ethics – to themselves and the general public – to rebuild the bridge between science and society. Recently, a call has been made for a revision of the way that research on food and farming is governed [27]. Combining the new professional ethics of Popper with the tenets of Gratton could help in developing a more reflective approach, both individually and organizationally, and thereby rebuild trust. However, others have gone much further. Bronowski [28] suggested that with increasing involvement of government in science, we endanger the integrity of all science and undermine the public trust in it. Bronowski called for the disestablishment of science.

Scientific Citizenship and the holarchy of governance

The total disestablishment of science would be unrealistic; however, there might be an alternative. If we can rebuild trust between scientific institutions and the local, national and global societies to which they belong, we believe that this will help heal the division between science and society. The process by which decisions are made with regard to scientific endeavor is a fundamental aspect of the good governance of science we call Scientific Citizenship. This applies at all levels: from the individual researcher in the laboratory to the institutions for whom they are working and out into local and global communities. Scientific Citizenship requires good governance, and has clear implications for the biotechnology industry. We maintain that the crisis of trust between science and society can be rebuilt through developing Scientific Citizenship.

What is required for the good governance of science to develop? In our opinion, it requires a change not so much in getting the public to set the research priorities but in the organizational structures and models on which the ways of working are based. We would argue that these new organizational structures need practices that support the intentions of individual research scientists and their organizations as internal stakeholders while simultaneously balancing this with the intentions of the primary and secondary external stakeholders of their organization (Figure 1). Based on this diagram, it can be imagined that conflicts of interests can arise between internal and external stakeholders and, to maintain a balance between the various stakeholders, there will be a need for good governance that incorporates: (i) clarity of the intention of each stakeholder (internal and external), and (ii) an appreciation of the micro (internal) and macro (external) economic, social and environmental contexts. Once these factors are recognized, they can then be brought together to articulate a sense of shared purpose that is transparent, accountable, reflective and open to change.

To facilitate this system of Scientific Citizenship through good governance, three realms of activity need to be identified (and separated because they are different): these are the realms of governance, management and implementation (GMI; Figure 1). The realm of governance upholds the impulse behind an intention by maintaining an awareness of overall expectations and underlying principles (e.g. sustainable agriculture). The realm of management supports the fulfillment of an intention by allocating and managing resources (e.g. secure and manage resources for 3 years for a team of 3 people to publish 3 high-impact manuscripts). The realm of

Box 1. Building a democratic enterprise

Six tenets that Lynda Gratton [25] thinks are fundamental to building a democratic enterprise:

- The relationship between the organization and the individual is adult to adult.
- Individuals are seen primarily as investors actively building and deploying human capital.
- Individuals are able to develop their natures and express their diverse qualities.
- Individuals are able to participate in determining the conditions of their association.
- The liberty of some individuals is not at the expense of others.
- Individuals have accountabilities and obligations both to themselves and the organization.

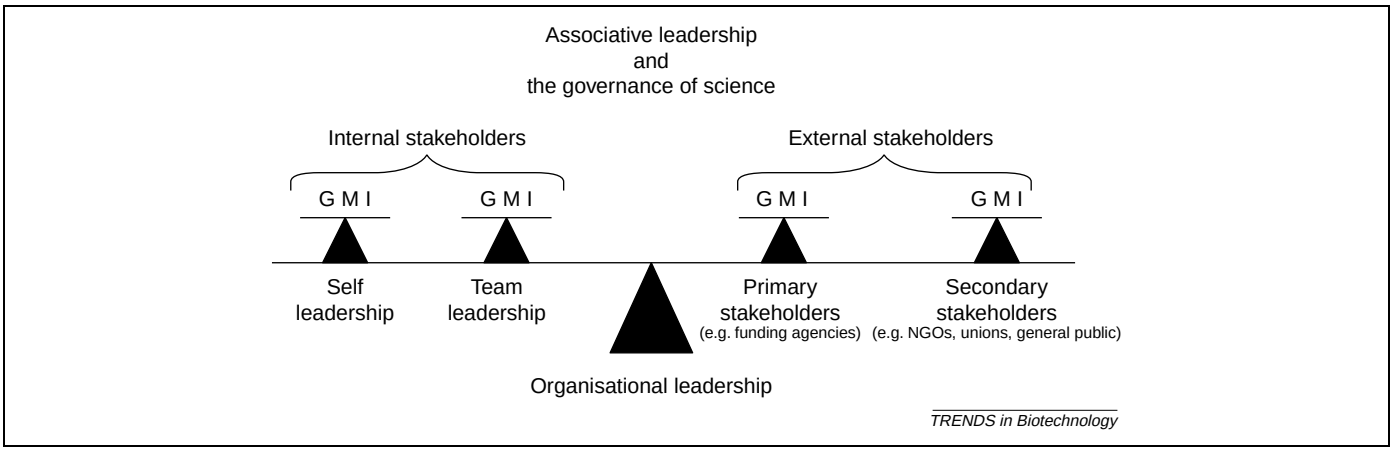

Figure 1. Scientific Citizenship through good organizational governance requires clarity of intentions, the fulfillment of which can be supported through actions in the realms of GMI: governance (G), management (M) and implementation (I). Governance: upholding the impulse behind an intention by maintaining and sharing an awareness of overall expectations and underlying principles (e.g. impulse = sustainable agriculture; intention = deliver crop protection through the seed). Management: supporting the fulfillment of an intention by allocating and managing resources (e.g. secure resources for 3 years for a team of 3 researchers to publish 3 manuscripts). Implementation: performing specific tasks and undertaking activities to fulfill the intention (e.g. a person at the bench extracting DNA from a bacterium and then reflecting on the results with team leader).

implementation is the execution and the undertaking of specific tasks and activities (e.g. extract DNA from a bacterium, write a grant proposal). The realms of GMI are related to each other as a nested hierarchy, known as a holarchy [29,30], with governance at the top.

Some next steps

We have argued that the present crisis of public trust in science is a crisis in the holarchy of governance, and this has occurred, during the past decade or so, because of the blurring of the boundaries between science and its technological applications as well as the motivations of the institutions involved. At the same time, the gatekeepers to knowledge, who used to be the editors of journals, are now the individuals and committees that review proposals for future research rather than completed research. Furthermore, because these review bodies contain individuals with commercial interests, conflicts of interest are inevitable, and the public voice concerns regarding issues of who owns and who benefits from this technology. Accountability needs to be re-examined [31], and we suggest a more open approach to science based on Scientific Citizenship and good governance as the way forward. This approach applies a Popperian view of professional ethics based on a holarchic model that separates the realms of GMI. The foundation of this holarchy-based model is more democratic because it clarifies and articulates intentions that are transparent and accountable to the public, and we believe it will help to build a bridge between science and the society that it serves.

How can we build Scientific Citizenship? Recently, in a study of work in the twenty-first century, it has been predicted that within the British context, the relationship between managers and their workforce will gradually change, the role of the unions will continue to decline and that a process of decentralization will take place [32]. The report emphasizes that:

> Some employees will develop complex self-organizing systems, with ground rules devised from above. *Teams and units will have increased freedom within frameworks of values* [authors' italics]. They will rely on sophisticated systems of feedback and accountability to drive change and innovation from below.

In this manuscript, we advocate a process whereby individuals and groups would be expected to take responsibility, and plan their work within a holarchy-based framework of mutual expectations and clarity of purpose using the GMI model outlined above. The traditional training of scientists has been focused and specialized and, outside of their subject discipline, they have not been expected to have an understanding of the philosophy or sociology of science, which puts the science they are undertaking into context. The review by Roberts is highly critical of the education of scientists, and stated that they receive '…inadequate training – particularly in the more transferable skills…[and] as a consequence, many employers do not initially pay those with PhDs any more than they would a graduate, viewing the training… [they] receive as inadequate preparation for careers in business R & D' [33].

For biotechnology, these issues are of great import but we must not simplify them as they are complex. For industry, the challenge is to manage this complexity and enter into a dialogue with the stakeholders [34]. The Royal Society has suggested a way forward by opening up the dialogue between scientists and society [35]. However, we would propose that moving the dialogue 'upstream' is insufficient to heal the rift between biotechnology and society. Recently, it has been suggested that we need to infuse the culture and practice of science with a new set of social possibilities [36]. Clearly, this suggestion is founded on the proposition that scientists need to understand the philosophical and social context within which scientific endeavor takes place. What is needed is good governance, acquired through building on what we call Scientific

Citizenship. A place to begin this is in the training of the scientists themselves.

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