Quadrant readers will remember America's 'science wars', spearheaded by the masterful Sokal hoax, a "hodgepodge of unsupported arguments, outright mistakes, and impenetrable jargon" designed to challenge standards of logic, truth and intellectual inquiry in scientific debate.[1] It is a great shame Australia never had its own overt science wars, because the issues that raged in these wars weigh even more pressingly today in this country. We need a public debate of this kind because our political leaders, the media that reports science, and the public consumers of the products of scientific research are all operating with dated (and in some cases dangerous) assumptions and agendas.

The MMR (measles, mumps and rubella) vaccine scare in Britain perhaps best exemplifies one extreme of this. At the heart of the scare was a perfectly legitimate study which identified a link between childhood vaccination and a virus found in the stomachs of autistic children. This finding, when reported, attracted attention disproportionate to its import, finally gathering so much momentum it led to widespread fear that vaccines directly cause autism. Ultimately, the scare led to public mistrust of all vaccines. Worse, after the original research was misrepresented in the media, it was subsequently also 'debunked' in the media — leading to more mistrust in science. As *Bad Science* author Dr Ben Goldacre noted:

> Now, even though popular belief in the MMR scare is — perhaps — starting to fade, popular understanding of it remains minimal: people periodically come up to me and say, isn't it funny how that Wakefield MMR paper turned out to be bad science after all? And I say: no. The paper always was and still remains a perfectly good small case series report, but it was systematically misrepresented as being more than that, by media that are incapable of interpreting and reporting scientific data.[2]

In Australian media, a key problem is that any science innovation is very difficult to unpack in a newspaper dial-a-quote or radio sound byte — and outside of a handful of newspaper supplements and leftist publications like *The Monthly*, Australia doesn't publish science essays longer than 5,000 words. In addition, science literacy among politicians, journalists and the public rarely accords with the sophistication of the scientific data being accessed. What has become unspeakable is that journalists and their

[1] Alan D Sokal *The Sokal Hoax: The Sham That Shook The Academy*, University of Nebraska Press (2000).
[2] Goldacre, Ben 'Don't Dumb Me Down', *The Guardian*, Thursday 8 September, 2005.

publics, like small children reaching for the medicine cabinet, do not always understand what is best.

Here is an Australian case in point. Some criticism has been directed to what is seen as Prime Minister Rudd's shameless populist tactic of inviting 'ordinary' Australians to the Labor government's 2020 Ideas Summit.[3] Even before Mr Rudd was elected, the then Opposition Leader displayed a populist answer to the fraught issue of genetic modification (GM) of crop plants:

> Labor recognises ongoing community concern about genetically modified crops being grown in Australia… A Rudd Labor government will ensure that the assessment process for GM license application is based on rigorous science, and that any evidence presented to support claims is subject to peer review *and thorough public consultation*… standards must be met to the satisfaction of the scientific community [and] *the consumer community*. [My italics.][4]

It sounds most reasonable and democratic — and it certainly follows the campaign by those in employed in the growing field of science sociology. For example, in his new book, *Edging towards BioUtopia: A New Politics Towards Re-ordering Life and the Democratic Challenge*, Griffith University sociologist Richard Hindmarsh argues that policy about genetic engineering should rest on public opinion. "Australian decision-making needs… active public inclusion for the best environmental, social, and technological decisions," he argues.[5] Yet if this were to occur, and if Prime Minister Rudd is as good as his word, there will be no new GM licenses approved in Australia. Not one. If indeed standards must be met to the "satisfaction… of the consumer community", innovation will be halted immediately.

When blood started being successfully transfused early last century and organs started being transplanted in the fifties and sixties, there was fierce mainstream community

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[3] For example, see Dennis Shanahan, 'Hard to reject what the best have to say', *The Australian*, 29 February 2008, available on http://blogs.theaustralian.news.com.au/dennisshanahan/index.php/theaustralian/comments/hard_to_reject_what_the_best_have_to_say, accessed 10 March 2008.

[4] See ALP National Platform and Constitution 2007, Chapter 10: Improving Health and Well-Being: A Health System that Delivers, available on http://www.alp.org.au/platform/chapter_10.php

[5] Hindmarsh, Richard Hindmarsh, *Edging Towards BioUtopia: A New Politics of Reordering Life & the Democratic Challenge*, University of Western Australia Press (UWAP), Perth, 2008.

objection, including (or especially) from the churches.[6] Likewise, today, between 70 and 90 per cent of Australians oppose GM food[7] because of an equally profound misunderstanding of the science, and the ethics surrounding that science.

When considering why the public is overwhelmingly against GM food, it is useful to keep in mind that we live in a society in which there are 20 times as many astrologers as astronomers.[8] Even those in the science professions hold deep-seated beliefs that run contrary to empirical evidence — for example, the oft-reported belief that infertile couples are more likely to conceive once they have adopted a child; or the erroneous belief in maternity wards that more babies are born during the full moon.[9]

Our chief scientist, CSIRO head Dr Jim Peacock, has called those who oppose GM "unprincipled minorities" and "ignorant".[10] As much as I admire Dr Peacock, I disagree with him on this point. Evidence consistently suggests opponents of GM are in fact the majority of Australians, and as Thomas Gilovich argues, people "do not hold questionable beliefs simply because they are stupid and gullible." Conversely, most people's ideas are not the product of irrationality, but of flawed rationality:

> So it is with the erroneous belief that infertile couples who adopt are subsequently more likely to conceive. Our attention is automatically drawn to the couples who conceive after adopting, but not to those who adopt but do not conceive, or those who conceive without adopting. Thus, to many people, the increased fertility of couples who adopt a child is a "fact" of everyday experience.[11]

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[6] For a very readable account of this, refer to Mary Roach's Stiff: The Curious Lives of Human Cadavers, Penguin Books, 2004.

[7] In polls taken by AC Neilson, Roy Morgan, Millward Brown, Swinburne University and *Choice* magazine a vast majority of Australians did not want to eat GM foods. A Biotechnology Australia 2006 study found that "The Australian public see great risks from GM foods and crops and concerns are continuing to rise." 80% of farmers surveyed in a 2002 poll taken by the SA Farmers Federation support a ban on GM food crops, and in an August 2003 Biotechnology Australia poll 74% of farmers surveyed were not considering using GM crops. In a 2007 Sydney Morning Herald poll, 84 per cent of respondents rejected GM food.

[8] See *How We Know What Isn't So: The Fallibility of Human Reason in Everyday Life*, New York, The Free Press, 1993. Thomas Gilovich visited Australia for the 1999 Brisbane Writers' Festival 'Science and Society' sessions, and said his research indicated this was the case in Australia also.

[9] Ibid.

[10] See Chee Chee Leung, 'GM critics ignorant, says scientist', *The Age*, 16 May 2007, available at http://www.theage.com.au/news/national/gm-critics-ignorant-says-scientist/2007/05/15/1178995158653.html accessed 8 March 2008.

[11] Thomas Gilovich, How We Know What Isn't So: The Fallibility of Human Reason in Everyday Life.

And likewise the public's attention is drawn to media reports that startle them. People hold beliefs because they are consistent with the information that is available to them; and so it is for genetic modification of food crops. The information available, largely through the PR industry and mainstream media, is being influenced by a new trend in how science journalism sees its role — not as a promoter of greater public understanding of science, but as a filter through which science must be scrutinised using fourth estate principles of scrutinising power.[12] This ostensibly noble ideal can simply not be applied to scrutinise science.

It's often said that to mount an absolute argument, one has to take it to its logical extreme. So let us take GM food to its logical — or at least its most fearsome — extreme. Let us suppose Australia had plans to commercialise a variety of wheat engineered with human genes.

Too far-fetched a scenario? Not at all. Human genes are at present engineered into tobacco plants in order to produce a protein called Factor V111, and into rice crops to produce a protein that when consumed triggers human immune responses.[13]

A few years ago, buried within a footnote of an article in the *Plant Biotechnology Journal* was an astonishing revelation.[14] Researchers at CSIRO had, according to the reference, abandoned plans to commercialise a variety of wheat that had been engineered with human genes. The genes were responsible for helping trigger immune responses in humans. When eaten, the wheat could potentially trigger a body's immune response to fight pre-cancerous cells, but the company's annual report, according to the footnote, stated:

> [T]he transgenic wheat was abandoned because of the potential of perceived moral issues among the public.

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[12] See Salleh and Hindmarsh, Op. Cit.
[13] USDA Backs Production of Rice With Human Genes By Rick Weiss Washington Post Staff Writer Friday, March 2, 2007; Page A02.
[14] Ajith Anand, Harold N. Trick, Bikram S. Gill, Subbaratnam Muthukrishnan 'Stable transgene expression and random gene silencing in wheat' *Plant Biotechnology Journal* Vol. 1 Issue 4 Page 241 July 2003, endnote 23.

A trawl through two of CSIRO's annual reports[15] reveals that the organisation had previously abandoned plans to commercialise two other projects which involved modifying organisms with an array of human gene sequences. One was a project that developed transgenic dairy cattle so they produced milk not allergenic to lactose-intolerant infants and those displaying other gastrointestinal symptoms when consuming cows' milk. Another was modification of malaria mosquitoes so they carry genes which produce human antibodies in their gut; thus rendering their bite less dangerous. Commercialisation of both these projects was abandoned along with the wheat project, possibly — if the claims in the *Plant Biotechnology Journal* are anything to go by — because of perceived ethical issues in the public and media perception.[16]

I hope to convince readers that, no matter what their faith or moral compass, arguing against the inclusion of human genes in crops or organisms on moral grounds rests on a misunderstanding of genetic science. It seems counter-intuitive, but I will briefly attempt to demonstrate this by explaining the very basics in a way that newspaper articles have failed to.

As any science sociologist will tell you, science can reduce life to the level of a mechanist's logic. And of course, this is true: a full understanding of life cannot be understood simply from amino acid patterns. Physics, chemistry and biology alone cannot alone explain the grace of living systems. Religion and humanity also suggest there is more to us — and all living creatures — than the sum of our quantifiable parts.

Contrary to the impression one may get from newspapers, scientists — including geneticists — agree with this view. Indeed, geneticists first pointed out that 99 per cent of our genes are not 'human' at all. That is, they exist in other creatures. We share about a third of our DNA with some fungi, for example, or with a yeast cell. We share around 98 per cent of our DNA with a chimpanzee — suggesting that there is very little about us, at this molecular level, that makes us 'human'. A few years ago the Human Genome Project decoded the human genome, producing an epic sequence of genes that make up our DNA. More recently, the chimpanzee genome was revealed. When the two per cent of differing genes was analysed, a startling revelation emerged.

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[15] CSIRO Annual Report 1998-1999; CSIRO Annual Reprot 1999-2000.

[16] When I visited CSIRO archives I attempted to enquire about this but the research's original authors had since left the organisation. CSIRO's Media Centre could not tell me whether or not this was the case.

Unexpectedly, the two per cent difference between chimps and humans mainly concerned not 'human' traits like brain development. Instead, much of the genetic differences between us and chimps lie in the gene coding for olfactory receptors. In short, chimps have a better sense of smell, and our 'humanity' — our ability to be moved to tears by Schubert, or to imagine a feat of engineering — appears not to be all that anchored in our genes.

So close are humans genetically to other organisms that the insulin manufactured by our pancreas, containing 52 amino acids, differs only in a two amino acids from the insulin manufactured in a bovine pancreas, and only in a single amino-acid from the insulin manufactured in a porcine pancreas. Thus, diabetics around the world are now daily injecting insulin derived from pigs but altered with genetically modified bacterium to get the final amino acid right.

So, to help us create a desired gene trait in a pharmaceutical, if we extract a gene sequence from a human that may be identical to that in (for example) a corn plant or a fruit fly — are we really extracting 'human-ness' at all?

By now the reader may rightly ask, "But if these gene sequences are indeed identical or almost identical to those in other creatures, why engineer with human genes at all? Why not use a gene sequence from another creature?" Ah! This is the labyrinthine science that the news media — with its emphasis on brevity and lay language — simply cannot explain. Short answer: because it's easier, less expensive and less risky.

Yet I will attempt to also summarise with a slightly longer answer, and hope not to suck the reader too far in to a microbial black hole. Human DNA is considered the 'instruction book' for the human body. And yet genes themselves need their own instruction books. As most of us understand from popular crime shows, the DNA scraped from the cells of a murder suspect's tongue will be identical to the DNA taken from the cells in a hair he left at the crime scene. Yet despite their identical DNA, somehow each cell 'knew' how to become hair or tongue, liver or skin.

This is because of what could be regarded as our genes' own meta-genes: an array of chemical markers and switches that lie along the double-helix. These are known collectively as epigenome, and they switch on or off particular genes. It is because their attendant epiginome that make human gene sequences — rather than precisely the same or almost the same sequences extracted from animals — human. And it is (paradoxically, perhaps) because of the epigenome that they human genes are extracted and engineered into plant to produce desired antibody traits (for example).

So when these sequences carry the correct epigenome, there is a greater likelihood of 'correct' gene expression in the new GM organism, which will subsequently discard the human epigenome and carry its own. In other words, the new wheat organism needs the 'human' epigenes for its desired trait, but subsequently it will no longer carry a shred of 'human-ness' — it will discard the human element.[17]

So I am arguing for the inclusion of human genes in some food crops, insects and livestock. I am unsure whether or not I have communicated an adequate explanation as to why, in the preceding two paragraphs. Yet this may have as much to do with my communication skills than with the complexity of the science involved, which takes a geneticist years to comprehend. How, then, could our government and public comprehend it? One of the most troubling features of the Rudd government is that no cabinet ministers have tertiary qualifications in the science, technology, engineering or mathematics (STEM) disciplines. As Dr Trevor Evans, CEO of the Australian academy of Technological sciences and engineering (ATSE), has said, "[This] does raise questions about the Government's potential for science and technology uptake at a time when many of the key issues confronting Australia… have a science and technology disposition."[18]

Furthermore, scientific explanations, particularly those in the preceding two paragraphs, are neither newsworthy nor brief: two important traits in a media story. Moreover, they provide an answer that would be unacceptable to a newspaper science reporter.

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[17] See Khalil Kashkush, Moshe Feldman & Avraham A. Levy 'Transcriptional activation of retrotransposons alters the expression of adjacent genes in wheat', *Nature Genetics* 33, 102 - 106 (2002)
Department of Plant Sciences, The Weizmann Institute of Science, Published online: 16 December 2002; | doi:10.1038/ng1063.

[18] Evans, Trevor, 'Where's the new government's science background?', *Focus*, issue 148, Australian Academy of Technological Sciences and Engineering (ATSE), February 2008.

Why? If I were to report this story using fourth estate principles I would scrutinise and report not the detail of the science, but:

(1) The public/community groups' views on engineering human genes into food crops
(2) The financial interests behind the development of this science

Why not report these things? Isn't this the role of the media?

In the special case of science reporting, I would argue: no. Journalists and their publics quite simply don't always understand the science involved. Reporting views by lay activist groups may be a valuable way to document public (or interest group) sentiment, but is not always an appropriate way to reach empirical truths. The second point is that to perform the sort of scientific feat involved in genetic engineering takes monumental investment. For example, genetically engineered 'Golden Rice', developed to produce pro-vitamin A to prevent blindness in millions of malnourished children, was funded from four sources of public finance totalling US$100 million: the philanthropic Rockefeller Foundation, the Swiss Federal Institute of Technology, the European Community Biotech Program and the Swiss Federal Office for Education and Science. On top of this, there are many more stakeholders, including 70 company patent claims on the genes, genetic techniques, DNA sequences, and gene constructs used to make the Golden Rice. Naturally, no industry would invest in A GM crop without the prospect of future returns. Yet as we saw with a series of Fairfax media articles and ABC stories during Victoria's GM moratorium 'debate', the vast commercial interests in the scientific outcome were reported as in and of themselves sinister. The science was therefore lost in the story.

So I would like to propose a revised approach among journalists and politicians to science debates like GM issues. Instead of asking "who benefits?", journalists could be asking: "Who could be likely to benefit most in future?" Important in this approach is recognition that scientists are both the 'experts' and the 'public'. With the media's emphasis on conflict, scientists are generally portrayed as a more unified group than their opponents in the humanities, social sciences and activist circles. Yet we, too, have health questions, social questions, ethical questions. We do not exist in a rarefied

vacuum. (Indeed, many prominent scientists — including Nobel Laureates — have publicly questioned the benefits of GM technologies.) But great moral questions can only be done when the facts are laid out accurately. In applying their ethical calculus to complex scientific questions, the media and the public — and consequently, policy-makers — very often err.

• *An earlier version of this article was presented at the 19th International Conference on Genome Informatics in Brisbane. Dr Sharon Gould holds a PhD in Applied Science (Biotechnology), and works as a biotechnology informatics consultant.*