Institution: University of Sheffield

Unit of Assessment: 9 – Physics

Title of case study: Public engagement and science policy in the nanotechnology debate

1. Summary of the impact

Nanotechnology emerged as a subject of public concern in the mid '00s, raising the fear that it might become "the next GM" – a potentially valuable technology becoming mired in controversy, based on widely publicised misconceptions about its nature and likely future trajectory. This has not happened in the UK; extensive public engagement activities, in which Jones was centrally involved, had a significant impact on the attitude of key NGOs and the wider public, raising the quality of debate about this potentially controversial new technology. The lessons learnt significantly influenced the development of science policy in the UK and elsewhere, with the first example of an explicit link between public engagement and the scoping of a significant funding programme. Professor Richard Jones's distinctive research programme in nanotechnology provided the basis which allowed him authoritatively to dismiss widely publicised visions of the future of nanotechnology, such as the idea of "grey goo", and to present a much more plausible range of outcomes, both positive and negative.

2. Underpinning research

Professor Jones's research group at Sheffield, working in collaboration with colleagues in the Chemistry department at Sheffield led by Professor A.J. Ryan, initiated a research programme in 2001, which exploited self-assembly and Brownian motion to create functional nanoscale materials and devices, including synthetic analogues to muscles and self-motile particles [**R1**, **R2**, **R3**, **R4**]. This was motivated by the realisation that the nanoscale devices of cell biology are based on design principles that exploit the special physics of the nanoscale world, design principles that are entirely unfamiliar in macroscopic engineering, but which could be used in principle in entirely synthetic systems.

This philosophy was outlined in Jones's 2004 book *Soft Machines: Nanotechnology and Life* (OUP), and the selected papers cited in Section 3 are examples of the group's experimental realisations of some of these ideas. The research has had sustained financial support from EPSRC, including "A synthetic self-motile vesicle" (EPSRC Adventure Fund 2003–06), "Soft Nanotechnology" (EPSRC Platform Grant, 2001–06, renewed 2006–12).

The importance of this approach to nanotechnology is that, by clarifying the proper analogy between cell biology and possible synthetic nanoscale machines and devices, it exposes the shortcomings of popular conceptions of nanotechnology arising from the work of K.E. Drexler, which underlie some of the overstated public concerns about the risks of radical nanotechnology, such as the possibility of out-of-control self-replicating nanomachines (the so-called "grey goo" problem, which gained public prominence in connection with public interventions in the debate by HRH the Prince of Wales in 2003).

Jones was awarded the Institute of Physics' Tabor Medal and Prize in 2009 "*for his more recent work in nanoscience, developing novel polymeric nanostructures and being involved with societal aspects of the field."*

3. References to the research [* = References that best indicate the quality of the research]

R1 Ryan, A.J., Crook, C.J., Howse, J.R., Topham, P., Jones, R.A.L., Geoghegan, M., Parnell, A.J., Ruiz-Perez, L., Martin, S.J., Cadby, A., Menelle, A., Webster, J.R.P., Gleeson, A.J., Bras, W. (2005). Responsive brushes and gels as components of soft nanotechnology. *Faraday Discussions,* 128, 55-74

R2* Howse, J.R., Topham, P., Crook, C.J., Jones, R.A.L. et al. (2006). Reciprocating power generation in a chemically driven synthetic muscle. *Nano Letters,* 6, 73-7 doi: 10.1021/nl0520617

R3* Howse, J.R., Jones, R.A.L., Ryan, A.J. et al. (2007). Self-motile colloidal particles: From directed propulsion to random walk. *Physical Review Letters,* 99, 048102 doi: 10.1103/PhysRevLett.99.048102

R4* Howse, J.R., Jones, R. A. L., Battaglia, G. et al. (2009). Templated formation of giant polymer vesicles with controlled size distributions. *Nature Materials,* 8, 507-11 doi: 10.1038/nmat2446

4. Details of the impact

Jones's public engagement work on nanotechnology has had distinct types of impact: it has improved the quality of public debate, including through its influence on the work of NGOs, and it has directly influenced science policy.

Jones has been involved in many science communication activities around nanotechnology since publishing a popular science book on the subject in 2004 (*Soft Machines: Nanotechnology and Life*, OUP), including lectures, Café Scientifiques and schools visits. He has maintained a blog (www.softmachines.org) concentrating on nanotechnology, public engagement and science policy, which has now accumulated 440 posts since it began in 2004, and currently attracts an average of 43,000 visits a month. He has written extensively in other media – some examples from the assessment period are given below. Since 2005 he has been involved in many two-way public dialogue events, including Nanojury UK and the Nanodialogues. He chaired the Nanotechnology Engagement Group, a body set up by UK Government to support the development of best practice in public engagement around nanotechnologies, and to ensure that public engagement feeds into policy and decision-making.**[S2]**

Between June 2007 and 2009, Jones was Senior Strategic Advisor for Nanotechnology at EPSRC **[S1]**, and in this capacity acted both as the public face for Research Council-funded nanotechnology in the UK and worked with the Research Councils to implement their nanotechnology strategy, which included an important role for public engagement. As Strategic Advisor, he was centrally involved in the commissioning of a public dialogue on nanomedicine, which was a highly innovative use of public engagement to inform science policy.

Specific examples of ways in which this engagement activity has had an impact on the awareness, attitudes and understanding of the public during the assessment period include:

1. *More realistic depictions of the future of nanotechnology, contra "grey goo" and nanobots*

Jones's research – with its emphasis on understanding the profound difference between the nanoscale design principles of cell biology and human-scale engineering – gave him the perspective needed to write what remains the most comprehensive and widely circulated critique of the popular, negative vision of nanotechnology. "Rupturing the Nanotech Rapture" appeared in the June 2008 edition of the US popular engineering magazine, *IEEE Spectrum* (300,000 circulation worldwide) **[S3]**. This counteracted the popular depiction of nanotechnology in the media, and in films, video games and comics, which derives from a particular vision of the future of the technology popularised by K. Eric Drexler. It is this vision of nanotechnology as conventional engineering scaled down to molecular scales that underlies popular tropes such as the idea of "*grey goo*" and medical "*nanobots*".

2. *Informing the public debate about nanotechnology in consumer products*

Jones's public engagement activities have been aimed at informing the public debate on nanotechnology, presenting a balanced assessment of the science while giving due weight to real risks and hazards, to help avoid a consumer backlash similar to that observed with GM foods. One particularly important theme has been the need to distinguish between engineering nanoparticles and self-assembled nanoparticles (of the kind studied in Jones's own research), which have quite different risk profiles. An example of Jones's popular writing on nanotechnology setting this general context was an article in *BBC Focus Magazine*, July 2008 (73,600 circulation). More reactive examples include a BBC Radio 5 live interview on 12 November 2008, setting in context a report from the Royal Commission on Environmental Pollution. When a paper was published on 20 May 2008 demonstrating the potential for some carbon nanotubes to have toxic effects analogous to those of asbestos, Jones briefed the Research Councils about the forthcoming paper, allowing them to prepare well-considered positions to the news when it emerged, and provided comments for the Science Media Centre, who summed up the resulting extensive press interest thus: *"despite the potential for a huge scare story the majority of coverage represented the research fairly."* **[S10]**

Jones had a sustained involvement with the consumer group *Which?* during a campaign about the use of nanotechnology in consumer products. He supplied background information for, and was extensively quoted in an article in the January 2008 *Which?* Magazine (circulation *ca.* 1.2 million), and was the scientific consultant for another article in November 2008, focusing specifically on cosmetics. *Which?* ran a Citizen's Jury on Nanotechnology, for which Jones acted on the steering group and appeared in person as a witness; he was a panel member, together with the Science Minister, at the public event that launched the results.**[S4**,**S5]**

In the potentially very sensitive area of the use of nanotechnology in food, Jones was the only academic invited to a round table at CIAA (Confederation of the Food and Drink Industries of the EU) on 19 September 2008. This involved food manufacturers, leading NGOs, and the European Commission. Jones spoke at a House of Lords Seminar on Nanotechnology on 4 November 2008, and gave both oral (30 June 2009) and written evidence to a subsequent House of Lords Science and Technology Sub-Committee on Nanotechnologies and Food. One area that Jones highlighted was the importance of nanostructures and nanoparticles in food that are naturally occurring or result from traditional food processing techniques (see final report, paras 5.27–5.32), resulting in recommendation 14: *"We recommend that, for regulatory purposes, any definition of 'nanomaterials' should exclude those created from natural food substances, except for nanomaterials that have been deliberately chosen or engineered to take advantage of their nanoscale properties."* This recommendation was accepted by government **[S6]**.

Causality, of course, is very difficult to prove, but it is notable that early fears of a GM-style campaign against nanotechnology in the UK have not materialised, and major NGOs in the UK have not come out in blanket opposition to the technology. For example, Greenpeace UK states *"Greenpeace does not have a stance on nanotechnology as a whole, because the applications will be too diverse… There may be some very beneficial uses of nanotechnology…."* **[S7]**. In contrast, a series of public debates on nanotechnology in France in 2010 had to be abandoned because of disruptive protests and nanotechnology labs in Mexico have been the subject of bombing attacks **[S8]**.

3. Influence on science policy nationally and internationally

As nanotechnology senior strategic advisor, and with the strong support of EPSRC's Societal Issues Panel, Jones was central to the commissioning, implementation and use of a major multi-site public ***engagement*** exercise as ***part*** of the framing of Nanomedicine Grand Challenge – the Nanomedicine Dialogue. This was an important and innovative experiment in the incorporation of public engagement in science policy. The current EPSRC Nanotechnology Landscape Document

[S9] states:

> *"The RS/RAEng report highlighted the importance of public engagement in this area, and this has led to a number of activities coordinated by Task Force 5 of the NRCG. EPSRC has involved its researchers in 2 public dialogues about nanotechnology, the latest of which fed public views and aspirations into the development of the Nanotechnology Grand Challenge in healthcare. This was groundbreaking in using the results of the public dialogue to help inform the choice of research area. This area benefits from having Professor Richard Jones as an ambassador for broader engagement. The public acceptability of research and nano products can often impact on their potential for commercialisation, further debate is likely on the risks versus benefits for areas where nanotechnology is seen to directly impact on human life e.g. food and drink, medicines, consumer goods, household care products, or the discussion into the use of nanosensors."*

This exercise has had a direct impact on Research Council policy, as demonstrated by a paper to EPSRC Council, 11 December 2008 (EPSRC57-08) on public dialogues, which summarises the recommendation of EPSRC's Societal Issues Panel on the Nanomedicine dialogue:

> *"It concluded that the exercise had been a ground-breaking and* "brave" *endeavour which had provided a very positive contribution to the decision-making process. SIP commended this approach to the Executive and Council.*" The paper goes on to say "*EPSRC executive considered the advice from SIP and accepted the recommendations made. The executive agree that, under the right circumstances, public dialogues provide a useful generic tool in developing the strategy and direction for specific research areas … Indeed, following a discussion at SIP in September, EPSRC and BBSRC have agreed to conduct a joint public dialogue exercise around the area of synthetic biology."*

In the field of science policy, the UK has been regarded as a leader in the area of public engagement around nanotechnology, and Jones's important role in this has been reflected by, for example, an invitation to give an invited talk at Polish EU Presidency event *"Governance and ethics of nanosciences and nanotechnologies Nanoethics 2011"*, involving National Academies of Science from across Europe and senior representatives of the European Commission.

5. Sources to corroborate the impact

S1 EPSRC – Director, Strategy and Business Relationships will confirm the impact of work overseen by Jones on policy thinking about public engagement.

S2 Democratic technologies? The final report of the Nanotechnology Engagement Group (http://tinyurl.com/ctyhong)

S3 IEEE Spectrum: Rupturing The Nanotech Rapture (http://tinyurl.com/nvlwgds).

S4 Which? Briefing *Small Wonder? Nanotechnology And Cosmetics* (http://tinyurl.com/pfvr7bg).

S5 Which? Citizen's Jury on Nanotechnology: report (http://tinyurl.com/la9p4yu) and briefing (http://tinyurl.com/ljotxjk).

S6 House of Lords, Science and Technology Committee, *Nanotechnologies and Food* Final Report, Jan 2010: (http://tinyurl.com/yfv6hfg); Government response, March 2010 (http://tinyurl.com/mjfmsec).

S7 http://www.greenpeace.org.uk/about/nanotechnology, accessed 6/9/2013

S8 http://www.rsc.org/chemistryworld/News/2010/January/22011001.asp; and http://www.nature.com/news/nanotechnology-armed-resistance-1.11287

S9 EPSRC Nanotechology Programe (http://tinyurl.com/n7mk3wp).

S10 Email from Senior Press Officer, Science Media Centre, 22 May 2008.