COMMENTARY

Science communication reconsidered

Tania Bubela[1,2*], Matthew C Nisbet[3], Rick Borchelt[4], Fern Brunger[5], Cristine Critchley[6], Edna Einsiedel[7], Gail Geller[8–10], Anil Gupta[11], Jürgen Hampel[12], Robyn Hyde-Lay[2,13], Eric W Jandciu[14], S Ashley Jones[15], Pam Kolopack[16], Summer Lane[2], Tim Lougheed[17], Brigitte Nerlich[18], Ubaka Ogbogu[2,19], Kathleen O'Riordan[20,21], Colin Ouellette[2], Mike Spear[13], Stephen Strauss[22], Thushaanthini Thavaratnam[23], Lisa Willemse[24] & Timothy Caulfield[25–27]

As new media proliferate and the public's trust and engagement in science are influenced by industry involvement in academic research, an interdisciplinary workshop provides some recommendations to enhance science communication.

Science communication receives significant attention from policy makers, research institutions, practitioners and scholars[1,2]. It is a complex and contentious topic that encompasses a spectrum of issues from the factual dissemination of scientific research to new models of public engagement whereby lay persons are encouraged to participate in science debates and policy.

Over the past several decades, the complexities of science communication have been magnified by institutional, social and technological change. Science increasingly is interdisciplinary, bureaucratic, global in scale, problem-based and dependent on private funding. This latter trend, in particular, raises issues of public trust in science, which studies have shown is diminished by researcher and institutional affiliation with the private sector, especially in the area of biomedicine[3,4].

Technology has also transformed the nature of the media system, creating an abundance of cable television, Internet and digital resources for the public to inform themselves about science and its social implications. With these new outlets, highly motivated individuals have a greater ability to learn about science and to become involved in collective decision-making[5]. Yet media fragmentation also means that if individuals lack an interest in science, they can very easily avoid science media altogether. There is a general concern that reduced quality of reporting by some media sources, primarily television and online, may have negative impacts, such as demands for inappropriately hyped medical services[6,7].

Jean-Francois Podevin/Science Photo Library

Science communication faces stiff challenges with the blurring of boundaries between public and private science and the fragmentation of audiences.

With this convergence of social forces and journalistic challenges in mind, we convened an interdisciplinary workshop on the changing nature of science communication, focusing specifically on biotech, biomedicine and genetics. What follows is a discussion of the questions and issues addressed by experts from the US, the UK, Canada, Germany and Australia. Our goal is to focus attention on key areas of expert agreement about two aspects of science communication: public engagement and science journalism. These two main themes are interrelated; the dissemination of knowledge is one part of a multifaceted approach toward increasing public involvement in science issues and decision-making. We conclude with specific recommendations for moving forward.

Models and assumptions guiding science communication

Despite increasing attention to new directions in public engagement, a still-dominant

*A list of affiliations appears at the end of the paper.
e-mail: nisbet@american.edu

assumption among many scientists and policy-makers is that when controversies over science occur, ignorance is at the root of public opposition. Concerns are raised about the state of science education and scientific literacy more generally[8,9]. Science communication initiatives are therefore directed at filling in the 'deficit' in knowledge, with the hope that if members of the public only understood the scientific facts, they would be more likely to see the issues as experts do. The strategy is thus to inform the public by way of popular science outlets such as television documentaries, science magazines, newspaper science coverage and more recently science websites and blogs.

Of course, some knowledge about science, and especially its role in society, is fundamentally important for a public that bears the risks and benefits of scientific and technological development[10]. Yet the narrow emphasis of the deficit approach does not recognize that knowledge is only one factor among many influences that are likely to guide how individuals reach judgments, with ideology, social identity and trust often having stronger impacts[10]. The deficit model also overlooks the fact that, given the abundance of competing content choices, traditional science media outlets reach only a relatively small audience of already knowledgeable science enthusiasts. In addition, on certain topics, such as cloning, the public is likely to draw strongly upon the portrayals featured in entertainment film and television, science fiction novels and other forms of popular culture[11–13].

A decade ago, a new 'public engagement' or interactive model emerged—one that emphasizes deliberative contexts in which a variety of stakeholders can participate in a dialog so that a plurality of views can inform research priorities and science policy[1]. These efforts toward two-way dialog with lay publics have taken various forms, such as deliberative polls, citizen juries, consensus conferences and *cafés scientifiques*. As a participatory process, each form might place a different weight on 'extended peer review,' whereby the 'publics,' or groups of individuals who are affected by the products of science, are invited to become part of a community of evaluators and decision-makers. Initiatives also vary in terms of how participants are asked for feedback, how much their feedback influences the final decisions and the timing of consultation[14].

Studies find that lay participants not only learn directly about the technical aspects of a subject, such as food biotech or biomedical research, but also learn about the social, ethical and economic implications of the science. Participants also feel more confident and efficacious in their ability to participate in science decisions, perceive scientists and their organizations as more responsive to their concerns, and say afterwards that they are motivated to become active on the issue if provided a future opportunity to do so[15,16].

Advocates for expanding these public engagement initiatives argue that consultation exercises often come too late (usually just as a science product, such as nanotechnology, is being introduced to the market), that lay input is not given enough weight in decision-making and that under these conditions the consultation process only serves a public relations function. They argue that engagement needs to move 'upstream' to when science or technology is in its formative stage, so that relevant publics can have a more meaningful say in matters of ownership, regulation, uses, benefits and risks[17–19]. Given this, the media could play an important role in informing the public about early-stage science policy debates and avenues for public involvement, potentially raising awareness and participation[20]. Yet a genuine role for lay participants' recommendations can come only with the realization that sometimes an engaged public might reach collective decisions that go against the self-interests of scientists. For example, one outcome of a recent consultation forum on nanotechnology was that several lay participants were motivated to form an advocacy group to act as a watchdog over research in their community[15].

Framing the message

The deficit model blames failures in science communication on inaccuracies in news coverage and the irrational beliefs of the public, but it ignores several realities about audiences and how they use the media to make sense of science. First, individuals are naturally 'cognitive misers': if they lack a motivation to pay close attention to science debates, they will rely heavily on mental shortcuts, values and emotions to make sense of an issue, often in the absence of knowledge[21,22]. Second, as part of this miserly nature, individuals are drawn to news sources that confirm and reinforce their pre-existing beliefs. This tendency, of course, has been facilitated by the fragmentation of the media and the rise of ideologically slanted news outlets[23]. Third, opinion leaders other than scientists, such as religious leaders, nongovernmental organizations and politicians, have been successful in formulating their messages about science in a manner that connects with key stakeholders and publics but at times might directly contradict scientific consensus or cut against the interests of organized science[24].

Under these conditions, audiences will pay more attention to certain dimensions of a science debate over others depending on how an issue is 'framed' in news coverage. Frames are interpretative packages and storylines that help communicate why an issue might be a problem, who or what might be responsible and what should be done[25]. Frames are used by lay publics as interpretative schemas to make sense of and discuss an issue; by journalists to condense complex events into interesting and appealing news reports; by policy-makers to define policy options and reach decisions; and by scientists to communicate the relevance of their findings. In each of these contexts, frames simplify complex issues by lending greater weight to certain considerations and arguments over others[26]. Framing is an unavoidable reality of the science communication process.

There is growing awareness among science organizations that if they want to be more effective at using the media to communicate with a diversity of audiences, they need to switch the frame—or interpretative lens—by which they communicate about a scientific topic, such as evolution, stem cell research or nanotechnology[27]. Instead of relying on personal experience or anecdotal observation, it is necessary to carry out careful audience research to determine which frames work across intended audiences. Communication is both an art and a science. For example, the US National Academies (Washington, DC) used focus groups and polling to inform the structure of a written report about the teaching of evolution and to plan publicity efforts. Their research indicated that an effective storyline for translating the relevance of evolutionary science for students was one emphasizing the connection to advances in modern medicine. Contrary to their expectations, the research concluded that an alternative frame emphasizing recent court decisions did not provide nearly as effective a message[28].

Yet turning to audience research requires a delicate balance on the part of science organizations. Any reframing of an issue needs to remain true to the state of the underlying science. For example, in promoting human embryonic stem cell research around the 'hope for cures', some advocates have given the false impression that available therapies are just a few years away, an interpretation that puts public trust at risk. Similarly, some industry advocates have re-framed food biotech as a moral quest to improve global food security, but their promise of 'putting an end to world hunger' dramatically oversimplifies a complex problem[29].

The challenges of science journalism

The media not only influence public perceptions but also shape and reflect the policy debate[30]. Few decisions are made by policymakers and stakeholders without the media in mind. Given this role and influence, there have long been concerns about distortion and hype in news coverage of biomedicine and biotech. The orientation toward hype is viewed internationally by many scientists, ethicists, policymakers and government officials as the primary shortcoming of the media.

In general, there is a stable baseline level of media coverage of biomedicine and biotech. Much of this news attention is driven by a small number of prestigious and highly influential scientific journals, with science framed in this coverage in terms of social progress and economic growth[31–33]. Numerous studies of media content have shown that coverage in newspapers is surprisingly accurate, with few errors of commission[31,34]. Assessing accuracy in the reporting of a single study, however, does not address whether the coverage contextualizes where the study fits within an emerging body of knowledge, drawing comparisons to other studies or expert views. Thus, as a caveat, accuracy in reporting and the dissemination of high-quality evidence are not necessarily synonymous[33].

In regard to perceptions of coverage, contrary to conventional wisdom, research has consistently shown that most scientists are satisfied with the media coverage of their own research and are more likely to be critical of science coverage generally[35]. Research similarly suggests that perceptions of bias in the coverage of biotech vary depending on a stakeholder's connection and personal commitment to the topic[36].

Studies have shown that hype in the media is most likely to originate with researchers using metaphors associated with breakthroughs[37] when in reality their research is one more incremental piece of a complex scientific endeavor. Prominent scientists certainly contribute to the creation of overly positive or negative expectations[38]. Numerous commentators have remarked that the media, scientists, the public and other interest groups can become complicit in generating a 'cycle of hype'[39]. The cycle is driven by enthusiastic researchers facing pressures from their research institutions, funders and industry; by the desire of institutions and journals to bolster their profiles; by a profit-driven media; and by the need of individual journalists to define events as newsworthy[39,40]. As one result of these factors, research has shown that positive results are more likely to be published[41], whereas studies that refute previously published research are less likely to gain attention. For example, the discovery of the 'gay gene' was published in *Nature* and received considerable media attention[42,43], but a study refuting these findings received limited press coverage[43].

A further source of hype may lie in errors of omission—what is left out of media narratives[34,44]. There is a lack of reporting on funding sources for research and potential conflicts of interest, information essential for the lay public to assess the credibility of the research[45,46] and which group of experts to trust. Public opinion surveys indicate a high degree of trust in scientists generally and university scientists specifically, but this trust declines when members of the public are asked their impression of industry scientists[3]. Comfort with a technology increases with public trust in regulatory authorities and government. In fact, unless a science issue is contested by rival cultural authorities, such as religious or political leaders, the public tends to defer strongly to the expertise of university and government scientists[47].

Details of methods and study design (especially for clinical trials), risks and timelines for the delivery of benefits are also underreported. Risks are often underreported because of the difficulties of conveying probabilistic information, which is inadequately understood by most journalists and by the general public[31,34]. However, it is not just probabilistic risks that are underplayed but also any broader discussion of social and ethical risks of the research. Equally of concern is the lack of discussion about realistic timelines for the delivery of benefits arising from what, in most cases, is still early-stage research. Omitting timelines may produce an impression in the public's mind that significant therapeutic benefits are imminent—the lay public and experts have very different perceptions of timelines. This is particularly dangerous in regard to stem cell research where people are desperate to gain access to stem cell therapies or 'miracle cures'.

The caveat about these previous content analysis studies is that the majority have concentrated on the print media, and primarily just the science beat, ignoring the fact that the media are not homogeneous. This approach ignores the degree to which local and national television news broadcasts, and increasingly the Internet, are now primary sources of public affairs information for the public[48]. Studies have also tended to focus narrowly on science journalists, but science debates receive their greatest attention when they shift from being covered just by these specialists to become the focus of political journalists, commentators and pundits. Under these conditions, the image of science morphs from a focus on discoveries packaged as progress, promise and technical background to a new emphasis on conflict and dramatic claims about risks and ethics[29,49].

This difference in perception, and the hype derived from errors of omission and framing, may already be leading to individual and social harm. The public has access to commercially available genetic tests marketed directly to consumers, which provide health information in the form of probabilistic risk factors[50,51], and to as-yet-unapproved stem cell therapies in jurisdictions with lower regulatory standards[52]. This raises important questions about the roles and responsibilities of the media.

Media roles and responsibilities

Many academic articles, editorials and reports draw on findings about errors of omission and accuracy to recommend best practices and checklists for journalists[53–55]. But do such endeavors confront the realities of science journalism and other news beats? The most important issue may not necessarily be content, but rather how the research is framed. In this regard, it is critical to understand the factors that shape the dominant interpretations in news coverage.

First, there is often a fundamental disconnect between how scientists and journalists interpret and describe the research process. For example, scientific papers are relentlessly quantitative, whereas media articles are often based on humanized accounts designed to connect with lay readers. Scientific articles are aimed at a narrow specialist audience, whereas media articles are aimed at a broader audience. As a result, journalistic accounts are based on personal anecdotes provided by researchers or by individuals who may directly benefit from the research, such as affected individuals or members of affected families. Without such connections, science stories are less likely to be published in competition with the news of the day.

New media are also fundamentally changing the nature of science communication. The role of the Internet as a major source of biomedical and science information for the public has both positive and negative consequences. Traditional media websites allow journalists to connect readers with source information through direct links to research or patient sites and articles. The expanded layout of web pages may address concerns about errors of omission, as more quantitative or probabilistic information may be provided in sidebars or graphics but only if the effort is made to provide this sometimes labor-intensive material. Special online comment sections allow readers to instantly contest or correct information contained in a story. Scientists and science journalists who double as bloggers provide readers with background and context about specialized areas of research. Science blogs create a dialog with readers, merging online interaction with real-world socializing at *cafés scientifiques* and other informal settings. Science bloggers frequently vet false claims made in the media or in policy debates and increasingly serve as important sources for journalists.

However, much of the information on the Internet comes from sources other than the mainstream media or scientist bloggers, and much of this may be of dubious quality. Corporate information sources generally are little more than direct-to-consumer advertising for products, services or both. For example, nutrigenomic testing services offered on the Internet are often tied to the sale of nutriceuticals and other products[56,57]. Only recently have corporations begun to take advantage of the social media properties of the web, entering into a dialog with stakeholders and publics via specially created sites that feature blogs, scientist profiles and discussion sections (see Johnson & Johnson's (Bridgewater, NJ, USA) corporate blog (http://jnjbtw.com), YouTube channel (http://www.youtube.com/user/JNJhealth) and Facebook page (http://www.facebook.com/ADHDMoms)). Other sites cater to special interest groups—for example, creationist or anti–stem cell research websites on the one hand and atheist or patient advocacy groups on the other—and are intended to strategically frame news coverage and/or the policy debate. Science blogs also engage in strategic framing, with some of the most popular science bloggers blending discussion of science with ideologically driven commentary on politics or religion. These popular blog sites become echo chambers reinforcing deficit-model assumptions about the public, singling out science literacy as the golden key to winning public support and to eroding religious belief.

Finally, the greatest challenge to science communication online remains simply *reaching audiences*. The availability of science information from credible sources online does not mean the public will use it. Even more than with the traditional media, if people lack an interest in science content on the web, they can very easily ignore it. This has implications for the public's degree of engagement with science policy debates.

Recommendations and challenges

The proliferation of information sources combined with increased industrial involvement in scientific research raise the issue of public trust and engagement with science. The primary concerns are the blurring of boundaries between public and private science and the fragmentation of audiences. Science communication, therefore, remains driven by an ever-more-complex relationship between institutions, stakeholders, the media and a diversity of publics.

In this context, clarification about the goals and assumptions of science communication is required, recognizing the complexity and variety of issues to be communicated. Current initiatives toward public education and involvement are presented as representing democratic reforms and being more inclusionary than past efforts, yet remain based on the deficit model, which research has shown to be insufficient. On this matter, then, there needs to be continued investment in public dialog initiatives, such as deliberative forums and consensus conferences. Yet, importantly, the focus of these deliberative exercises should be an honest effort at relationship- and trust-building[58] rather than persuasion, with mechanisms for actively incorporating the input of lay participants into decision-making[59].

When it comes to effectively working with media organizations to engage key audiences, it is necessary to recognize the importance of framing as well as the differing assumptions and imperatives of scientists, journalists and key publics. Public trust and the perception of media portrayals will vary by an individual's social identity and values. Science communication efforts should therefore be supported by careful audience research, such as that done by the National Academies on evolution. This strategy does not mean engaging in false spin or hype, but rather involves drawing upon research to explore alternative storylines, metaphors and examples that more effectively communicate both the nature and the relevance of a scientific topic, such as human embryonic stem cell research.

Graduate students, as the future spokespeople and decision-makers at science institutions, should be taught about the social and political context of science and how to communicate with the media and a diversity of publics. The latter includes an emphasis on the importance of meaningful public dialog initiatives as well as of relationship-building with journalists and editors[60]. There is a danger, however, of this type of public engagement emphasis becoming too conflated with marketing and public relations.

The wide-ranging factors contributing to media hype and errors (largely of omission) need to be more explicitly recognized so as to allow science institutions and media organizations to formulate appropriately informed communication policies.

To enhance our understanding of science communication in the context of new media, the focus of research on science communication should be expanded to include online and digital media, while recognizing the continued agenda-setting nature of traditional news sources. Given the fragmented nature of Internet audiences, if organizations want to broaden their reach when producing science content online, they need to find ways to facilitate incidental exposure, gaining the attention of key publics at places on the web where they are not actively looking for science information. There also will need to be laws protecting consumers from false or hyped claims on websites that market health services and products directly to the public.

Much as we have ever-improving measures of public opinion about science and an increasing number of survey data sources and studies to reference, there also needs to be investment in the systematic tracking of news and cultural indicators, including traditional news outlets but also talk radio, late-night satirical programming, religious media, the web and new documentary genres as well as entertainment television and film. Each of these media zones may constitute a different cultural context in which the public will interpret science.

At journalism schools and news organizations, the development of a new 'science policy' beat should be encouraged. This will fill in the gaps between the technical backgrounders preferred by science writers and the conflict emphasis of political reporters, providing important background for debates on science policy. In this context, discussion of science as a social institution could include funding structures, public-private institutional relationships and commercialization. An open public discussion of the blurring public-private divide in science could only enhance public trust.

Finally, if there is a major threat to science journalism, it is that science journalists are losing their jobs at for-profit news organizations. Some suggest that scientists-as-bloggers might be able to fill the gap[61], yet for reasons reviewed earlier, this is unlikely to be an effective solution. New models of foundation-, university- or government-supported science journalism are needed, with these online digital formats blending professional reporting with user-generated content and discussion.

ACKNOWLEDGMENTS

The workshop was supported by grants from Genome Canada (grant no. G53400000 to T. Caulfield, E. Einsiedel, P. Phillips and M. Veeman), The Stem Cell Network (to T. Caulfield, E. Einsiedel and B.M. Knoppers) and The Advanced Food and Materials Network (grant no. 18G to T. Caulfield and D. Castle). We thank N. Hawkins at the Health Law Institute (Edmonton, Alberta, Canada) for administrative support.

1. House of Lords. *Science and Society* (House of Lords, London, 2000). <http://www.parliament.the-stationery-office.co.uk/pa/ld199900/ldselect/ldsctech/38/3801.htm>.

2. The Royal Society. *Factors Affecting Science Communication: A Survey of Scientists and Engineers* (The Royal Society, London, 2006). <http://royalsociety.org/page.asp?id=3180 2>.
3. Critchley, C.R. *Public Underst. Sci.* **17**, 309–327 (2008).
4. United Kingdom Research Councils. *UK Public Attitudes to Science, 2008: A Survey* (RCUK, Swindon, 2008). <http://www.rcuk.ac.uk/cmsweb/downloads/rcuk/scisoc/pas08.pdf>.
5. <http://well.blogs.nytimes.com/2008/09/29/decoding-your-health/>.
6. Orkin, S.H. & Motulsky, A.G. *Report and Recommendations of the Panel to Assess the NIH Investment in Research on Gene Therapy* (National Institutes of Health, Bethesda, Maryland, USA, 1995). <http://www.nih.gov/news/panelrep.html>.
7. Stockdale, A. *Sociol. Health Illn.* **21**, 579–596 (1999).
8. National Science Foundation. *Science and Technology: Public Attitudes and Public Understanding* (National Science Board, Arlington, Virginia, USA, 1998).
9. UK Office of Science and Technology Science and the Public. *A Review of Science Communication and Attitudes to Science in Britain* (Wellcome Trust, London, 2000).
10. Sturgis, P. & Allum, N. *Public Underst. Sci.* **13**, 55–74 (2004).
11. Haran, J., Kitzinger, J., McNeil, M. & O'Riordan, K. *Human Cloning in the Media: From Science Fiction to Science Practice* (Routledge, Abingdon, UK, 2007).
12. Nisbet, M.C. & Goidel, K. *Public Underst. Sci.* **16**, 421–440 (2007).
13. Nerlich, B., Clarke, D.D. & Dingwall, R. *Soc. Res. Online* **4** (1999) <http://www.socresonline.org.uk/socresonline/4/3/Nerlich.htm>.
14. Einsiedel, E. Public engagement and dialogue: a research review. in *Handbook of Public Communication on Science and Technology* (eds. Bucchi, M. & Smart, B.) 173–184 (Routledge, London, 2008).
15. Powell, M. & Kleinman, D.L. *Public Underst. Sci.* **17**, 329–348 (2008).
16. Besley, J.C., Kramer, V.L., Yao, Q. & Tourney, C.P. *Sci. Commun.* **30**, 209–235 (2008).
17. Wynne, B. *Community Genet.* **9**, 211–220 (2006).
18. Wilsdon, J. & Willis, R. *See-through Science: Why Public Engagement Needs to Move Upstream* (Demos, London, 2004).
19. Rogers-Hayden, T. & Pidgion, N. *Public Underst. Sci.* **16**, 345–364 (2007).
20. Goidel, K. & Nisbet, M.C. *Polit. Behav.* **28**, 175–192 (2006).
21. Downs, A. *An Economic Theory of Democracy* (Harper, New York, 1957).
22. Popkin, S. *The Reasoning Voter* (University of Chicago Press, Chicago, 1991).
23. Mutz, D. in *Red and Blue Nation*, vol. 1 (eds. Nivola, P. & Brady, D.W.) 222–263 (The Brookings Institution, Washington, DC, 2006).
24. Nisbet, M.C. & Mooney, C. *Science* **316**, 56 (2007).
25. Gamson, W.A. & Modigliani, A. *Am. J. Sociol.* **95**, 1–37 (1989).
26. Scheufele, D.A.J. *Communication* **49**, 103–122 (1999).
27. Nisbet, M.C. & Scheufele, D.A. *Scientist* **21**, 39–44 (2007).
28. Labov, J.B. & Kline Pope, B. *CBE Life Sci. Educ.* **7**, 20–24 (2008).
29. Nisbet, M.C. & Huge, M. *Int. J. Press/Politics* **11**, 2, 3–40 (2006).
30. Caulfield, T., Bubela, T. & Murdoch, C. *Genet. Med.* **9**, 850–855 (2007).
31. Bubela, T. & Caulfield, T. *Can. Med. Assoc. J.* **170**, 1399–1407 (2004).
32. Nisbet, M.C. & Lewenstein, B.V. *Sci. Commun.* **23**, 359–391 (2002).
33. Durant, J., Bauer, M. & Gaskell, G. *Biotechnology in the Public Sphere: A European Sourcebook* (Michigan State University Press, Lansing, Michigan, USA, 1998).
34. Holtzman, N.A. *et al. Community Genet.* **8**, 133–144 (2005).
35. Peters, H.P. *et al. Sci. Commun.* **321**, 204–205 (2008).
36. Gunther, A.C. & Schmitt, K. *J. Commun.* **54**, 55–70 (2004).
37. Nerlich, B. in *Cognitive Foundations of Linguistic Usage Patterns* (eds. Schmid, H.J. & Handl, S.) (Mouton de Gruyter, Berlin, in the press).
38. Nerlich, B. & Halliday, C. *Sociol. Health Illn.* **29**, 46–65 (2007).
39. Caulfield, T. *Trends Biotechnol.* **22**, 337–339 (2004).
40. Bubela, T. *Clin. Genet.* **70**, 445–450 (2006).
41. Vickers, A., Goyal, N., Harland, R. & Rees, R. *Control. Clin. Trials* **19**, 159–166 (1998).
42. Conrad, P. & Markens, S. *Health* **5**, 373–390 (2001).
43. Petersen, A. *J. Commun. Inq.* **23**, 163–182 (1999).
44. Mountcastle-Shah, E. *et al. Sci. Commun.* **24**, 458–478 (2003).
45. Cook, D.M., Boyd, E.A., Grossmann, C. & Bero, L.A. *PLoS One* **2**, e1266 (2007).
46. McComas, K.A. & Simone, L.M. *Sci. Commun.* **24**, 395–419 (2003).
47. Brossard, D. & Nisbet, M.C. *Int. J. Public Opin. Res.* **19**, 24–52 (2007).
48. <http://pewresearch.org/pubs/928/key-news-audiences-now-blend-online-and-traditional-sources>
49. Jasanoff, S. *Nature* **450**, 33 (2007).
50. Gollust, S.E., Wilfond, B.S. & Hull, S.C. *Genet. Med.* **5**, 332–337 (2003).
51. Mayo Clinic Staff. Genetic testing you can order online. *Women's Health* (Mayo Foundation for Medical Education and Research, 26 March 2008). <http://www.mayoclinic.com/health/genetic-testing/GA00058>.
52. Lau, D. *et al. Cell Stem Cell* **3**, 591–594 (2008).
53. Blum, D., Knudson, M. & Marantz Henig, R. (eds.). *A Field Guide for Science Writers.* (Oxford University Press, Oxford, UK, 2005).
54. Schwitzer, G. *et al. PLoS Med.* **2**, e215 (2005).
55. Thompson, L. in *Genes and Human Self-Knowledge* (eds. Weir, R., Lawrence, S.C. & Fales, E.) 104–121 (University of Iowa Press, Iowa City, Iowa, USA, 1994).
56. Bubela, T. & Taylor, B. *Health Law Rev.* **16**, 39–47 (2008).
57. U.S. Government Accountability Office. *Nutrigenetic Testing: Tests Purchased from Four Web Sites Mislead Consumers* (GAO-06-977T, 2006). <http://www.gao.gov/products/GAO-06-977T>.
58. Yarborough, M., Fryer-Edwards, K., Geller, G. & Sharp, R.R. *Acad. Med.* (in the press).
59. Borchelt, R. & Hudson, K. *Sci. Prog.* Spring/Summer: 78–81 (2008).
60. Geller, G., Bernhardt, B.A., Rodgers, J.E. & Holtzman, N.A. *Genet. Med.* **7**, 198–205 (2005).
61. Brumfield, G. *Nature* **458**, 274–277 (2008).

[1]School of Public Health and [2]Health Law Institute, Law Centre, University of Alberta, Edmonton, Alberta, Canada. [3]School of Communication, American University, Washington, DC, USA. [4]Genetics and Public Policy Center, Johns Hopkins University, Washington, DC, USA. [5]Division of Community Health & Humanities, Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland, Canada. [6]Faculty of Life and Social Sciences, Swinburne University of Technology, Hawthorn, Victoria, Australia. [7]Faculty of Communication and Culture, University of Calgary, Calgary, Alberta, Canada. [8]Berman Institute of Bioethics and [9]Department of Medicine, School of Medicine, Johns Hopkins University, Baltimore, Maryland, USA. [10]Department of Health, Behavior and Society, Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, USA. [11]Applied Research and Analysis Directorate, Health Policy Branch, Health Canada, Ottawa, Ontario, Canada. [12]Department for Sociology of Technology and Environment, University of Stuttgart, Stuttgart, Germany. [13]Genome Alberta, Calgary, Alberta, Canada. [14]Science Journalism Research Group, School of Journalism, University of British Columbia, Vancouver, British Columbia, Canada. [15]Faculty of Communication and Culture, University of Calgary, Calgary, Alberta, Canada. [16]Dalla Lana School of Public Health, University of Toronto, Toronto, Ontario, Canada. [17]Canadian Science Writers Association, Toronto, Ontario, Canada. [18]Institute for Science and Society, University of Nottingham, Nottingham, UK. [19]Faculty of Law, University of Toronto, Toronto, Ontario, Canada. [20]Centre for Material Digital Culture, University of Sussex, Brighton, UK. [21]ESRC Centre for Economic and Social Aspects of Genomics (Cesagen), Institute for Advanced Studies, County South, Lancaster University, Lancaster, UK. [22]Canadian Broadcasting Corporation, Toronto, Ontario, Canada. [23]Faculty of Communication and Culture, University of Calgary, Calgary, Alberta, Canada. [24]Stem Cell Network, Ottawa, Ontario, Canada. [25]Health Law Institute, [26]Faculty of Law and [27]School of Public Health, University of Alberta, Edmonton, Alberta, Canada.