An opinion piece invited by the editors.

The review I might have written on the unrefereed publication by Ben-Ami *et al.* (2010) on kangaroo harvesting

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Preamble

For a thorough dissection of the Ben Ami et al. (2010) paper, readers are referred to the paper by Cooney *et al.* in this volume. Readers will note that I am acknowledged in that paper for providing comments and input. A couple of months after I had done so it struck me that there was actually a serious flaw in the logic of Ben-Ami *et al*; it was judging the current kangaroo industry against a putative future industry, the one I have been talking up as a possibility for more than 25 years, in which kangaroo meat is valued sufficiently to be appreciated by woolgrowers in the rangelands as a component of their income. I mentioned this flaw to the editors of Science under Siege and was encouraged to write a short contribution pointing it out. The Ben-Ami *et al.* paper was not peer reviewed. Had it been, this flaw in scholarship should have been picked up. Because editors rely on reviewers to check for this type of gaff, I have chosen the peer review format; 'the review I might have written'.

The way peer review in science works, journal editors send out submitted manuscripts to several reviewers with knowledge of the relevant research area and asks for their opinions of the paper in a written critical evaluation. The reviewers are not identified, either to each other or to the authors (although sometimes a reviewer will elect to self-identify). The editor then considers the reviews, makes a decision and advises the author/s, usually providing the reviewers' comments and asking that the points raised be addressed satisfactorily in a revised submission or, alternatively, rejecting the paper. If the reviewers are in disagreement, further review/s are commonly sought. If an editor receives a paper which is relevant to work by particular individuals, it is highly likely that at least one of those will be included among the referees.

The paper "Advocating kangaroo meat: towards ecological benefit or plunder?" by Ben-Ami *et al.* 2010, had it been submitted for publication to a scientific journal, would quite possibly have come to me for review because the idea it set out to explore, *inter alia*, commonly abbreviated to "sheep replacement therapy for rangelands", is one that I have been championing since 1987. In such a case the reviewer will be easily identifiable to the author/s and would probably choose to sign his/her name to the review.

Reviews usually have two sections, one for transmission to the authors and one just for the editor's eyes, giving the reviewer an opportunity to offer some additional advice. I have followed that format.

What follows is the review I might have written if the paper in question had been submitted to a refereed journal and had landed on my desk seeking an opinion.

Comments for the authors

A substantial part of this manuscript (MS) addresses ideas that I have been promoting since a paper published in 1987 (Grigg 1987, 1988, 1989, 2002; Grigg *et al.* 1995; Grigg and Pople 1999; Lunney 2010). So it is appropriate that I sign this review. The MS has a number of serious shortcomings which I will identify. Unfortunately, because the MS contains so many apparent misunderstandings this review is, of necessity, somewhat lengthy. For convenience I will divide it into several sections.

Judging the current kangaroo industry against a putative future industry

Possibly the most serious flaw in the MS is that it fails to distinguish between the current kangaroo harvesting industry and a putative future industry, in which the ideas I have spelled out initially in 1987, and which have come to be known by the shorthand appellation 'sheep replacement therapy for rangelands', are already implemented. They have not, but the MS uses the lack of achievement of the benefits alluded to as possible gains under that still hypothetical scenario as a criticism of the current industry. This is very peculiar logic.

In the postulated future scenario that I and some others have been promoting, wool growers get sufficient return from harvests on their properties of more highly valued kangaroos, driven by market-engineered higher prices for kangaroo meat, to enable them to maintain a good income with fewer sheep and, thus, reduce grazing pressure. As acknowledged in my 2002 paper, this has not yet occurred; meat prices are still too low.

This is the scenario from which the MS derives four supposedly underpinning assumptions to assess and against which to judge the merit of the current kangaroo industry. It is a scenario I spelled out first in 1987, stimulated by seeing the extent of damage done by overgrazing in the sheep rangelands. The idea became somewhat better developed over the years but retained its essential elements. That is, if kangaroo meat becomes worth more, woolgrowers could gain an additional income stream which would allow them to carry fewer sheep, to the benefit of the land. My argument was (and still is) that kangaroos provide

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good, healthy meat, Australia has a monopoly on the product, and there must be a price point above which woolgrowers would stop giving their kangaroos away to the shooters and take a more direct interest themselves. In several papers I spelled out various ways that I thought a marketing campaign could achieve this, most recently in print in 2002. Since then I have come to the view that it may be worth exploring the potential for a niche market in body builders and elite athletes because of the suitability of the meat for that (not an original idea, it was suggested to me by someone else). Consumption by patients following cardiac surgery is another possible niche (or used beforehand, to obviate the need!). All of these ideas are seen as radical or impossible by one or another, and so far no properly funded marketing campaign has occurred.

This proposed scenario is not happening yet, but the MS asserts that kangaroo harvesting has therefore failed in achieving conservation gains. It may be that the proposal I have been putting forward is ahead of its time, or maybe it never will be feasible, but this is surely not a basis on which to judge the current kangaroo industry.

The MS's four assumptions

The MS erects a set of four assumptions which it claims "*underpin the sheep replacement concept and the eating of kangaroo meat on environmental grounds*". Three of them are badly distorted and only one is actually relevant to the current industry.

I will quote and then comment on the four assumptions they 'confronted' (to use the authors' word).

Their assumptions are (from their Executive Summary):

> *"Key assumptions in replacing sheep with kangaroos as a meat source have had little proper evaluation. For the first time we examine the four key assumptions and confront them with published scientific evidence to assess their bearing on the sustainability of kangaroo harvesting in Australia.*

These assumptions are:

a. (a) that increased consumption by humans will lead to an increased value of kangaroo meat;

b. (b) that an increased value in kangaroo meat will lead to sheep replacement;

c. (c) that destocking will lead to a sufficient increase in numbers of kangaroos to service demand for red meat formerly supplied from sheep; and

d. (d) that proper regulatory mechanisms are in place to counter increased market demand for kangaroo products that may result in over-exploitation."

For starters, the wording in this introduction to their 'assumptions' is a distortion. The sheep proposed to be (partially) replaced by kangaroos in the rangelands produce wool, not meat, so the motivation behind advocating 'sheep replacement therapy' has nothing to do with replacing lamb and mutton with kangaroo. This appears to be a classic case of 'erecting a straw man', as I will discuss further below.

Now to the assumptions themselves:

Assumption 'a'. There is nothing inherently wrong with this idea, but in stating it and discussing it, the authors have ignored the crucial bit. The crucial bit is that we can expect a price rise only once demand starts to outstrip supply, that is, if and when quotas are filled regularly and harvest limits are reached. I have explained this repeatedly in numerous publications. The laws of supply and demand are tenets of economics. As I wrote in 2002, quotas are filled only rarely, so demand is still well under supply. The situation has not changed; indeed with the collapse of the Russian market the situation has become worse. There is little doubt that if demand for kangaroo meat were to grow to the point where is bangs up against the limited supply, an increase in price would surely follow. Indeed there was a short period when this happened in South Australia.

So what does the MS say about this assumption? Well nothing actually. There is no mention of the connection I have been drawing for 25 years between price, supply and demand. In this section the MS refers to 'only minimal competition between sheep and kangaroos', 'overexploitation is a strong possibility', 'existing regulatory mechanisms have not been truly tested', 'product quality' issues and a discussion about current prices for kangaroo meat being variable and low. That is, the topics discussed do not relate to the assumption being 'confronted'. Nevertheless, the MS concludes "*In conclusion, increased consumption does not guarantee the increased value of kangaroo meat*." Well, we don't and can't know that yet because the increased consumption, increased demand and potential consequent price rise have not yet occurred.

Assumption 'b'. There is nothing inherently wrong with 'assumption b' as an idea either, but it is hard to evaluate it because it too has not yet happened. If woolgrowers ever do become able to make significant income from kangaroos it is highly likely that they will take the opportunity to reduce total grazing pressure by lowering sheep numbers.

What does the MS say about this supposed 'underpinning assumption'? Well, again, nothing really. It refers to the 'high cost of fencing', but I have published repeatedly that I do not see kangaroos being fenced in, and I don't recall fencing being advocated by any of the other researchers who promote kangaroo harvesting as a conservation tool. Mainly this section discusses various models involving cooperatives formed over several properties, and how the returns are not likely to be there. But their discussion does not allow for any increase in the value of meat, should it happen, which I have always seen as a necessary precursor to wool growers carrying fewer sheep.

I do have to wonder if the authors have actually read the numerous papers on this topic or, if they did, I wonder if they were written so poorly that they did not understand them. Since the papers were refereed and managed by editors, being poorly written is arguably not the case.

Assumption 'c'. The authors identify as an assumption underpinning "*the sheep replacement concept and the eating of kangaroo meat on environmental grounds*" that "*destocking will lead to a sufficient increase in numbers of kangaroos to service demand for red meat formerly supplied from sheep*". This is nonsense. As I said above, the sheep in the rangelands are

mostly producing wool, not mutton and lamb. The notion that lowering sheep in the rangelands will need an increase in kangaroos to fill some meat supply gap is absurd. But the authors seem to have taken the idea to an extreme, implying that kangaroos will have to increase in numbers sufficient to meet the whole of Australia's lamb and mutton consumption and, in places, the whole red meat requirement! I have said repeatedly in my publications that the maximum reasonable sustainable harvest that could be expected from our kangaroo populations would provide about 2% of Australia's red meat consumption requirements (so butchers do not need to feel threatened!).

What does the MS say about this assumption? It reports tortuous calculations leading to the conclusion that a complete replacement of the red meat requirements by kangaroos was not possible. D'oh! We knew that in 1987.

Assumption 'd'. Yes, this is fair enough. Sustainable use of wildlife should always have appropriate regulations and harvest limits set in relation to good data on trends in numbers and taking seasonal conditions into account. Indeed, the Australasian Wildlife Management Society, Ecological Society of Australia and Australian Mammal Society all have Position Statements on the sustainable use of wildlife which emphasise these elements very strongly, as do all of the State kangaroo management plans. There are now more than 25 years of experience in regulating the modern kangaroo industry, and the track record is actually pretty good. There are regular aerial surveys, quotas are set annually and state kangaroo management plans are reviewed periodically with input from stakeholders and the general public. With the continual focus on and criticism of the kangaroo industry I have little doubt that these will always be under close scrutiny.

The MS draws attention to several cases where quotas were unwittingly exceeded, but this is now less likely under better tag management. The MS is correct in pointing out that the present system is largely untested because quotas are rarely taken. Indeed, with filled quotas being a precursor for the future scenario I envision, the regulatory mechanisms will need to be robust (as I have often said and several times written). There is, however, some experience to go on, because there have been cases where quotas have been fully taken earlier in a year than shooters expected, and applications were lodged for an increase to the quotas. So far the agencies have stood firm, but I agree with the authors that this will be crucial.

Please note that only the last one of these four assumptions is actually relevant to the current industry.

Finally

Scientists learn to live with their work or speculations being misunderstood and misinterpreted. Usually such misunderstandings are genuine and one tries to clarify things in subsequent writing or, if shown to be wrong, to accept it. In this case, one interpretation is that the authors did not read and understand properly the papers they cited. Another interpretation is that information has been cherry picked and misinterpreted to suit a particular philosophy, so it becomes an 'opinion piece'. If the first case is correct, the document is poor scholarship. If the latter, it is also dishonest because, while there is nothing wrong with expressing opinions, they should be so identified and it is dishonest to dress opinion up as science. In either case, the MS as presented does not, in my opinion, qualify as acceptable for publication in a scientific publication.

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Comments for the editor

As you will judge from my Comments to Authors, I cannot recommend this for publication in its present form. As written, it confounds the current kangaroo industry and a putative future kangaroo industry so it is logically flawed and is therefore not good science. An objective assessment of either or both of these could be worthwhile, and you may like to encourage the authors to set their minds to that. I doubt, however, that they would be interested in bringing to their discussion the objectivity that this would require. Should they decide to do so, I would be willing to look at a revised version.

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Breaking the siege: guidelines for struggle in science

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ABSTRACT

When scientists come under attack, it is predictable that the attackers will use methods to minimise public outrage over the attack, including covering up the action, devaluing the target, reinterpreting what is happening, using official processes to give an appearance of justice, and intimidating people involved. To be effective in countering attacks, it is valuable to challenge each of these methods, namely by exposing actions, validating targets, interpreting actions as unfair, mobilising support and not relying on official channels, and standing up to intimidation. On a wider scale, science is constantly under siege from vested interests, especially governments and corporations wanting to use scientists and their findings to serve their agendas at the expense of the public interest. To challenge this system of institutionalised bias, the same sorts of methods can be used.

Key words: science; dissent; methods of attack; methods of resistance; vested interests

Scientists and science under siege

In 1969, Clyde Manwell was appointed to the second chair of zoology at the University of Adelaide. By present-day terminology he was an environmentalist, but at the time this term was little known and taking an environmental stand was uncommon for a scientist. Many senior figures in government, business and universities saw such stands as highly threatening. In 1971, Manwell and his wife Ann Baker wrote a letter to the Adelaide *Advertiser* criticising aspects of the South Australian government's fruit-fly spraying programme. The senior professor and head of the Department of Zoology at the university, H. G. Andrewartha, complained to the Vice-Chancellor, leading to an attempt to dismiss Manwell. The saga lasted four years and involved everything from inquiries to student protests. The attack on Manwell can be interpreted as serving the interests of a pesticide-industry establishment threatened by criticism from a reputable scientist.

Scientists can feel under pressure, not just to do good research, but to conform to outside demands, sometimes unwelcome or even abhorrent. For example, they may be told to change their research directions, to keep quiet about findings, to alter wording in their papers or to say nothing while results are misrepresented. If they speak out, they may be threatened, reprimanded, publicly attacked or even lose their jobs.

Science can be said to be under siege when outside pressures influence or force scientists to serve goals other than truth and the public interest. There is plenty of evidence that science is and has been under siege. For example, in a survey of Australian scientists in the 1990s, more than half answered yes to the question "Do you believe that scientists may jeopardise their career prospects or research funding success by speaking out on environmental issues?" (Wilson and Barnes 1995) — and less than one in five said no. Numerous environmental scientists have come under attack because of their research or speaking out about it (Kuehn 2004). On some topics, such as nuclear power and fluoridation, it can be very risky for scientists to take a view contrary to the dominant one (Freeman 1981; Waldbott 1965). In some countries, any scientific dissent that challenges government positions can lead to discrimination or worse (Schoijet and Worthington 1993).

Overall, there is quite a lot of evidence of suppression of dissent (Martin 1999). It has gone on for decades, but most working scientists ignore it as long as it doesn't affect them personally. Sometimes, though, entire communities become aware and concerned because of the blatant and wide-ranging nature of the attacks on scientists, such as in the US under the George W. Bush administration (Mooney 2005), though there is plenty of evidence of similar problems in earlier times (Boffey 1975; Deyo *et al.* 1997; Primack and von Hippel 1974; Wilkinson 1998).

I will take for granted that there are ongoing pressures on scientists to serve vested interests. My focus here is on how to respond. There is surprisingly little attention to methods and strategies for defending dissent, by scientists or others. I present the backfire framework, a way of understanding methods used by perpetrators of perceived injustice. I apply this framework first to the Manwell case and then to the big picture of the relationship between powerful groups and science. In conclusion, I outline the normal assumptions made by apolitical scientists, contrasting them with a more engaged approach for breaking the siege.

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The backfire framework

When people think someone has done something wrong, they often become concerned, disgusted or outraged. What can the perpetrator do to minimise this adverse reaction? An ordinary perpetrator — a house thief, for example — usually can do this only by disguising the action or by hiding, namely not getting caught. Powerful perpetrators — such as governments — have more options. There are five main ways they can reduce outrage:

- cover up the action
- devalue the target
- reinterpret what happened by lying, minimising the consequences, blaming others or using a framework that puts things in a favourable light
- use official channels that give an appearance of justice
- intimidate or bribe people involved.

These same five sorts of methods are found in all sorts of arenas, including bullying, censorship, unfair dismissals, police beatings, massacres, torture and wars (Martin 2007).

If you oppose the unfair treatment, you can respond to every one of these methods:

- expose the action
- validate the target
- interpret what happened as unjust
- avoid official channels; instead, mobilise support
- resist intimidation and bribery.

This framework of methods provides a way of understanding struggles in science. First consider the attack on Clyde Manwell.

The Manwell case

Clyde Manwell's apparent offence, in the eyes of his attackers, was to question the orthodoxy about use of pesticides. Others had openly criticised the fruit-fly spraying programme, but Manwell was the first to do so who had strong scientific credentials — being a professor of zoology at the leading university in Adelaide. Other critics could be dismissed as ill-informed. Manwell could not be so easily ignored. (For information on the Manwell case, see Badger 1986; Baker 1986.)

The legitimate approach would have been an open discussion of the issues. Professor Andrewartha could have approached Manwell as a peer to discuss differences. Or he could have written his own letter to the Adelaide *Advertiser.* Instead, he wrote to the Vice-Chancellor to make a complaint. Furthermore, his letter was confidential. So far as the wider public and scientific community were concerned, this was a form of *cover-up*: Andrewartha's attack was behind the scenes.

Shortly after Manwell and Baker's letter to the newspaper was published, Manwell was criticised in state parliament. This was a method of *devaluation.* For example, one of Manwell's parliamentary critics, H. K. Kemp, speaking in the South Australian Legislative Council on 11 March 1971, said "To see this system [of fruit fly control], which has been built up over the years and proved capable of doing the job, being capriciously endangered by the actions of one man, who cannot be ignorant of the implications of his actions, is a sad thing indeed." Later during the saga, one of the members of the University Council — who was also a colleague in the Zoology Department — recommended to Manwell that he see a psychiatrist, and offered the names of three. Suggesting that Manwell was mentally ill was also a form of devaluation.

Andrewartha's initial letter to the Vice-Chancellor was entirely about Manwell's letter to the *Advertiser.* Andrewartha followed up with another letter to the Vice-Chancellor, raising several other matters including that there were errors in Manwell and Baker's recently published book and that Manwell had presented inappropriate material in four lectures. These other matters became the subject of considerable scrutiny. This could be considered to be an attempt at *reinterpretation.* Andrewartha's main concern was Manwell's public criticism of pesticides; by introducing complaints about other aspects of Manwell's performance, the attack on Manwell could proceed under a different guise, avoiding the key issue of free speech.

Andrewartha's attack was made through *official channels*, namely complaints to the Vice-Chancellor. The University Council set up a Commission of Inquiry to look into the allegations. The Commission and the Council found that even if the allegations were true, they did not warrant any penalties via university rules. Subsequently the Council appointed a committee of three academics to deal with residual problems in the Zoology Department — but this committee never examined the accuracy of Andrewartha's accusations.

Manwell also used an official channel: he sued Andrewartha for libel. This had the effect of reducing public discussion of the issues, which could be said to be *sub judice.* This was probably one of the factors that made the affair drag out: it was 1975 before it was resolved. The settlement of the case did not eliminate Manwell's problems: he remained the second professor of zoology, in a department run by Andrewartha. Manwell did not know at the time that his predecessor, the previous second professor of zoology, had also had a conflict with Andrewartha, but in that case the university administration had resolved the conflict by moving the second professor out of the department, away from Andrewartha's authority.

A primary form of *intimidation* in this case was the possibility that Manwell might be dismissed. He also suffered harassment, for example being denied honours students, having his third-year course on comparative biochemistry and pollution unilaterally cancelled by the head of department, and receiving anonymous threats of violence. He was also denied research funding (Manwell 1979).

Manwell survived. It's worth looking at the counter-methods he and his supporters used.

The counter to cover-up is *exposure.* Andrewartha's letter and much else about the case were revealed in articles in the student newspaper *On Dit.*

The counter to devaluation is *validation.* Manwell's cause would have been assisted if prominent figures had come to his defence. Apparently this did not occur in parliament. However, a number of university colleagues privately complained about his treatment and 30 from outside Australia wrote letters in his defence.

The counter to reinterpretation is *interpreting the attack as unjust.* Manwell and Baker in their subsequent writings focused on their challenge to pesticide interests, relegating the other complaints by Andrewartha, for example about teaching, to secondary status.

The counter to official channels is to avoid them and instead to *mobilise support.* Powerful support for Manwell came from students; hundreds of them — and some staff members — attended a meeting and forced the closed Commission of Inquiry to be public. However, Manwell himself used official channels when he sued Andrewartha for libel. This limited the capacity for mobilising support because many people expected the courts to provide justice.

The counter to intimidation is *resistance.* Rather than giving up and leaving, or keeping quiet about his concerns about pesticides, Manwell refused to acquiesce. In the following decades he continued his criticisms of pesticides and agriculture more generally (Baker and Manwell 1988; Manwell and Baker 1988). Furthermore, he provided inspiration to many others by writing articles about suppression (e.g. Manwell 1978) and corresponding with other dissidents in science (Hawkeswood 2010). Manwell and Baker helped put suppression of dissent in science on the map in Australia (Martin *et al.* 1986).

The Manwell case is full of complexities — as indeed are most cases. I have not addressed many of the factors involved, for example the personalities of key individuals. In describing a case such as this, there is a risk of giving a picture that is one-dimensional, with one side — the dissident and supporters — portrayed as virtuous and flawless and the other side — the attackers — portrayed as nasty schemers. Actually, in struggles of this sort all participants commonly believe they are doing the right thing. Andrewartha should be remembered for more than his conflict with Manwell: he was a prominent scientist who made significant contributions to population ecology (Birch and Browning 1993). My aim in using the Manwell case is to illustrate methods used in struggles involving dissent.

Advice for dissidents

To be able to defend dissent, it's useful to see beyond the peculiarities of individual cases to the regular patterns and to develop an effective strategy.

Any scientist can come under attack. Public dissidents are simply at greater risk. Others are targeted because of their race, gender or personal style, are picked on by a bully or simply are in the wrong place at the wrong time. Scientists who think "It couldn't happen to me" are especially vulnerable when it does.

To begin, it is useful to understand that power struggles in science are like power struggles anywhere: the game is about power, not rationality. Be prepared for the other side to play unfairly. In Manwell's court case, the university accused Baker of working too many hours and produced a carbon copy of a typed contract showing a stipulated condition at the bottom. Luckily for Baker, she was able to produce the original — and the stipulated condition was not there. Someone had falsified the carbon copy. These days this sort of thing would be done electronically.

Be prepared for the other side to use the five methods of inhibiting outrage: cover-up, devaluation, reinterpretation, official channels, and intimidation — and be prepared to counter each of these methods. Quite a few dissidents acquiesce too easily and play their opponents' game.

The fewer people who know about the attack, the more easily perpetrators can get away with it. Many targets are reluctant to speak out, often because they are embarrassed or humiliated by what is being done to them. They hope things will improve without publicity — so they keep quiet. Alternatively, they might make a complaint to a superior, write a letter to a professional body or make a complaint to a grievance body — in other words, they hope for justice within the system using official channels. These are two common responses, and they are seldom effective. They are usually quite helpful to the attacker.

I've talked to numerous whistleblowers who think their own cases are different: they know truth is on their side and that anyone can see it, so they believe going to the ombudsman or some other agency will vindicate them. Nine times out of ten, they're wrong (De Maria 1999). Truth is not enough.

For most scientists responding to attack, the most common mistakes — from the point of view of the backfire model — are acquiescing in cover-up and relying on official channels. However, taking the issue to wider audiences doesn't have to mean media coverage. A typical sequence of actions in mobilising support is to approach colleagues, meet with a few friends, develop a plan of action, prepare a short factual summary of events, show it to a few people to check it and see how well it communicates, circulate it to a selected distribution list, gather information about what's happening at work, take stock of the state of play and plan for the next step — if needed. Such a small-scale mobilisation of support helps to expose information in a controlled fashion, provides validation by bringing supporters on board, challenges the attacker's interpretation, avoids official channels and resists intimidation.

Dramatic, high-stakes attacks, such as the one against Manwell, are rare. Much more common are subtle forms of harassment and disadvantaging, such as difficulty in getting access to equipment, delays in obtaining approvals, heavier-than-usual teaching loads, derogatory rumours and unfair rejection of papers. Because these sorts of problems happen so often anyway, it's hard to prove any of these constitutes suppression of dissent. Manwell suffered a lot of this low-key harassment too.

Perhaps the most important step for anyone who feels under attack is to seek advice and support. Many targets start believing what others say about them. It's valuable to obtain opinions and help from others.

Many scientists are fortunate enough to go through their entire career and never experience a serious attack. This means it is hard to comprehend what's involved and sometimes hard to empathise with those who are attacked. Suffice it to say that it is far more traumatic than most people can imagine.

Many whistleblowers who suffer reprisals lose their jobs and sometimes their careers, but this is only part of the story: their health suffers, their relationships are put under severe stress and sometimes falter, and their very understanding of the world is thrown into turmoil. Prior to speaking out, many whistleblowers were conscientious, successful performers who believed the system worked. When suddenly they are attacked for doing a public service, their faith in the world is shattered, with no ready alternative (Alford 2001).

If one of your colleagues is under attack, you can provide a valuable service by trying to understand what it's like and, if they are willing to talk about it, by just listening. Doing more than this to help is valuable too, but you need to be careful: by supporting someone who has been targeted, you might become a target too.

Because only a few scientists come under direct attack, there's very little collective wisdom about how to respond. It would be like doing an experiment the very first time — you have to be lucky to get it to work, because usually trial and error are needed. But serious attacks are so rare that gaining experience is difficult. Therefore it is personally valuable to help a colleague or send a note of support to someone you've heard about through a media story.

One of the key elements of attacks is intimidation. Many targets are so frightened that they retreat, unwilling to stand up for themselves. However, the bigger impact of attacks is on third parties, namely everyone else who sees what happens and becomes afraid to step out of line. The way to challenge this is to resist. The same demonstration effect applies: each person who resists and develops an effective strategy becomes an inspiration to others. Manwell's resistance inspired many at the time and continues to be an example of how to oppose suppression of dissent.

When under attack, sometimes the wisest strategy is not to resist, instead acquiescing or leaving. Each individual has to weigh various factors, including the risk to their career, their psychological resources, likely allies and opponents, and consequences for colleagues and families. There is no single course of action best for everyone in every circumstance.

When a scientist does decide to fight, there are no guarantees. Even the best methods may not be enough against a powerful opponent. What can be said, though, is that studies of many struggles offer some general principles that make success more likely. The single guiding principle is to mobilise support. That means documenting the case carefully and accurately and making information known to others. It means behaving ethically, because that is more likely to win support in the long run. It means being clear about the issues at stake and concentrating on the ones of broad significance. It means not relying on official channels, because they put the matter in forums where wider support is less relevant. It means refusing to be intimidated, demonstrating to others that resistance is possible.

For a single scientist to resist attack is important, both personally and for inspiring others. But the challenges for science go beyond individual attacks. It is time to look at a broader picture using the same strategic framework.

Science under siege: the bigger picture

The common picture of science is that it is neutral. Scientists are searching for the truth, not to serve any particular agenda. As long as scientists verify their findings and publish them, their job is done. Cases such as Manwell's are unwelcome departures from the norm.

There's another picture: knowledge and power are inevitably intermixed. Powerful groups — governments and large corporations — fund research areas they are interested in. They pick the results that serve their interests and ignore others. This is what is meant by the saying that "science is political" (Arditti *et al.* 1980; Dickson 1984; Rose and Rose 1976a, b).

The status of scientific research depends heavily on its image as being neutral. People are more likely to trust science if it is seen as independent of vested interests. Therefore, powerful patrons of science have much to gain by hiding or legitimising their role. If people realised research agendas are being shaped by special interests, they might be upset. So it can be predicted that the powerful patrons of science will use the five methods of inhibiting outrage.

Cover-up The attention in scientific journals and media accounts is almost entirely on research that is actually done. There is far less attention to research that isn't done. If funding is available in an area, scientists can be found to work on it; if there's no funding, few scientists will take the initiative to pursue it. The result is that there are whole areas of what can be called "undone science" (Hess 2006). For example, there's lots of medical funding for diseases in rich countries and relatively little for far more lethal diseases affecting poor people. There is vastly more funding for new drugs than into uses of substances that can't be patented. There is far more funding for centralised energy sources like nuclear power and coal than for energy efficiency and decentralised renewable energy sources. There are lots of neglected research areas — areas of undone science — but this process and consequence are usually invisible.

Devaluation Critics of the way science operates, especially those who question the power structure of science, are portrayed as political, even as "anti-science." Dissidents of all sorts are dismissed as unscientific.

The scientists who are valued, in the normal conception, are those who keep quiet and do their jobs, even if that means taking grants from corporations whose products they are studying. Conflicts of interest are seldom a source of concern as long as they are in the service of powerful groups.

Going public is somehow seen to demean the credibility of a scientist as a scientist, in the eyes of other scientists. Those who popularise science are usually seen as less serious about their research.

Reinterpretation Scientists carry out their work through a set of conventions about how the world works, how research should be done and how to present the findings. Thomas Kuhn's idea of a scientific paradigm captured this idea. Subsequent scholars have qualified and modified Kuhn's conception, but the basic insight remains: scientists approach their task through a set of preconceptions or assumptions. These provide criteria for assessing what counts as good research and valid knowledge.

What Kuhn and most of his successors left out of the picture is the connection between prevailing sets of scientific ideas and powerful groups in society. An industry can provide funding and potential jobs for those who adopt a research programme that is industry-friendly, with potential dangers awaiting those who challenge the programme. Manwell learned this when he questioned what could be called the pesticide paradigm, a framework for research in the field in which questions about the effectiveness of pesticides were legitimate but alternative ways of dealing with pests were not.

Scientists adhering to the dominant way of thinking about issues are completely sincere. That is what makes paradigms so effective: they infiltrate the very criteria that scientists use to assess the significance of problems, the appropriateness of research methods and the characteristics of knowledge. It makes them acutely sensitive to the weaknesses of alternative approaches while often unaware of the shortcomings of their own viewpoints.

This process is most effective when paradigms and powerful interests are closely aligned, as with genetic engineering. However, sometimes there is a clash, as with climate change, in which the dominant scientific view is contrary to the interests of the fossil fuel industry. Scientists who question climate-change orthodoxy receive far more attention — and industry support — than those who question genetic engineering orthodoxy. (On the latter, see Delborne 2008.)

Official channels Scientific journals, scientific societies and research organisations serve to define the appropriate way to do science. An orthodox scientific career operates within a standard pattern of taking courses, apprenticeship as a research student and jobs as scientists. It is rare for anyone to succeed in science following a different path, for example being self-taught or researching outside the conventional career structure. Publishing outside the standard journals offers little credibility.

The standard system makes it easier for scientists to accept the role of dominant groups — governments, big corporations and scientific elites — in setting research agendas and criteria for acceptable knowledge. Within the official system, researchers with different agendas often have to struggle for credibility.

There are alternatives. In community research, done by activists and community members to pursue topics of local relevance, there is attention to environmental, health and social issues often neglected by mainstream science.

Suppression Those who challenge the system are at risk of being attacked. Dissent is welcomed as long as it is within the system parameters. The Manwell case is just one of thousands.

Responding

Given this picture of the power dynamics of science, what does it imply for working scientists? First consider the normal assumptions of scientists who are apolitical: they would prefer to ignore power dynamics and get on with their research. Here are some typical attitudes:

- My job is to do good science.
- If my research has social relevance, my task is to present the facts. I shouldn't be political.
- I should leave judgements and struggles to others.
- If, despite my caution, I come under attack, then I'll acquiesce, namely change my research or keep a lower profile.

These sorts of attitudes are typical of the loyal employee who believes those running the enterprise are capable and trustworthy. Scientists often see the "enterprise" as science itself and believe their loyalty is to its normal operation.

This would be fine if science, as a social institution, was indeed a dispassionate search for the truth. But if, instead, powerful groups are shaping and benefiting from the way science is organised — and benefiting from the perception that science is neutral — then the typical attitudes serve these powerful groups.

Consider then an alternative approach, based on challenging each of the five methods of inhibiting outrage.

- Expose what science is and isn't done. For example, reveal the role of military or corporate sponsors and point out areas of public interest where little research is being done.
- Validate scientists who do research and speak out in the public interest. For example, point out that they are free of conflicts of interest affecting other scientists.
- Question assumptions underpinning conventional research. Explain how paradigms can be aligned with the interests of powerful groups.
- Mobilise for change and don't rely on scientific elites to do it.
- Resist attacks and help others to resist.

When large numbers of scientists mount a challenge along these lines, it often means supporting a social movement. Very occasionally, scientist-activists become a social movement themselves.

- Scientists in several countries in the 1940s and 1950s mobilised for science in the public interest. However, these movements were crushed by governments in the emerging cold war.
- Scientists have supported environmental campaigns for decades. Indeed, some environmental research preceded and helped stimulate the rise of the environmental movement in the 1960s.

- Scientists and engineers critical of nuclear power were crucial players in anti-nuclear campaigns from the 1960s onwards.
- Scientist critics of the US "star wars" anti-missile system proposed in the 1980s campaigned in parallel with the anti-nuclear-war movement of the time.
- Scientists have played key roles in challenging dangers from tobacco, lead and other substances, taking on powerful industries.
- Climate change scientists have confronted a vociferous denial campaign underwritten by fossil fuel interests.
- Outspoken scientists have challenged the Bush administration's pressures to manipulate science for corporate goals.

Many of these campaigns seem to be mainly about the applications of science. But the struggles sometimes got down to the level of hypotheses and data analysis. For example, the debate over nuclear power included disagreements about the effect of low-level ionising radiation, including the shape of the dose-response curve (Diesendorf 1982).

The historical pattern seems to be that science is always under siege, in the sense that powerful groups want science to serve their special interests at the expense of wider social goals. However, few scientists recognise this as much of a problem, because of the methods of inhibiting outrage: the influences on science are hidden, dissidents are devalued, the job of scientists is perceived to be doing good science, scientific elites are available to take care of the politics, and challengers are intimidated. In a few periods, though, there is a wider perception of threat, when the pressures become too blatant or when scientists become aware and empowered by mobilisations in other parts of society. In other words, when citizens become concerned about an issue, their concern can rub off on scientists.

Conclusions

Individual scientists occasionally come under direct attack because of their research or public statements. This is often a tremendous shock, and it is not obvious what to do because it doesn't happen often — and who would want to gain experience by repeatedly coming under attack? Therefore, it is wise to learn from what happens to others.

In a wide range of injustices, powerful perpetrators regularly use the same sorts of methods: they hide their actions, devalue the target, reinterpret what happened in ways that minimise consequences and blame others, use official channels to give an appearance of justice, and intimidate or bribe people involved. By recognising these methods and countering each one of them, it is possible to be more effective in resistance. This doesn't make the struggle easy, nor is it a guarantee of success, but it can increase the odds of being effective. It's also important to know when to acquiesce and when to resist.

However, pressures on science are not just on individuals — they are systemic. Science has always been shaped by social forces, especially by powerful patrons. Today that means mostly governments and corporations that fund research. Usually this state of affairs seems normal. By using a variety of techniques, dominant groups — including most scientific elites — minimise awareness and concern about the way scientific agendas are shaped.

The idea that science can be pure and separate from society is an illusion. Research is always embedded in society: it is funded from social resources, it is carried out by social beings (scientists are human), its agendas are influenced by prevailing ideas and it has social consequences. The goal should not be a pure, independent science but rather a science that is shaped by and serves a desirable conception of society.

Science is inherently contentious, just as the way society operates is inherently contentious. That means scientists need to make choices. The default option is to accept the way things are, without questioning or resistance. The more active option is to take a stand. And if you're going to take a stand, you should try to be as effective as possible.

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