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Selective flows of knowledge in technoscientific interaction: information control in genome research

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Abstract. In recent years, the selective flow of knowledge has emerged as an important topic in historical and social studies of science. Related questions about the production of ignorance have also captured attention under the rubric of agnotology. This paper focuses on information control in interaction, examining how actors seek to control the flow of scientific knowledge as they interact with others, either in face-to-face encounters or in modes of communication involving circulating documents, data, materials and other entities containing knowledge. The analysis uses an ethnographic approach to study how actors work to control which knowledge becomes available to whom, when, under what terms and conditions, and with what residual encumbrances. Secrecy, for example, is not framed as an isolated, *sui generis* phenomenon, nor as one side of a secrecy/openness dichotomy, nor even as a pole on a secrecy/openness continuum. Instead, the analysis explores how actors manage a dialectic of revelation and concealment through which knowledge is selectively made available and unavailable to others, often in the same act. The emphasis on selective revelation highlights partial transfers of knowledge, targeted distribution, matters of timing, and the rights and encumbrances that attach to knowledge at different points in its transit. Examples are drawn from genome research, a field marked by ongoing disputes about modes of information control.

In recent years, historical and social studies of science have increasingly challenged traditional conceptualizations that imagine science to be naturally open, regard secrecy as inherently marginal to scientific activity, or place moral virtue securely and uniformly on one side of an open/closed divide.[1] Related questions about the selective circulation of knowledge and the production of ignorance have also gained new salience.[2]

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1 See, for example, the introduction to this issue. Michael A. Dennis, '"Our first line of defense": two university laboratories in the postwar American state', *Isis* (1994) 85, pp. 427–455. Judith Reppy (ed.), *Secrecy and Knowledge Production*, Ithaca: Cornell University Peace Studies Program, 1999; John Cloud, 'Imaging the world in a barrel: CORONA and the clandestine convergence of the earth sciences', *Social Studies of Science* (2001) 31, pp. 231–251. Brian Rappert, *Experimental Secrets: International Security, Codes, and the Future of Research*, Lanham, MD: University Press of America, 2009.

2 See, for example, James Secord, 'Knowledge in transit', *Isis* (2004) 95, pp. 654–672. Peter Howlett and Mary Morgan (eds.), *How Well Do Facts Travel?*, Cambridge: Cambridge University Press, 2011. Robert Proctor and Londa Schiebinger (eds.), *Agnotology: The Making and Unmaking of Ignorance*, Stanford: Stanford University Press, 2008.

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To extend these lines of inquiry, this paper focuses on information control in interaction, considering how actors seek to control the flow of scientific knowledge as they interact with others, either in face-to-face encounters or in modes of communication involving circulating documents, data, materials and other entities containing knowledge. The paper takes a symmetrical approach to phenomena as different as secrecy and publication in scientific journals, treating both as members of the same overarching category, namely practices that aim to effect control over which knowledge becomes available to whom, when, under what terms and conditions, and with what residual encumbrances.[3] Secrecy, for example, is not framed as an isolated, *sui generis* phenomenon, nor as one side of a secrecy/openness dichotomy, nor even as a pole on a secrecy/openness continuum.[4] Instead, the paper explores how actors manage a dialectic of revelation and concealment through which knowledge is selectively made available and unavailable to others, often in the same act. The emphasis on selective revelation highlights partial transfers of knowledge, targeted distribution, matters of timing, and the rights and encumbrances that attach to knowledge at different points in its transit.

The paper develops this perspective in the context of genome research. The traditional conception of science as open and technology as secret, while arguably unduly simplistic in any context, is particularly inapplicable to such fields as genomics, in which the distinction between science and technology is often empirically elusive.[5] The struggle between the publicly funded International Human Genome Consortium and Celera Genomics is clearly the most famous example in the field of a contest prominently involving data access, ownership and control. Celera, a private company, was founded in 1998 by J. Craig Venter and Perkin-Elmer Corporation, shortly after Perkin-Elmer developed a powerful new DNA sequencing machine based on capillary gel electrophoresis. Celera sought to sequence the human genome before the public project could, precipitating an acrimonious dispute.[6] The debate featured conflicting visions of appropriate control over sequence information, with the public project promoting the principle of immediate, open-to-any-and-all, free-of-charge access to data unencumbered by residual rights. In contrast, Celera advanced a business model based on differential access for paying subscribers, who would receive preferential treatment, and non-subscribers, whose access (if granted at all) could be constrained in various

3 On the importance of temporality as it pertains to secrecy and disclosure see Mario Biagioli in this issue. See also Stephen Hilgartner, 'Access to data and intellectual property: scientific exchange in genome research', in *Intellectual Property and Research Tools in Molecular Biology: Report of a Workshop*, Washington: National Academy Press, 1997, pp. 28–39. James A. Evans, 'Industry collaboration, scientific sharing, and the dissemination of knowledge', *Social Studies of Science* (2010) 40, pp. 757–791.

4 See Koen Vermeir, in this issue.

5 On the traditional historiography see Vermeir, op. cit. (4).

6 For an ethnographic account of the immediate reaction to the announcement of the formation of Celera see Stephen Hilgartner, 'Staging high-visibility science: media orientation in genome research', in Simone Rödder, Martina Franzen and Peter Weingart (eds.), *The Sciences' Media Connection – Public Communication and Its Repercussions. Sociology of the Sciences Yearbook*, Dordrecht: Springer, 2011. See also John Sulston and Georgina Ferry, *The Common Thread: A Story of Science, Politics, Ethics, and the Human Genome*, Washington, DC: The Joseph Henry Press, 2002. J. Craig Venter, *A Life Decoded – My Genome: My Life*, New York: Viking, 2007. Adam Bostanci, 'Sequencing human genomes', in Jean-Paul Gaudillière and Hans-Jörg Rheinberger (eds.), *From Molecular Genetics to Genomics*, Routledge: London, 2004.

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ways.[7] Far from being limited to this celebrated dispute, however, manoeuvring over the enclosure and disclosure of knowledge is ubiquitous in genome research.[8]

Below, I examine this manoeuvring from an ethnographic perspective, drawing on extensive fieldwork in the genome research community over the past two decades, including participant observation in laboratories and meetings and qualitative interviews. After outlining some elements of a theoretical perspective for examining the selective flow of knowledge in interaction, the paper briefly explores two illustrative examples.

Interaction and the flow of knowledge

Dramaturgy and information control

One starting point for this inquiry is the dramaturgical sociology of Erving Goffman, which offers a general perspective on the social world based on the metaphor of the theatre. The term 'information control' is drawn from Goffman, who uses this concept in his account of the self, developed initially in *The Presentation of Self in Everyday Life* and further in *Asylums* and *Stigma*.[9] What is distinctive about Goffman's perspective is its focus on the dialectic of revelation and concealment through which social actors – or 'performers' – present themselves to their 'audiences'. In a variety of contexts Goffman attends to the artful staging of social life, examining the theatrical techniques actors use to present their identities and exploring the slippages that often disrupt the show. One can grasp how the dramaturgical perspective operates by considering Goffman's concept of 'region behaviour' – activity intended to separate two regions – the front stage (which is publicly presented) and the backstage (which is not). In traditional theatre and in everyday life, performers partition physical space, and structure their speech and bodily comportment, in ways intended to shape what audiences perceive.[10] Through the strategic use of words, gestures, clothing and many other devices, people create virtual 'regions', attempting to highlight their creditable attributes while hiding stigmatizing ones. In other words, what Peter Galison aptly terms 'anti-epistemology' – the art of obscuring knowledge and making it difficult to secure – is not restricted to the national security community but is a mundane feature of interpersonal encounters.[11]

Goffman's point is not simply that the analyst can treat such phenomena using the metaphor of theatre; he also argues that social actors themselves possess a profound

7 Sulston and Ferry, op. cit. (6). Venter, op. cit. (6). See also William Blair & Company (securities analysts), 'PE Corporation – Celera Genomics Group', Basic Report, 9 December 1999, pp. 1–58.

8 Stephen Hilgartner, 'Data access policy in genome research', in Arnold Thackray (ed.), *Private Science: Biotechnology and the Rise of the Molecular Sciences*, Philadelphia: University of Pennsylvania Press, 1998, pp. 202–218.

9 Erving Goffman, *The Presentation of Self in Everyday Life*, New York: Doubleday, Anchor Books, 1959; *idem*, *Asylums*, New York: Penguin 1961; *idem*, *Stigma*, New York: Simon & Schuster, 1963.

10 Goffman, *The Presentation of Self*, op. cit. (9), pp. 106–140.

11 Peter Galison, 'Removing knowledge', *Critical Inquiry* (2004) 31, pp. 229–249, 237.

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theatrical self-consciousness, experiencing themselves as attempting to shape how they appear. Nor is his claim that all performers cynically attempt to mislead their audiences (although some clearly do), for he stresses that delivering sincere performances requires the strategic management of impressions to avoid fostering unintended messages. But no matter how cleverly performers seek to shape the impressions that they foster, their ability to control information is inevitably imperfect, and discrediting information often leaks out. Body language or tone of voice, for example, can convey unintended messages that call into question the authenticity of a performance. At times, audiences tactfully ignore these unintended messages, allowing the inept performer the benefit of the doubt. At other times, they warily seek signs that the performance is misleading, striving to avoid being taken in.

Theatrical considerations are reflected in social organization through the formation of what Goffman calls 'teams' – groups of people who work together to stage a performance. In a real theatre, teams of actors, writers, set designers, directors and stage crews work to deliver an effective show.[12] Goffman argues that analogous teams are found in many settings. Team membership is defined not by formal organizational structures but by shared engagement in 'dramaturgical cooperation' – collective work to manage the impressions that audiences receive in the interest of pulling off a compelling performance.

Goffman's central interest was the study of face-to-face interaction, and his approach can be immediately applied to such scientific encounters as conversations, lectures and professional meetings. But it also can be extended to consider collective modes of information control expressed in the production and selective circulation of texts and other entities that contain knowledge, which also can be regarded as performances prepared with audiences in mind. This approach has been used to address the question of how credibility is performatively constructed by scientific advisory organizations.[13] It is also relevant to the practices of the military and intelligence agencies.[14] Such contexts feature ongoing collective management of what to include in – and omit from – texts, and with whom to share them and when. The dramaturgical perspective highlights the construction of enclosed regions where knowledge can be strategically packaged in preparation for its (possibly partial) presentation to wider audiences. It also highlights the gatekeeping activities that precede the release of texts (and other entities that contain information). It highlights slippages and leakage of information from the world of the backstage, calling attention to processes through which regimes of information control break down. And it highlights the construction of contained (sometimes virtual) spaces within which groups, defined in part by their access to concealed

12 Goffman, *The Presentation of Self*, op. cit. (9), pp. 77–105.

13 Stephen Hilgartner, *Science on Stage: Expert Advice as Public Drama*, Stanford: Stanford University Press, 2000.

14 Brian Balmer, 'A secret formula, a rogue patent and public knowledge about nerve gas: secrecy as a spatial–epistemic tool', *Social Studies of Science* (2006) 36, pp. 691–722. Kathleen M. Vogel, '"Iraqi Winnebagos of death": imagined and realized futures of US bioweapons threat assessments', *Science and Public Policy* (2008) 35, pp. 561–573.

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knowledge, enjoy privileged epistemic positions and identities.[15] Most fundamentally, this perspective frames information control as entailing dynamic interaction and suggests that strategic information management must be ubiquitous in science, found – as it is in social life more generally – in any physical or virtual space where performers and audiences meet.

Containers and materiality

The familiar image of a white-coated figure gazing intently into a test tube metaphorically captures a second aspect of this perspective. To develop an analysis of information control adapted to the laboratory, one needs to extend the concept of 'information' to include a wide range of material entities. Thus, in considering this iconic image, my focus is not on the scientist, or the gaze, or the white coat, despite the rich resonances of each. Instead, I want to foreground the lowly test tube as an exemplar of an important dimension of scientific practice: the procedures and machinery used to contain objects of technoscientific significance and choreograph their circulation through specific channels. If the white coat can symbolize the cultural authority of science, then the test tube can be a metaphor for the social and technical machinery intended to enclose and protect entities of technoscientific interest, to regulate their disclosure and package them for shipping, to structure the channels through which they circulate, to effect control over their uses and futures. The metaphor of containment and controlled circulation is meant to highlight the materiality of both the means of containment and the entities – or 'technoscientific things' – that are packaged therein. The term 'technoscientific things' is used broadly here to refer to entities that relevant actors believe to be of potential epistemic, technological and/or strategic significance in ongoing, emerging or imagined technoscientific activity. Technoscientific things come in many forms, including such entities as biomaterials, datasets, software, texts, speech, visual displays, specialized instrumentation, skilled personnel and assemblages of these items.[16]

Spaces containing knowledge are formed – and, on occasion, breached – using a variety of means, and practices aimed at regulating the flow of technoscientific things play a central role in science. These practices are enacted using a diversity of machinery, including the relatively tangible (like the snap-cap tubes common in the life sciences) and the relatively virtual (like the password-protected databases and auditing software of a contemporary laboratory information system). They also include a variety of transformations that materials and information undergo during laboratory work. These transformations take place continually within laboratories for a variety of technological and epistemic reasons, including preparing things for circulation by, say, packaging

15 Hilgartner, op. cit. (13), pp. 15–20, 54–69, 79–85. Balmer, op. cit. (14). Hugh Gusterson, *Nuclear Rites: A Weapons Laboratory at the End of the Cold War*, Berkeley: University of California Press, 1998. Michael Aaron Dennis, 'Secrecy and science revisited: from politics to historical practice and back', in Reppy, op. cit. (1), pp. 1–16.

16 See the discussion of data in Stephen Hilgartner and Sherry I. Brandt-Rauf, 'Data access, ownership, and control', *Knowledge* (1994) 15, pp. 355–372.

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biomaterials, wrapping electronic data in metadata or editing texts to meet length constraints.[17] Such transformations not only enable circulation, but also provide opportunities for building varying kinds of constraint and freedom of action into the very things that circulate. For example, during the extraction of genomic DNA from a tissue culture, the cells are destroyed and cellular matter is discarded so that the isolated DNA can subsequently be analysed, free of contaminants. The cells, which no longer exist, cannot be studied or reproduced, so a researcher who receives live cells from a colleague enjoys more freedom of action than one who receives an aliquot of purified DNA. As in the case of the trapdoor functions that underlie public-key cryptography, materials and data in laboratories often pass through trapdoor transformations – one-way operations that render their outputs unusable for particular purposes. These trapdoor transformations are often routine parts of scientific practice, as mundane as performing statistical operations that cannot be reversed to yield the original data. They also include changes introduced for the express purpose of constraining downstream users, such as redacting a document. In either case, trapdoor transformations build encumbrances directly and materially into the things themselves, thus allowing things to circulate while constraining their users.[18]

Trapdoor transformations are only one mechanism for establishing constraints intended to control future uses of circulating things. Other mechanisms include those that rely on trust (like a colleague's promise) or sanctions (like the threat of criminal penalties) or sealed packages (like embedding a microchip in epoxy). Through such mechanisms, alone or in various combinations, actors can inscribe qualitatively different forms of freedom and constraint into circulating things. In this way, the (in)capacities of technoscientific things and their users are co-produced.

Regimes of closure

The dynamic interactions alluded to above do not take place on an open field, unconstrained by history, identity and institutions. For this reason, we need another concept: the *regimes of closure* that constitute generic agents of certain types, along with their rights, duties, privileges and concepts of normal courses of action as they pertain to other agents and to control over technoscientific things. These regimes, which often take legal or quasi-legal forms, are embedded in institutionalized discourses and practices (e.g. scientific publication, military or trade secrecy, patent law, privacy and even the epistemic cultures of particular scientific fields).[19] By 'generic agents' I mean

17 See Howlett and Morgan, op. cit. (2).

18 See, for example, Stephen Hilgartner, 'Mapping systems and moral order', in Sheila Jasanoff (ed.), *States of Knowledge*, London: Routledge, 2004, pp. 131–141, 138–139.

19 On authorship regimes see Mario Biagioli and Peter Galison (eds.), *Scientific Authorship: Credit and Intellectual Property in Science*, New York: Routledge, 2003. On intellectual property regimes see, for example, James Boyle, *Shamans, Software, Spleens: Law and the Construction of the Information Society*, Cambridge, MA: Harvard University Press, 1996. Charlotte Hess and Elinor Ostrom, 'Ideas, artifacts, and facilities: information as a common-pool resource', *Law and Contemporary Problems* (2003) 66, pp. 111–145. Lawrence Lessig, *Free Culture*, New York: Penguin, 2004. Sheila Jasanoff, *Designs on Nature*,

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well-institutionalized discursive constructs – such as the 'author', the 'inventor' or the 'human research subject' – that are widely used as framing devices to describe abstract situations or to conceptually package concrete ones (in which specific agents are implicated). Regimes also involve generic spaces – such as 'the individual's body', the 'scientist's laboratory' or 'the published literature' – in which technoscientific things are found. In addition, regimes of closure involve generic technoscientific things, such as 'scientific papers' or 'anonymized DNA samples'.

In many situations, the relevant regime provides some mixture of informal guidance and legal force about the appropriate relations among these agents, spaces and things as they pertain to regulating the distribution of control. No researcher, for example, has the right to pierce the human subject's skin with a needle and extract technoscientifically interesting DNA from her body without permission. The material is neatly contained, at least in the imaginary of bioethics, not only inside her body but also within a regime of human-subject protections and, more broadly, of individual rights. Yet freedom of action for the researcher can be contractually constructed. Using the legal instrumentation of informed consent and contract law, the right to control the future use of the material can be extracted from the subject and transferred to the scientist along with the blood sample. Residual encumbrances, such as a duty to keep the identity of the source confidential, may also be legally constituted, attached to the material and transferred along with the material to future users. As this example suggests, encumbrances not only are sometimes removed but also may be added using legal devices (for example, material transfer agreements, non-disclosure agreements and military classification), allowing targeted, partial or limited circulation. Patents, which require unconstrained disclosure of descriptions of inventions while granting monopolistic encumbrances on their use, are another example.

Some of the regimes operative in the laboratory are specific to particular fields of science and even particular research projects. In academic molecular biology, the professor who is 'head' of the laboratory enjoys extensive authority over both its internal operation and its external interactions. Subordinates are typically granted some rights (such as authorship on multi-authored papers) in connection with specific projects deemed to be 'their' work, but the laboratory head retains ultimate authority over everything done in 'his' or 'her' lab. This regime frames expectations about how rights in laboratory products will be allocated as projects develop or personnel join and leave research teams, but disputes occur with some regularity. Rather different patterns are found in other fields, such as high-energy physics.[20] Quasi-formal regimes pertaining to the disposition of technoscientific things also are sometimes imposed by funding agencies, or used to help constitute multi-laboratory collaborations.[21]

Princeton: Princeton University Press, 2005, pp. 203–224. Stephen Hilgartner, 'Intellectual property and the politics of emerging technology', *Chicago-Kent Law Review* (2009) 84, pp. 197–224.

20 On the epistemic cultures of molecular biology and high-energy physics see Karin Knorr Cetina, *Epistemic Cultures: How the Sciences Make Knowledge*, Cambridge, MA: MIT Press, 1998. See also Peter Galison, 'The collective author', in Biagioli and Galison, op. cit. (19), pp. 32–55.

21 See Hilgartner, op. cit. (8). Human genome project information, 'Summary of principles agreed at the First International Strategy Meeting on Human Genome Sequencing', Bermuda, 25–28 February 1996, Human

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As this discussion suggests, manoeuvring about the control of technoscientific things takes place in a context of multiple regimes. To understand their operation, it is important not to focus on any one regime in narrow isolation from those that surround or, more accurately, are entangled with it, for doing so will paint a misleadingly one-dimensional picture.[22] The regime of scientific publication provides an instructive example. People who consider publication in isolation from other regimes often appear to imagine that it constitutes a world of unfettered openness. And in a sense, it does. The scientific literature steadily accumulating in libraries represents a massive storehouse of information that approaches open-to-any-and-all, free-of-charge, no-questions-asked access.[23] Moreover, taking an idea (which economists would call a non-rival good) from the literature does not reduce its availability to others. The duties of those who use such facilities are few, consisting mainly of following proper citation practices and respecting copyrights. Indeed, the image of the open scientific literature as the ultimate repository of scientific knowledge is arguably the root metaphor on which the commonplace understanding of science as 'naturally open' is based. But before we stop the analysis with the self-congratulatory conclusion that the open literature is the endpoint where information control stops and wide-open access begins, we might consider what happens to the facts, data, ideas, papers and technoscientific things that a researcher finds in the literature, copies and transfers to his or her laboratory. There, in the enclosed space of the laboratory, a regime of privacy governs: the scientist is under no obligation to share his or her work, but enjoys the privilege of deciding whether to reveal it, when, and to whom. Things taken from the literature and transported into the laboratory enter a private space: the fact of their presence in the laboratory, the uses to which they are put, the new things they are used to create – all these fall under the exclusive control of the laboratory. As this example suggests, analysis of regimes of closure needs to consider how closure, disclosure and re-enclosure – a phenomenon whose many permutations we might gloss as 'dis(en)closure' – operates at points where regimes interact.

My point is not that the openness of the literature is a sham. It is not. Indeed, in my opinion, public libraries – for their institutional vision as well as for their contents – rank among the most impressive achievements of human civilization. The point is rather that openness in science is in some ways transient even where it is most complete. For a library to be completely open, the things within it must be completely unencumbered. And for those things to be unencumbered, the users of those things must be allowed freedom of action to use them as they see fit within the enclosed spaces of their private thoughts and actions. Openness is in part constituted by its other.

Genome Organisation, Singapore, 1996, available at www.ornl.gov/sci/techresources/Human_Genome/research/bermuda.shtml; Hilgartner, op. cit. (18).

22 Stephen Hilgartner, 'Biomolecular databases: new communication regimes for biology?', *Science Communication* (1995) 17, pp. 240–263.

23 Online publication may be even more open but also has limits; see Rob Kling, Lisa B. Spector and Joanna Fortuna, 'The real stakes of virtual publishing: the transformation of E-biomed into PubMed central', *Journal of the American Society for Information Science and Technology* (2004) 55, pp. 127–148.

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Controlling the flow of technoscientific things

Above, I have outlined some aspects of a perspective for analysing the dynamic interactions that shape the selective distribution of technoscientific things and the allocation of control over them (in its many qualitatively different forms). But if information control is ubiquitous, as I argue it is, then a question that immediately arises is whether it is significant in any particular context. Something that is everywhere may be so commonplace that it is of little interest to actors and analysts alike. However, in the case of genome research, a number of kinds of evidence converge to show that attention to the practical and moral aspects of information control has been extremely salient at least since the late 1980s, the period addressed in my research. For one thing, during the past two decades, problems of access to genome data and materials have inspired ongoing policy debate.[24] Survey research also provides broad and quantitative, if superficial, evidence that the flow of information and data is a matter of widespread concern among US geneticists and life scientists, and further that substantial numbers of geneticists and other life scientists reported having their requests for data denied.[25] Moreover, genome scientists treat matters of data access, ownership and control as salient matters in their day-to-day interactions. Ignoring this aspect of genome research would produce an impoverished historiography.

An especially rich picture of information control in the lived world of genome science emerges from ethnographic fieldwork, including both observation of interactions among the researchers themselves and qualitative interviews behind closed doors. As a limited illustration of some of the concepts sketched out above, let us briefly consider two accounts of informal conversations in which I participated during fieldwork at the Cold Spring Harbor meetings on genome mapping and sequencing – a series of annual international scientific meetings of much importance during the Human Genome Project.[26] Both conversations, which took place during breaks in the schedule on a single afternoon, pertained to issues of the enclosure and disclosure of technoscientific information or materials. I chose conversations from the same afternoon not because there was anything terribly extraordinary about them (in fact, additional examples from the same and similar afternoons appear in my field notes), but because this mode of selection suggests how commonplace attention to information control actually is. Moreover, the scientists involved do not overlap, and they include researchers from

24 See National Research Council, *Mapping and Sequencing the Human Genome*, Washington: National Academy Press, 1988; 'Summary of principles', op. cit. (21). Lee Rowen, Gane K.S. Wong, Robert P. Lane and Leroy Hood, 'Publication rights in the era of open data release policies', *Science* (2000) 289, p. 1881. Wellcome Trust, 'Sharing data from large-scale biological research projects', Report of a meeting organized by the Wellcome Trust and held on 14–15 January 2003. National Research Council, *Sharing Publication-Related Data and Materials: Responsibilities of Authorship in the Life Sciences*, Washington: National Academy Press, 2003. P^3G Consortium, George Church *et al.*, 'Public access to genome-wide data: five views on balancing research with privacy and protection', *PLoS Genetics* (2009) 5, e1000665.

25 Eric G. Campbell, Brian R. Clarridge, Manjusha Gokhale, Lauren Birenbaum, Stephen Hilgartner, Neil A. Holtzman and David Blumenthal, 'Data withholding in academic genetics: evidence from a national survey', *Journal of the American Medical Association* (2002) 287, pp. 473–480.

26 The first meeting was held in 1988. The series was later renamed Genome Sequencing and Biology.

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several different technical domains within genomics. In addition, the scientists brought up matters of information control themselves and most of the time directed their remarks to one another, not to me, so their attention to these matters cannot be attributed to my interventions. One should note, however, that these conversations each involved scientists from more than one academic laboratory and/or company. (Some of the actors, as often occurs in biotechnology, had connections to both academic and commercial organizations.) Such interorganizational encounters might be expected to stimulate trading of information and hence raise issues of information control. That said, each interaction will be presented below in a short account created from field notes.

The dialectic of revelation and concealment

The first encounter illustrates several aspects of the dialectic of revelation and concealment, especially as it is found in face-to-face interaction:

> I was walking out of the auditorium with a molecular geneticist I will call Andy, when Andy called out to two other scientists he knew: 'So CCDs are the way to go?'[27] It was sort of a follow-up question to a discussion from earlier in the meeting. Bill and Clyde stopped and a conversation ensued. After a minute, Andy asked Bill, who is from Unnamed University and has connections to Company One, 'Is Company One going to do anything with capillary gel electrophoresis?' Bill kind of smiled coyly in a way that suggested that this was treading near the boundaries of confidential territory, but he said with what I read to be an I-can't-really-tell-you-but-let-me-tell-you-anyway tone, that he would be very surprised, extremely surprised, if they don't do anything with it.

This sort of opened up the topic of advances in electrophoresis, and Clyde started asking what was going on with gel mathematics. He seemed to know that some of the people involved in the Company One/Unnamed University nexus had been studying what happens in this type of sequencing gel. The issue that he considered important to understand is exactly where the molecules are in real time as they are moving down the gel. Not all of the DNA molecules move at the same rate even if they are the same size, because the different fluorescent tags on them slow them down to different degrees. A mathematical understanding of the behaviour of the molecules in the gels is necessary for sequencing machines; the base calling and ordering algorithms must be adjusted to take account of these differences. So Bill and Clyde went back and forth on this for a little bit, with Clyde probing Bill with technical questions. Bill finally said, 'Yep, the gel mathematics, they are now understood.' Clyde said, 'I never saw the reference.' Bill said, 'Company One did the study and Company Two has also done the study.' Clyde said, 'Oh, that's why.' No one needed to say what was obvious to everyone present, namely that the companies had decided not to publish papers on the topic, owing to their desire to retain a competitive edge in the race to improve sequencing machines. It was clear that this was all that Bill was going to say, and no one pushed for more.

This ethnographic vignette illustrates the dialectic of revelation and concealment in conversation, as information is concealed, revealed and concealed as it is revealed. The

27 Here and below, names and selected details have been changed to make individuals unidentifiable.

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participants appear to self-consciously recognize their efforts to control the flow of information. In particular, Bill seems to be artfully releasing some information (for example that the company has studied and now understands gel mathematics) while withholding other information (such as even the briefest gloss on what was found).[28] At the same time, Andy and Clyde seem interested in extracting information from Bill. The artful construction of regions – by Bill and (apparently) by both companies – is a salient aspect of the interaction. In addition, everyone seems to accept that for the company to impose a regime of secrecy in this context is well within the normal range of ordinary action.

The conversation also points to the selective enclosure and disclosure of different kinds of information. The unpublished findings of research on 'gel mathematics' that the two companies apparently conducted seem to be instances of what the national security community would call 'objective secrets', a kind of knowledge deemed to describe stable and universal facts.[29] The conversation also involves what that community would term 'subjective secrets' – information of the 'loose lips sink ships' variety that is deemed transient and particular.[30] For example, Bill's comportment and speech seemed to self-consciously point to a boundary marking off the confidential terrain of information about Company One's activities, although (in what may have been another layer of self-conscious information control) he took no steps to clarify whether he was edging up against that boundary or breaching it while maintaining deniability. It is also possible that to deter competition or encourage exuberance among stock analysts and their technical consultants (Clyde might be such a person), Company One wants relevant people to 'know' that it understands the gel mathematics, yet does not want to tell outsiders the details. Bill invited the other participants to know *that* the Company knows without permitting them to know *what* the Company knows (or does not know).[31]

As this discussion suggests, this conversation, though brief, seems to involve information-control practices pertaining to both objective secrets (about gels) and subjective secrets (about company activities). More deeply, however, the conversation points to ambiguities in the distinction between objective and subjective secrets. Company One's unpublished findings about gel mathematics (which might be imagined to be objective secrets) remain, at least for outsiders not privy to the work, incompletely vetted and consequently of at least questionable epistemic status. Company insiders, on the other hand, might have more extensive grounds for being convinced, but outsiders cannot be sure. Bill seems to believe that the phenomenon is 'now understood' but this leaves important questions open: should one share his confidence that the company has achieved the correct (or the deepest or the most useful) understanding? Can one be

28 For examples of similar manoeuvring in the context of animal research see Tora Holmberg and Malin Ideland, 'Secrets and lies: "selective openness" in the apparatus of animal experimentation', *Public Understanding of Science* (in press), available at http://pus.sagepub.com/content/early/2010/08/23/0963662510372584.abstract.

29 Galison, op. cit. (11), pp. 233–234.

30 Galison, op. cit. (11), pp. 233–234.

31 On 'story stocks', hype and share prices see Michael Fortun, *Promising Genomics: Iceland and deCODE Genetics in a World of Speculation*, Berkeley: University of California Press, 2008.

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certain that Bill is not bluffing or overstating his certainty? Should Bill's assertion that Company Two 'has also done the study' be taken to indicate that the two companies did 'the [*same*] study' (something Bill did not exactly say) and found the same thing? Can we assume that the two (possibly) secret studies 'replicated' each other? Company outsiders who implicitly or explicitly answer 'no' to such questions will not perceive the company's knowledge of gel mathematics to be classifiable as an objective secret. By adjusting the level of scepticism, the outsider can slide back and forth from 'we know that the company knows the objective secrets of gel mathematics but will not disclose them' to 'we know only that one scientist in the Unnamed University/Company One nexus disclosed the subjective and possibly secret claim that it has studied and understands gel mathematics but hasn't published what that person says the company knows'. Information-control practices thus not only shape the social distribution of objective and subjective information; they also shape the social distribution of the capacity to be confident about which information can be regarded as subjective versus objective. Far from only being about access, as consequential as that is, these practices also shape the epistemic qualities of knowledge.[32]

The boundaries of groups

Above, I used the terms 'insider' and 'outsider' without exploring how the division between insiders and outsiders is constructed. Information control plays an important role in the construction of group boundaries. This comes out clearly in our second vignette:

> This conversation took place during the interlude between the last talks of the afternoon and the cocktail hour, when I took a walk with a small group of scientists. The party included Frank and George, two junior scientists who had both worked in John's laboratory, and a junior scientist, Eileen, from another genome facility. John, who was a well-known researcher and head of the lab under whom Frank and George had worked, was not present. We were slowly strolling along, and I got, just for a second, a little ahead of the group, to talk to another scientist who wanted to leave something in my car. When I stepped back in, Eileen was asking whether or not she should share with John a novel and useful DNA collection she had recently created. Frank started telling her, 'Look, he doesn't understand that collaborations have to be two-way. You don't want to do that. He just wants to take, take, take. He never wants to give anything back.' Frank and George started into an extended tirade about the conflicts around data, materials and ideas that happened after they stopped working under John.

This conversation underlines the role of 'sharing' technoscientific things in efforts to constitute collaborations, which genome researchers usually imagine as transient alliances among individuals and/or research groups. These alliances are typically entered into by laboratory heads whose 'ownership' of resources and authority over 'their' laboratory underwrites their ability to make commitments. Eileen seeks information about whether she should consider providing some potentially valuable biomaterials to a well-known researcher. Such interlaboratory exchanges of resources are common in molecular biology, since no single laboratory can produce everything it needs. However,

32 Dennis, op. cit. (15).

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as Karin Knorr Cetina notes, cooperation is problematic in the individualistic culture of molecular biology.[33] Although some resources are transferred with no strings attached, others are deemed too valuable to provide without a plan for joint publication or some similar shared 'ownership' of research results. The terms of such exchanges are incompletely standardized and frequently become points of tension. Eileen's inquiries are a mode of intelligence gathering aimed at learning who can be trusted to participate in (what she considers) 'fair' exchanges. The promise of the materials and her control over their disposition gives her much power to decide with whom to explore their potential. Similarly, she enjoys strong control over when she transfers the materials. Finally, she is in a strong position, at least initially, to specify the rights that she and her collaborators will hold in any outputs of their work. (A few months later, I interviewed Eileen privately and she explained her method of selecting collaborators in strategic terms. Her account prominently mentioned reputation in ways that support Steven Shapin's argument about the importance of character in the small, familiar worlds of technoscientific practice.[34]) But let us return to the conversation:

> Frank and George were both extremely angry at the way they had been treated, and they related a number of episodes of what they considered to be outrageous demands for continued control over their work and over information that they had produced after John ceased to be their supervisor. For example, Frank had made a list of experiments that he was working on or had planned, and 'Somehow this list found its way into John's hands', and John sat down with Frank and pulled out the list and went down it as a checklist saying, 'No, you can't do that experiment, my group is going to do that experiment. If you want to do that experiment, I will supervise you.' I said, 'You don't want to do that because his name will obscure yours, right, because he is famous and you're not?' He said, 'Exactly. If he is co-author on the paper, no one will remember that I had anything to do with it at all.' Frank said that he basically refused to abide by these rules. Many of these experiments, he claimed, he had never discussed with John, and there was no basis for John to claim that he was involved in any way.

George also started telling stories about how John was trying to appropriate their data and ideas. He provided an example of a particular idea that John had forbidden him to pursue. He said that he had thought of that idea himself, that it was obvious, that there was nothing proprietary about it – all of the necessary materials were publicly available. But John's view, according to George, was somehow that this idea was his and that it would be inappropriate for George to do it. I asked George, 'What kind of argument did he make to try to justify that?' He said that John presented the issue as, 'You used to work for me, and there's a hierarchy. It's up to you to follow instructions. Anything you do at the time you're working for me, I own.' It was not done in terms of an argument such as, 'On 12 April we discussed this idea.' John did not claim that previous discussions had led to the development of that particular idea.

Here the conversation offers a one-sided account of a dispute about whether a particular set of technoscientific things falls under John's authority as a laboratory head. George and Frank contest his claim to jurisdiction on temporal grounds and by asserting

33 Knorr Cetina, op. cit. (20), pp. 234–240.

34 Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation*, Chicago: Chicago University Press, 2008.

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that they independently developed the relevant ideas, whereas John reportedly asserts that the ideas were part of what they did while working for him. This ethnographic vignette shows how information control is entangled in practices that shape group boundaries, both during the formation of groups, as illustrated by Eileen's inquiries about potential collaborators, and during their dissolution, as shown by the dispute over who 'owned' work undertaken 'within' a contested period that included (or, to highlight a point of contention, preceded or followed) the departure of personnel.

Conclusion

This paper has outlined some elements of a perspective for analysing the selective flow of knowledge in technoscientific interaction, and has briefly explored empirical examples in the field of genome research. Many more examples would be required to illustrate all of the aspects of the perspective outlined earlier in the paper. However, these two ethnographic vignettes illustrate how information is selectively – and sometimes simultaneously – revealed and concealed in interaction. They also show how strategic information control can affect the epistemic qualities of knowledge and how control over technoscientific things is entangled with the construction of social groups. More broadly, this paper suggests that studying the selective flow of knowledge can illuminate the interactions that allocate control over knowledge and shape its social, temporal and spatial distribution.

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