Our own worst enemies?

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ABSTRACT

The status of scientists in public opinion is discussed in relation to several areas of controversy. In England the social status of scientists is affected by long standing prejudices in society and the education system, and to some extent these views have had influence in Australia. It is suggested that the issues which give rise to public concern about science vary between countries, but that interactions of science with business and the perceived lack of openness in release of findings have undermined public confidence.

Changes in the publishing industry have profound consequences for the practice and accessibility of science. These changes have received little comment or analysis, but potentially have both positive and negative consequences. The application of new managerial approaches with short term vision to scientific research risks long term damage and may limit the ability of scientists to respond to public needs and concerns.

Key words: ANZAAS, education, genetic modification, ivory tower, scientific publication, science and society

Introduction

We live in a world in which almost every aspect of everyday life is enabled or influenced by science and technology; including, for example, information technology and communications, transportation, agricultural productivity, pharmacology, and medical diagnostic procedures. Remove these benefits of scientific discovery and modern civilisation would rapidly collapse. Nevertheless while many see mobile phones and the social media as absolute essentials of life, amongst many of the same constituency there is profound distrust of science and scientists.

Although governments are called on to make decisions on possible regulation of, or investment in, new technologies few politicians have any great understanding of (or frequently respect for) science. Amongst the few exceptions have been Mrs Thatcher in England and Chancellor Merkel in Germany, both women and both chemists who had active (albeit brief in the case of Mrs Thatcher) research careers.

Amongst the population at large there is widespread interest in astrology (which is frequently confused with astronomy), alternative lifestyles and medicines and anything 'organic'. Astrology could be dismissed as harmless fun, were it not for the fact that it does influence individuals' decision making (if there were any shred of credibility to astrological predictions then they might be expected to be consistent, but instead the astrology columns in popular media differ widely amongst themselves). In the case of the alternative movement there may well be merit in some folk medicines and practices, but among adherents there is a pronounced antipathy to evidence-based evaluation.

Positive rejection of science is seen in the opposition to any teaching of evolution, associated with, but not restricted to, the holding of particular religious views. In recent years there has been the development of vocal opposition to acceptance of the concept of anthropogenic climate change. There is obviously a spectrum of opinion but at the extreme not only is there a misunderstanding of the nature of science but personal vilification and threats to climate scientists. In the context of NSW there is currently a distinctly anti-science component in the opposition to marine parks (Lockwood 2011).

Within the education system there have been declines in interest in taking sciences and maths at high school (Cory 2011). It is perhaps an inevitable consequence of the aging process that we look back at our past through rose coloured glasses and bemoan the decline in standards in the youth of today – a view expressed by pontificating professors since at least the late nineteenth century. Whether or not this is true is difficult, perhaps impossible, to determine objectively. It is certainly the case that as knowledge increases, and fashions change, the curriculum has altered (I hesitate to say 'evolved') so that topics we might have slaved over for hours are not taught at all today – which is not of itself evidence of deficiencies in the youth of today. Nevertheless, the relative decline in numbers of students taking science is a worrying trend if it results not only in a reduction in the numbers of practising scientists but also in a general decline in scientific literacy.

The English Disease

Australia, given its colonial heritage, has embedded within its culture some at least of the ambivalent approach to science that has long been apparent in Britain.

Waldegrave (1993) observed that there was a perception in the United Kingdom "that culture means the arts, and that the sciences are some mysterious, inferior, and separate activity." (At the time William Waldegrave was the Minister for Public Service and Science in the British Government). He went on to observe that "Even the BBC with its world-renowned range of programmes on science and natural history, sometimes appears guilty of this misleading assumption. Science is a mainstream element in European culture. This is I think a point more widely accepted and understood in France than in the United Kingdom".

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Britain was the birth place of the Industrial Revolution, and became the world's greatest imperial power on the back of scientific discoveries. Nevertheless, and despite the high esteem in which engineers like Brunel were held in Victorian England, many of the pioneer industrialists, as they became wealthy, aspired to join the ranks of the landed gentry, and did not regard science or engineering as proper career paths for their sons (and certainly not for their daughters).

This situation was perhaps partly the result of the class system but also (and related to class) the power and influence of the ancient universities. The pernicious consequences for the education system and science were described in a trenchant address by Perry (1914), delivered in Sydney. The quotes below both present his thesis and illustrate the robustness of academic debate at the time:

> *..."The education given in England to boys till they leave school at twenty and till they graduate at a University is almost altogether classical"....*
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> *... "I have not referred to the fact that classical scholarship leads to power and wealth in the Church and State, to palaces and baronies, to purple and fine linen, leaving such things out of account, I have a suspicion that this worship of classics is like one's fondness for the rhymes, often rubbishy rhymes, that associate themselves with our infancy and boyhood."*
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> *..."in patent cases a clever judge takes in the most elementary scientific knowledge with very great difficulty."*
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> *..."watching the performance of an Oxford Man of Letters is like watching a good billiard player or a skilled musician. His mind is filled with the thoughts of other men, pigeonholed ready for use. It is extraordinary that a man can have been so educated as to be a good debater, to be able to make a fine speech, that he may have taken a degree at Oxford, that he may have passed examinations in classics, philosophy and mathematics, and yet be exceedingly ignorant, illogical and unscientific."*
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> *..."Poor boys cannot get this training unless they are so unlucky as to get scholarships, or are induced to attend University extension lectures; and it results that nearly all our best writers, writers with imagination and originality and initiative and individuality have been boys of the common people. Although poor boys are most frightfully handicapped for the race to distinction, I do not think that the poor boy is much handicapped by mere heredity, for he is naturally nearly equal to a boy of the highest lineage."*
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> *..."The University man, ignorant of science, becomes a ruler of our great nation, his duty during war and peace being that of a scientific administrator, and without turning a hair he fraudulently accepts this important duty for which he is utterly unfit. The gods must surely laugh when they see these rulers of ours gibing at scientific things, giving important posts to non-scientific men who scorn and obstruct the scientific men who are under their orders. If Oxford scholars were merely like so many monks in their monastery, living the lives and following the studies which they love, I would say nothing. The revenues so used up are, I think, of no great importance to the country, and busy men elsewhere can only be benefited in knowing that at Oxford and Cambridge there are those lovely lamaseries where men are living in serene air apart from the struggles of the world, living what they think to be the higher kind of life, that of the amateur copying the lives of the scholars of Constantinople before they were so mercifully scattered in 1453, copying the meditative ways of the divines and hermits of the fourth and fifth centuries. Unfortunately the Oxford hermits have by a series of accidents become the rulers of the greatest empire that the earth has ever seen, and it is very obvious indeed through many other things than the starting of South African wars that they are unfit for their job."*

(Perhaps in deference to any Antipodean emancipists in his audience Perry concluded:

> *"In this Address I have said nothing about the education of women. I have always advocated higher education for girls, and it is surely wicked to teach girls as if they were boys. Men are concentrative and they specialise; women observe more and more about many things, and they really have more capacity for acquiring mental powers.....The education of men is in a bad way, but that of women is becoming much worse.")*

The influence of the British education system remained pervasive. Darling (1939) was critical of the achievement of a pass in Latin at the Intermediate standard being a prerequisite for entry to Medicine at Melbourne University, arguing that his point was:

> *"what the Faculty wants was the power of logical thought and clear expression, and that such a power should be able to be tested directly within the scope of subjects relevant to the medical course and not by the indirect method of an examination in Latin at a very low standard."*

I have quoted extensively from Perry (1914) because he illustrates what has become a self perpetuating problem, as recognized by Waldegrave (1993). In UK society, scientists and engineers are still frequently regarded as being inferior second class citizens, and non-science graduates from Oxbridge still predominate amongst UK parliamentarians. This contrasts with much of Europe (particularly Germany) and the US where scientists and engineers have long been accorded high status. (Nevertheless, as is apparent in America, general respect for scientists does not preclude the existence of a large and well organised anti-science minority). Whether the situation in Britain would have been different had Prince Albert, German and pro-science and industry, not died so early is something about which we can only speculate.

The assumption as to the superiority of the classics over the sciences in tertiary education was certainly exported to the colonies and was clearly demonstrated in the interaction between Sir William Manning, Chancellor of the University of Sydney 1878-1895, and Professor Liversidge, the Professor of Chemistry and leading light in ANZAAS (Macleod 2009). Although under Manning's leadership the professional schools of law, medicine and engineering were established, and women were admitted as equals of their male contemporaries, he was firmly of the view that teaching in the Arts was the epitome of a university education.

In the twentieth century the importance of science in everyday life further increased, but while individual scientists were recognized by the award of honours, the status of science in the public mind was little improved. In 1959, in the Rede lecture at the University of Cambridge, C.P. Snow (Lord Snow) introduced into public discourse the phrase 'The Two Cultures', to suggest a major dichotomy between the sciences and the humanities, and subsequently much sound and fury was expended debating the correctness and utility of the distinction. The ferocity of the debate was increased by an *ad hominem* counterblast from the literary critic F.R. Leavis. Today, Snow is a figure on the edge of history, a physicist, novelist and UK politician (in which role he rose to the height of Parliamentary secretary to the Minister of Technology 1964-1966). His scientific contribution has faded into the mists of the past and his novels are largely unread. Snow certainly placed much of the blame for the existence of the dichotomy on the education system – as had been pointed out many times previously (although the humanities, then growing rapidly in the new universities, themselves comprised a collection of disciplines that would not have been regarded as worthy of departmental status before the mid-nineteenth century).

Snow's lecture, when converted to print (Snow 1961), was really a fairly light contribution. It is perhaps unfortunate that the sciences and humanities did not wait a few more years when they could have joined forces to make common cause against the rise of the third force in modern universities, business and managerial studies, which attract some of the brightest school leavers and yet have been responsible for a managerial culture inimical to traditional academic practice in science and the arts and, as illustrated by Watson (2009), has done great damage to the language.

The legacy of the historical development of the English education system may partly explain the low esteem in which science is held; if we are to improve our standing we start from a low base. It does not so easily explain the violent opposition to particular areas of science.

The place of science in a nation's culture, and the areas of science that are controversial, vary between nations (Durant and Gregory 1993). Even within the context of a single country, generalisations can always be countered by exceptions, and this is even more the case when international comparisons are made. Nevertheless I think some generalisations can be made, before I turn to Australia.

Scientists as the 'bad guys'

Many societies are inherently conservative and scientific ideas and innovations arising from science frequently threaten the established order. The response of the Luddites in the early 1800s to the Industrial Revolution was to many an understandable response to the scale of change, although neoclassical economists refer to the Luddite view of the world as the 'Luddite fallacy' – their assumption that increases in productivity per worker would result in a smaller workforce. Tabarrok (2003) argues the case against this position "If the Luddite fallacy were true we would all be out of work because productivity has been increasing for two centuries". The Industrial Revolution created opposition to science, but it also helped encourage the Victorian self education movement, of Working Men's Institutes and various Naturalists' societies, which demonstrated great enthusiasm and support for science. Today there is still fear of the consequences of innovation but the organised and institutionalised self education movement is far less obvious, replaced perhaps by solitary pursuit of information on the web.

The more general fall from grace of science can be related to perceptions of the role of scientists in various events. The development and application of chemicals in both World Wars (Jefferys 2009) served to place chemistry under a cloud, and the development of nuclear weapons likewise provoked reaction against physics (although, despite widespread abhorrence of the bomb I recall considerable support in the 1950s and 60s for the 'peaceful atom' and nuclear power generation – support that has waned considerably since).

To many of the general public, biology is thought of as medical research. Events like the release of thalidomide before adequate testing had occurred and instances of unethical behaviour in some (very few) medical research programmes have generated opposition to and scepticism about medical research and helped fuel the growth of alternative medicine (a field which itself is not free of examples of unsubstantiated claims and charlatans). Opposition to vaccination programmes in particular brings out the anti-science factions.

At least in some countries, biologists more generally are under a cloud created by opposition to use, and particularly release into agriculture, of genetically modified organisms (GMOs). More recently, ecologists are attacked for being perceived as having blotted their copybook in relation to climate change and a variety of conservation issues (vegetation clearing, marine parks, bush fire management), although this is far (at least as yet) from the view of the broader public.

Making very broad generalisations, it seems to me that amongst the developed first world nations of the northern hemisphere the issues that generate opposition to science differ on either side of the Atlantic.

In the US opposition to the study and teaching of evolution is strong, and even amongst those not actively opposed to evolution there are many who do not accept the concept. There is also, again for purportedly religious reasons, opposition to, and restriction of, use of various stem cell technologies. On the other hand there is widespread recognition of the importance of science and technology in the development of modern America and an almost ideological support for major companies to pursue their goals with minimal regulation. Thus there is general support for an adoption of use of GMOs (paradoxically, given that the existence of the genetic variation utilised in biotechnology is the result of evolution and selection).

The situation in Europe is somewhat different. There is widespread opposition to use of GMOs in agriculture and this is reflected in government policies in most

countries. While many of the concerns are unfounded (Gray 2004) or, where there are risks, they could be controlled, I suspect that the GMO issue is a convenient focus for much wider and more complex concerns about post Second World War changes to European society, particularly in rural areas. Post war governments have pursued policies aimed at food security (a response to the shortages resulting from disruption of global trade during the war) and cheap food (which has seen the development of very large supermarket chains and the decline of local shops (Adam 2004)). Availability of agricultural subsidies led to massive over-production, often at the expense of natural areas or valuable wildlife habitat, while the disposal of the resultant commodity mountains resulted in distortion of world trade and adverse impacts on the agricultural economies of countries far from Europe. An increasingly urbanised population nevertheless retained or imagined visions of a countryside and rural society far different from current reality. There is deep suspicion of what is seen as the pernicious influence of mega agro-industry, where so much power is seen to be concentrated in the hands of a few global companies, reliant upon modern research in biotechnology, molecular biology and chemistry.

GM is just one manifestation of the influence of big business, but the fact that in addition to these very broad apprehensions, specific questions about perceptions of food safety and quality, and possibly risks to human health, can be raised, has served to make GM the focus of opposition to the way multinational business can influence the way of life of populations across the world. Opposition was also encouraged by perceptions of the behaviour and attitude of the major companies. The attempted introduction of GM in Europe was a public relations disaster for the companies, widely seen as 'scientists' dictating to the community. Similar perceptions are currently apparent in NSW and Queensland in relation to proposals to explore for and subsequently extract coal seam gas (Rowan 2011).

Other recent events in Europe have served to heighten concerns about the direction 'science' is taking agricultural practice and its consequences for human health and nutrition. These events have no connection to GM, but in the public debate have been confounded with GM and agro-business.

The advent and spread of Mad Cow Diseases (BSE - Bovine Spongiform Encephalopathy) can be connected to the use of animal products in cattle feed in intensive lifestock rearing – a practice apparently approved of, and endorsed by, animal scientists. The major outbreak of foot and mouth disease in 2001, and the accompanying mass slaughter of cattle and sheep, again fed public concerns about the nature of modern agriculture.

Public concern about the influence of the multinational agro-industrial complex was first raised by Rachel Carson (Carson 1962, see also Lear 1997). 'Silent Spring' can be seen now as the trigger for the establishment of the modern environmental movement. Carson was subjected to vigorous attacks by scientists working directly or indirectly for the chemical industry. The unfairness and inappropriateness of many of the attacks did little for the credibility of science amongst the public at large. Much of the scepticism about agro-industrial companies so evident in Europe was first triggered in the 'Silent Spring' era, but persists today. In America opposition to agro-industry is strong amongst a radical fringe, but it is less of a mainstream concern.

Whether or not public opinion is rationally based or not is not the issue – rather, it is that these opinions generate sentiment antagonistic to science, and that scientists have either not been provided with the opportunity to redress the balance, or that the attempts made have been unconvincing.

Also in relation to food supply and of considerable concern to the public are the state of the world's fisheries and the regulation of the fishing industry. Governments have acted in the fisheries arena for many years of the basis of the advice of scientists, and yet fisheries are still in decline (Clover 2004). The issues are difficult and complex, but the outcomes of management to date have not engendered confidence in scientists.

There is one topic where opposition to scientific practice is much more intense in Europe than in North America and that is in regard to animal experimentation. While there would be general agreement that there need to be strict codes of conduct and approval, there is a small but very active group for whom the regulatory system will always be inadequate; rather, total prohibition of any animal experimentation is the goal. Members of animal rights groups have been responsible for acts of sabotage and of violence against individual researchers. Threats of continuing action have been sufficient to deter some institutions from building laboratories and have limited the possibilities for carrying out some sorts of research.

Where is Australia?

In comparison to the northern hemisphere it would be my interpretation that Australia occupies a mid Atlantic position. There is much greater concern about GM and greater regulation than in North America, but the strength of the opposition is less than in Europe (although the recent destruction of GM wheat at a CSIRO research facility in Canberra represents a marked escalation of activity). In relation to restrictions on stem cell research Australia is less rigid than the US, but not as free as parts of Europe. The rejection of climate science is given a high profile in some sections of the media (perhaps a higher profile than the size of lobby might otherwise warrant), and in this we differ little from northern hemisphere western nations.

Although the influences of science and technology on the growth and development of the British nation were being recognized amongst some of the ruling class at the time of Australia's colonization, the number of scientists and their influence was still small. However, the colony was expected to be a source of new, curious and potentially useful objects and organisms, and scientific exploration of the continent was a high priority. It was not only from London that the importance of science was pressed. The leaders within the colony itself also included enthusiasts

for science (that science was viewed as a noble calling is perhaps illustrated by the words on the memorial, in St. James Church, Sydney, to James Gilbert, naturalist and collector who died on Leichardt's 1844-5 expedition to Port Essington – *Dulce et decorum est, pro scientia mori*). Australia was thus probably more receptive to, and accommodating of, science than Britain and, by the late nineteenth century there was already established the tradition of a strong scientific public service in the colonies, concentrated particularly on agriculture and natural resources.

During the decade leading up to Federation high priority was placed on science as the engine for the soon to be newly born nation to develop its economic independence. The creation of a national scientific institute was widely advocated, but it was not until 1926 that the Commonwealth was able to establish the Council for Scientific and Industrial Research (CSIR), the precursor to the Commonwealth Scientific and Industrial Research Organization (CSIRO) that was founded in 1949 (Collis 2002). CSIR and CSIRO conducted research on a vast range of topics, and soon became a source of national pride. In modern parlance it became a trusted 'brand', widely respected and seen as an independent source of advice to government and the public. Compared with some overseas government research agencies the organization developed an ethos that gave a great deal of freedom to individual researchers and a focus on research excellence. While this at times generated strains between the organizations and the government of the day (O'Dea 1997, Collis 2002), for the most part government was supportive of the research direction and, notwithstanding the usual grumbles from scientists about inadequate funding for particular projects, provided support which on international comparisons was generous. Not all of CSIRO's projects achieved the outcomes hoped for (Collis 2002), but the success rate was high. The organization was very active in public education in the broadest sense, through extension activities and publications for its obvious partners, through the media, and through engagement with school education.

The successes of CSIRO overshadowed the not inconsiderable value of state government agencies. Research by state governments in areas such as agriculture, forestry, fisheries, and the environment has been considerable, but while sectorial user groups have been actively engaged with the research institutions, the broader public has remained largely ignorant of the engagement of the state governments in research. That research is divided in the states amongst a number of departments rather than sheltering under a single science umbrella has perhaps limited the opportunities for city-based media coverage. The research output of state based museums and botanic gardens, the backbone of much of our understanding of Australia's biodiversity, falls under the public radar, there being little recognition that these are research institutions.

What's the problem?

Australia has a long established tradition of world class research, major scientific institutions, a strong university sector, a well educated public, and a history in which scientific achievements have been acknowledged and respected. True it is that for well over a hundred years, at ANZAAS[1] congresses and the like, scientists have expressed concern over the lack of understanding of science in the wider community, and have issued calls for greater funding, but this is not unique to Australia. Why is it that many scientists now believe that science is under siege? Have there been changes in our lot in recent years and, if so, what can we do about it?

My impression is that there has been a change, and that even amongst the constituency that historically supported science, there is now a greater questioning of whether science works for the public.

Towards the end of the Second World War Eric Ashby, then Professor of Botany at the University of Sydney in a leading article in the '*Sydney Morning Herald*' (June 21, 1944) argued for a Magna Charta for science. He suggested that

> *"….the scientist believes that his work, freely applied to social needs, could cure many of the ills of society.*
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> *Today he sees, and is obliged to take part in, the very enthusiastic application of his work to the destruction of human life, but scientists in all the democracies are now making up their minds that tomorrow their work shall be applied with equal enthusiasm to enrich human life.*
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> *When he asks for the planning of science in Australia the scientist does not mean more bureaucracy and more controls. He means planned opportunity so that he can do his work efficiently; scientific foresight on the part of Governments, so that social needs are anticipated, and legislation which will guarantee that knowledge shall be or freely available as the law; never the monopoly of the few, and never withheld from the people."*
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> *Ashby acknowledged that even then there would be those who would be doubtful of such idealism. "Some sections of the pubic, which have a profound distrust of "professors" (and who seem to imagine that "professors" are synonymous with "scientists") are suspicious of this assumption of social responsibility by scientific workers. What is the need (they ask) for this planning of science? Is it going to mean more controls over the public? Are these scientists doing nothing more than protecting their own interests?"*

The aspirations expressed by Ashby were partly met in post war decades, but more recently the matters about which he was most deeply concerned have again become issues, but scientists have not spoken out against them. The trust which Ashby was urging be placed on scientists has not been met, so that those elements in the public who expected more have been disappointed.

1. The Australian and New Zealand Association for the Advancement of Science (prior to 1930 the Australasian Association for the Advancement of Science, Macleod 1988, 2009).

Were scientists like Ashby, who wanted scientists to serve the public, and those members of the public who supported the same concepts, naïve idealists? Could scientists have done more to have met Ashby's goals, or are we as much victims of the system as the public?

The commodification of information

The particular focus of Ashby's concerns in 1944 was what he saw as the danger of control of research and invention by domestic and international cartels. In particular he drew attention to the international cartel of I.G. Farbenindustrie, I.C.I., Du Pont, Allied Chemical and Dye, and Mitsui which controlled the price and availability of dyestuffs pre-war (see also Jeffreys 2009).

In post-war years Ashby's ideas seemed to have borne fruit. When the CSIRO Division of Entomology formulated an insect repellent it was made freely available to the Mortein company where it became the basis of Aerogard, which rapidly became a national icon. It was then CSIRO policy that discoveries developed with public funding should be available, and while Aerogard was a high profile example of the policy in action there were many others (Collis 2002).

Today, information is seen as money, and the managerial approach taken in both government institutions and universities requires that 'intellectual property' be protected at all costs. While the intention of securing extra income for institutions is welcome, the practice restricts the availability of information. In addition, very few discoveries result in massive financial returns – the bureaucracy to administer intellectual property is expensive but the odds of a win are not much better than those of Lotto. (There have been very few Gatorades, although Wi-fi is a winner for CSIRO (Townsend 2011))

Research is expensive (although not doing research is, in the long term, even more expensive). From the perspective of Treasury one solution is to require government research agencies to earn a proportion of their budget from external earnings. This has been the situation for both Commonwealth and State research institutions since the 1980s (Collis 2002), although for state agencies 'external' can include funding through Commonwealth granting schemes. Where the external funding is from the private sector the mantra of 'commercial-in-confidence' can be raised and the restrictions on dissemination of knowledge feared by Ashby (1941) return (see Townsend 2010). A current example of inability of the public to have access to information has arisen in the coal seam gas debate where data arising from contract research conducted by CSIRO for Santos is protected from public gaze by confidentiality requirements (Cubby 2011, Klan 2011, Manning 2011). There will obviously be occasions when confidentially is necessary, but blanket application without consideration of the broader public interest gives rise to distrust of public institutions. The involvement of government agencies undertaking contracts for, or with, private companies may also create a perception that the role of public service as an unbiased source of advice to government has been comprised.

Scientific and tertiary educational institutions must properly account for the funding they received, but, while they should be run in a businesslike manner, it could be argued that they are not in themselves 'businesses' in a commercial sense. Standard managerial business models applicable to the manufacture of widgets cannot simply be transferred to the running of academic institutions.

One of the advantages of research by government agencies historically was that it offered opportunities for long term studies, unconstrained by the short term cycles of granting bodies. Much of the understanding of ecological processes that we now possess was only possible because of long term studies. Today it is increasingly difficult to obtain commitments for long investment, despite general recognition of the value of long term monitoring and research. Within agencies retirements result in a loss of corporate memory, and in some cases the physical record of past studies has been mislaid or actually destroyed. For studies still continuing, the digital age brings new dangers - without commitment to proper archiving and upgrading to new generations of hardware and software, current records may be less durable than old fashioned hard copy. Nearly a thousand years after its compilation the Domesday book is still an important available source of historical ecological data, but will the same be true of today's information?

Within the universities, dependency of external funding also limits the potential for long term studies. In 1981 when Beadle's magisterial overview of Australian vegetation was published - the culmination of a career of fieldwork around the continent - the author acknowledged the University of New England for the majority of funding and support (Beadle 1981). The major external funding bodies, then and now, would be unlikely to support such descriptive studies, but today the discretionary funds at the disposal of departmental heads are so limited that even short term project funding is likely to be minimal.

To the vast majority of the general public, unaware of the details of research funding mechanisms, but aware of media coverage of particular large grants, the consequences of lack of support for long term research are not an issue. Even amongst many scientists, while they would like more funding of their own discipline, there is little appreciation of the need to have a balance of long, medium and short term funding. For those scientists who do care and for those few informed members of the public it is a matter of despair.

There is currently much discussion of the need to establish long term environmental research sites and projects and this is clearly an advance, but it seems to me that much of the discussion displays a naïve believe in the magic pudding. With a short term political electoral cycle, and limited understanding amongst politicians and bureaucrats of the issues, continuity of both funding and physical resources remains uncertain. In NSW the history over recent years of restructuring and closure of facilities, with little evidence of a coherent overall vision or plan is testimony to the perils of ill-informed short-termism.

Publish or perish?

Some of the greatest changes in the practice and culture of science have come about as a result of technological change in publishing.

I would be strongly of the view that as scientists we have an obligation to publish the results of research. Work that remains unpublished is lost, and as such represents a waste of time and resources. Nevertheless, current norms in publishing are potentially damaging to science and to the broader public.

Historically, the publication of scientific journals was very largely the province of the learned societies (not exclusively, *Nature*, for example, was always a commercial venture). Today relatively few societies carry out all the roles involved in publication (local societies such as the Royal Zoological Society of NSW and the Linnean Society of NSW being examples of the few). Many of the major journals associated with scientific societies are published on their behalf by one of the large commercial houses, which nevertheless remain reliant on substantial voluntary input from referees and editors. In addition, there is now a large number of journals established on purely commercial grounds by the publishing houses.

Globally there has been a steady reduction in the number of publishers (the result of industry 'rationalization'), so that now the great bulk of scientific journals are published by one of a very small number of multinational companies, who collectively show the attributes of the cartels so criticised by Ashby (1944). Curiously this control of the world scientific literature by so few seems not to excite any interest from corporate regulators around the world.

The global restriction of the publishing industry has coincided with this shift towards electronic publication. This has made distribution easier and quicker but has reduced the choices available to librarians. Many titles are no longer available individually, but as part of packages. Should publishers restructure the package then there is no guarantee of continuity of long term access to particular titles.

The shift to electronic publication substantially changes the role of libraries. When journals existed as words on paper they were physically present in libraries on shelves. In the case of university libraries, for example, journals were accessible not just to staff and students but were a resource available to members of the general public. Although there were some restrictions, the public could not just walk in off the street and gain instant access, a member of the public with an interest in particular issues could normally make arrangements to see the current literature. Today there would be little joy for a member of the public entering the portals of a major institutional library – current issues of journals are not on the shelf, but only available electronically. For staff and students this permits instant access on their computers any time of the day or night and from anywhere in the world with access to the internet, but only after the appropriate password has been entered. The library subscriptions are valid only to registered users; a member of the general public (even if a taxpayer whose taxes have contributed to paying the library's subscription) is not part of the deal. For a member of the public wishing to make an informed submission on some major issue there are now considerable hurdles in the way of obtaining the necessary information. Information is now more readily available to some, at the cost of exclusion of others.

I also have concerns about the possible longer term consequences of electronic subscription to the viability of scientific societies. In the past one of the attractions of membership was provision of a personal hardcopy of the journal, giving freedom from the constraint of having to visit a library to obtain access. Now, if one is a student or staff member of a subscribing institution, that incentive for joining has gone, replaced by instant electronic access. I am not aware yet of any evidence that electronic access has caused a reduction in new members, but if it were to occur then although societies might continue to receive income from publishers, the collegiate component of their activities might suffer.

Along with the change to electronic publication has been the development of means of tracking citations of authors and assessing the impact of journals. In an age when institutions are, properly, being held accountable for their use of public money, the ability to generate a few simple metrics has been a godsend to university and institutional administrators. Calculated indices are frequently available at the touch of a button courtesy of the members of the publishing cartel. Unfortunately the indices provided are frequently incomplete and biased, failing often to capture books, many conference publications and journals not within the calculator's stable of publications. Additionally, the metrics fail to capture 'quality' as distinct from quantity. Quality is elusive to define and measure, and requires time and knowledge to evaluate (one way to gain a high citation index would be to write a very flawed paper, to which others would feel compelled to write rebuttals).

The simple, but simple minded, indices have their uses, but in the hands of those several steps removed from the research process can be a dangerous weapon.

The ranking of journals is also fraught with dangers. All practitioners know that some journals have higher standards than others; they also know that to get a message to target audiences some journals are more appropriate than others. The attempt to rank all journals into single national lists, without taking into account differences in publication practices between disciplines is potentially damaging for those disciplines adjudged by others not to have a discipline specific journal in the top tier. Again evaluation has to be more than superficial – a 'bad' paper can still get published in a 'good' journal and a paper of greater value can be published in a journal not regarded as top tier.

A further point, particular relevant in ecology, is that the indices tend to have a short time horizon, whereas some ecological (and taxonomic) works tend to be cited over a very long period.

Another development which is relevant to this discussion is the establishment of open access journals. These have the advantage of not requiring affiliation to an institution, but are accessible free of charge (except for the cost of internet access) to anyone. Unfortunately there is rarely such a thing as a free lunch; publication even in electronic format incurs costs which will need to be met.

If the funding does not come from the end user or their institution, it could come from philanthropy, where an endowment funds publications, or it could be a charge on the originator of the manuscript. Although some institutions and grant giving bodies may provide the necessary funds; in other cases the cost could be a strong disincentive to publication. In the US, publications arising from government funded research have to be available without cost – but such a requirement is not yet policy for bodies elsewhere, even though it is frequently mooted.

The sheer volume of the scientific literature, and the rapid rate of growth, make it difficult for the younger scientist, let alone the general public, to place new research in a broader context. Brenner (1985) wrote:

> *"For most young molecular biologists, the history of the subject is divided into two epochs: the last two years and everything else before that. The present and very recent past are previewed in sharp detail but the rest is swathed in a legendary mist where Crick, Watson, Mendel, Darwin – perhaps even Aristotle – coexist as uneasy contemporaries."*

The same could be said in many other disciplines today. One of the positive advantages of the electronic era is that increasingly the older literature is being scanned and made widely available. The past is now more accessible to more people than was previously the case, although students need to be actively encouraged to appreciate that much good science exists there.

The ability to conduct extensive literature searches, and retrieve papers, without ever setting foot into a library can be regarded as promoting more efficient use of time, and is doubtless welcomed by our managers. Nevertheless it reduces the chances of the serendipitous encounter with the unexpected – a paper in a different field whose title attracts interest and which turns out to be relevant to a completely different problem.

Breaking out of the ivory tower

If scientific input is essential to address many pressing policy issues, how well are scientists engaged in public debate and the creation of policy? In many instances the answer would be not well, if at all, and in some ways less well than a century ago.

In Australia there is a long tradition of coverage of scientific issues in the media. Greater coverage would be desirable but much of what we have is high quality. An interesting trend in the 'quality' press in Australia and overseas is the increase in the number of science stories linked directly to papers in scientific journals (particularly, but not exclusively, open source). In Sydney the science feature on Thursdays in the '*Sydney Morning Herald*' regularly provides examples of this practice. Unfortunately I suspect that much is preaching to the converted, and that engagement across the whole spectrum of the public is limited. The anti-science hysteria generated in radio land and some of the print media in relation to climate change and some other issues will possibly adversely affect attempts to promote rational debate on other aspects of science and policy, and perhaps discourage the taking of science to HSC and beyond.

For a century a major role in promoting science in Australia was played by ANZAAS. . It had a number of roles; as facilitator of interdisciplinary interaction between scientists, fostering the establishment of new disciplines in Australia, lobbying government, encouraging science education and seeking to promote science to the wider public. The ANZAAS congresses were major events, attracting large attendances and hosting vigorous debate. The published records of the congresses make fascinating reading (and also demonstrate that there is little new under the sun; the 1939 Congress, for example, included discussion of the concept of *terra nullius* and concerns about possible impacts of the burning of fossil fuels). In many ways ANZAAS became a victim of its own success – most of the divisions of ANZAAS gave rise to specialist scientific societies (in some cases more than one) which ran their own conferences, negating the need to get together as part of a national science festival. There were many advantages to national science in this specialization, but it was at the expense of ANZAAS, and of opportunities for interdisciplinary contacts. ANZAAS continued as a leading player until past its centenary, but attendance at congresses rapidly declined in the 1990s. ANZAAS is not dead, and still has potential roles to play, but is certainly diminished compared to its heyday. The growth of many other societies is certainly an element in the decline but is probably not the whole story. The British Association for the Advancement of Science similarly gave birth to specialist groups but the meeting of the BA is still a major event, particularly given to the discussion of new trends and importantly policy issues. In conjunction with the Royal Society the BA is responsible for the publication of *Science & Public Affairs*, which is not a theory laden discussion amongst policy specialists but an attempt to identify and discuss issues of concern to the public. Unlike ANZAAS, which achieved a great deal on funding which was always tight, the British Association has sustained its prosperity. In the USA the annual meeting of the American Association for the Advancement of Science (the publishers of *Science*) is still a very large and important event, at which papers covering major recent advances in science are presented. Why was support for a general science congress in Australia not sustainable? As a past chair of ANZAAS I had many conversations with leading scientists in a range of disciplines who all spoke warmly of their own previous experiences at Congresses and lamented the decline in ANZAAS's role. However, when challenged to attend ANZAAS events, and to support their students' attendance the enthusiasm rapidly waned – discipline-specific conferences were too important to miss and there was insufficient time to attend every event even if they were, in a general sense, 'good ideas'.

The absence of an effective national interdisciplinary science forum which engages with the public (in genuine dialogue, not paternalistically) is a major deficiency. Events like Science Week have an important role, and may be in an age when everyone is, or claims to be, time-poor, individual events rather than dedicated conference are the best we can hope for, and will certainly have a larger potential audience amongst the interested public than an annual conference.

The role of the Academy

If the attempt to have a popular, membership-based body to link science with society (ANZAAS) has run out of steam, what is the role of the elite body for science, the Australian Academy of Science? Across the Tasman, the Royal Society of New Zealand encompasses both a membership-based general science society and an elite academy within the one organization.

The public at large has probably little idea what the Academy is, let alone what it does (and indeed that ignorance is possibly shared by many scientists). Election to the Academy is a great honour, and the Academy functions internationally in conjunction with other national academies and is a source of advice to government. In terms of engaging in public debate and seeking to educate the general public, the Academy today has a low profile. In its earlier years the Academy was active in promoting nature conservation and produced publicly available reports on topics as diverse as the Atmospheric effect of Supersonic Aircraft, the Use of DDT in Australia, the Education of Scientists and the National System of Ecological Reserves.

The Academy also produced a series of publications based on meetings of the Science and Industry Forums dealing with issues of broad public interest – the papers being not unduly technical and offered "for public information". Topics included transport in Australia (Potts 1978), scientific advances and community risk (White 1979 – a volume including several papers on the then very new prospects in generic engineering, and irrigation and water use (O'Loughlin 1980)). I have found the whole series very useful and informative, but there is little indication that they achieved wide circulation or had great influence. Addressed more at the scientific community than the broader public was 'Fire and the Australian biota' (Gill *et al.* 1981), a landmark publication in Australian ecology. Over the last decade or more the Academy has not produced many publications for the wider audience, but the 2010 publication 'The Science of Climate Change. Questions and Answers' (Australian Academy of Science 2010) was very much aimed at the wider public. At the time of its release there was some comment in the media, but it has otherwise attracted little attention.

If you can't beat them – join them

If as scientists we perceive that part of the reason for lack of public understanding of and support for science lies in the failure of politicians to appreciate the issues, then should scientists be more involved in the political process?

A scientific career as a stepping stone to political glory is not something which has appeal to most scientists, and even if more scientists were to put up their hands they would have to face the risks of preselection let alone the uncertainties of the ballot box. While there will be a few exceptions, on the whole I cannot see scientists ever becoming a major grouping in any elected assembly. One of the advantages of an unelected upper house, as exemplified by the House of Lords, is that it does provide opportunity to engage experts in the legislative process. Some of the reports of Committees of the House of Lords, which includes amongst its number distinguished scientists, have been models of how to introduce science into parliament. However, it is not a model likely to be introduced elsewhere.

If not seeking election could scientists nevertheless engage in public political debate? Most scientists would probably regard this as a potentially career limiting move. In the interwar years a number of prominent scientists in the UK were very active in public fora, almost exclusively on the left of politics (Goldsmith 1980, Wersky 1978). There was strong support amongst this group for developments in the Soviet Union, which was seen as providing a model of using science for social benefit. As more was learnt about Lysenko and the assault on Mendelian genetics for ideological reasons, this support had to be renounced (Huxley 1949). While the rejection of Lysenko was necessary and reflected well on the western scientists concerned and their maintenance of the supremacy of the scientific method, the whole episode left many burnt fingers and lingering distrust of adopting public positions on political issues. In the immediate post war era any kind of communist tendencies was career-limiting. The establishment of the CSIRO was marred by a smear campaign from the opposition and sections of the media against the CSIR and universities for employing persons who were claimed to be communists (O'Dea 1997; Collis 2002).

The formation of FASTS (Federation of Australian Science and Technology Societies), now rebranded as STA (Science and Technology, Australia) created a means for scientific societies to lobby politicians, and the annual Science meets Parliament forum has been a successful means of informing and enthusing members of Parliament about science. Translating this backbench support into front bench action has been harder, but STA is one of the success stories in increasing understanding of science amongst politicians.

Discussion

Australian scientists have been reluctant to express concerns over the changes to the administration and organisation of science, even though a number of the changes have been responsible for lessening of respect for scientists amongst an increasingly sceptical public. (Public scepticism is not just addressed at science; there is unfortunately similar scepticism about many other institutions in public life). It is readily understandable why there has been silence; upsetting the managers is not a path to advancement. Nevertheless the concept of scientists as champions of the public interest advanced by Ashby (1944), and as reflected in the hopes invested in the CSIRO and universities, is now less apparent. Science is not apart from society but part of it and the range of views and opinions amongst scientists is broad, just as it is amongst society as a whole. Many scientists would still hold to the ideas that Ashby (1944) advanced, it is just that individually and collectively, the way to uphold them is not clear.

Barry Jones tried hard to increase the status of scientists and respect for their role in society, but expressed frustrations that scientists did not lobby effectively for their own cause (Jones 2006). The status of scientists in Australian society is not less (and indeed may be higher) that in other western nations, but is clearly less than in the emerging economies in Asia. Science has been essential for the development of modern society and as scientists we expect science to provide the keys to future advances and the development of sustainability. The task, however, is to still the convince the broader public that this is the case, so that there will be continuing support for governments to provide the environment, regulatory, administrative and financial, for science to flourish and importantly to serve the public interest. There is still a long way to go.

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