

14 Messy Shapes of Knowledge—STS Explores Informatization, New Media, and Academic Work

The Virtual Knowledge Studio¹

The Internet is firmly entrenched in the daily lives of millions of people, faithfully reproducing existing patterns of power inequalities across the globe, including critical differences in access to the Internet itself (Castells, 2001; Wellman & Haythornthwaite, 2002; Woolgar, 2002b). Understanding the way people integrate the Internet into their routines and how they thereby construct what “the Internet” actually means and what it is about has attracted scholars from the very beginning of the Internet (Dutton, 1996; Ito, 1996; Walsh, 1996; Lazinger et al., 1997; Porter, 1997; OECD, 1998; Molyneux & Williams, 1999). This scholarship has, unsurprisingly, itself reproduced all conceivable positions with respect to the technology, its construction, and its impact on the world—from enthusiastic stories about the new life on the net (Rheingold, 1994; Turkle, 1995; Hauben & Hauben, 1997) to dark broodings about the undermining of civil society and civility due to an unfettered spread of either exhibitionism or privacy invasion, with empirically minded sociologists, anthropologists, and psychologists in between (Webster, 1995). These positions do not provide equal resources to Internet users for self-understanding. Techno-optimism is dominant. Technology critique is mobilized much more sparingly and often only in specific contexts (such as the fear of global Internet terrorism). Of course, users are regularly disappointed and turned off by their experience in surfing the Web (Henwood et al., 2002; Wyatt et al., 2002). This does not affect, however, the public discourse about the Internet so much—nor the sales of the hardware needed for Internet access—partly because there is always the next promise (Lewis, 2000), partly because these disappointments are backgrounded in the news media (Vasterman & Aerden, 1995). In the meantime, the chase for “the new, new thing” (Lewis, 2000) does have material effects that influence the technological, political, and economic ordering of life.

One of these effects is the iterative generation of various forms of “impact talk,” a genre strongly related but not identical to particular forms of technological determinism (Bijker et al., 1989; Smith & Marx, 1994; Wyatt, 1998; Wyatt et al., 2000; see also Wyatt, chapter 7 in this volume). First-time users, as well as more advanced users, of a particular Internet-based tool can ground their experiences in a coherent story about “the impact of the Internet.” Examples of this way of making sense of the Internet are very common. Grandparents are excited that they can e-mail their

grandchildren overseas; librarians, having gotten used to the digital library technologies, are talking about the revolution that Google Scholar promises to deliver (finally?) in accessing scholarly information; the music industry is forced to reinvent itself in response to large-scale peer-to-peer file sharing that was impossible before the advent of the Internet; parents face new challenges in educating their young children in how to use and not to use chat channels; teachers experience the effects of cut-and-paste writing of their pupils and respond with monitoring software. In short, "impact talk" is not only a variety of philosophical perspectives—some more deterministic than others—it is also a practical discursive processing of embodied experience.²

"Impact talk" about the Internet is also paramount in academia with respect to the future of knowledge creation itself. Board members of traditional academies of science do not hesitate to speak about the revolutionary impact of the Internet on the conduct of science. The open-access movement has embraced the Internet as the ideal technology to undermine excessive monopolies of publishers on the provision of scientific information and to realize the old dream of the World Brain (for a recent review, see Drott, 2006). General science journals like *Nature* and *Science* regularly report on specific changes that have been made possible by the combination of research instrumentation with Internet-based communication tools in the physical and life sciences (Blumstein, 2000; Schilling, 2000; Sugden, 2002; Cech, 2003; Anon., 2004a,b, 2005a; Shoichet, 2004; Wheeler et al., 2004; Cohen, 2005; Giles, 2005; Marris, 2005; Merali & Giles, 2005; Santos et al., 2005; Walsh et al., 2005). New ways to construct the objects of research out of the combination of new and old data are key motifs here. Data sharing also promises to enable the tackling of old questions in new ways in fields as diverse as epidemiology, systems biology, world history, archeology, cognitive sciences, and language evolution (NRC, 1997, 1999; Arzberger et al., 2004; Colwell, 2002; Koslow, 2002; Marshall, 2002; Van House, 2002; Esanu & Uhlir, 2003; Kaiser, 2003; Wouters & Schröder, 2000). At the same time, data sharing stands for a different regime of managing data sets and data production and requires the mobilization of more specialized data expertise than most researchers can deliver (Wouters & Schröder, 2003). It also raises new issues in copyright law, privacy protection, quality control of scientific data, and the private-public partnerships. Every month, new Web sites are born that use new ways to communicate research results, data, and insights (*Science* and *Nature* keep track of them on a weekly basis). In fact, there is no aspect of research or research organization that does not seem to be somehow affected in the short-to-medium run by the combination of digital research instruments and the Internet (Walsh, 1996; OECD, 1998; Walsh, 1999). To sum up, these developments add up to the plausibility of the claim of a qualitatively new state of science in which informatization of research practices is central: e-science or cyberscience (Wouters, 2000; Beaulieu, 2001; Hey & Trefethen, 2002; Hine, 2002; Berman, 2003; Nentwich, 2003).

To a veteran STS scholar, these reports may not be very convincing, however. After all, the way empirical materials and facts are combined to produce a plausible story or vision of the future is never innocent and always deconstructible. And students of science and technology often profess to *hate* technological determinism and other

forms of reification. Often, "impact talk" feels too close to these perspectives to be comfortably included in STS work. For the historically minded scholar, a common response has been to show historical precedents of the new, new thing. For example, the telegraph is a nice counterexample to the claimed novelty of the Internet (Woolgar, 2002b). This approach amounts to deconstructing the novelty of the claimed revolution, usually combined with a critical analysis of the purported effects. Another reaction to "impact talk" is to turn the claims about the novelty of the Internet into empirical questions. This has been done from the very beginning of the discussion about the Internet (for an overview of early work, see Dutton, 1996). This line of thinking has led to a large body of empirical work that has convincingly shown that some aspects of life have not been changed by the emergence and use of the Internet while other aspects have indeed been transformed but in a different way than claimed or expected (Wellman & Haythornthwaite, 2002). This perspective has also been productive in the discussion about the impact of information and communication technologies (ICT) on academic work (see for a recent example Gunnarsdóttir, 2005). Thanks to this body of empirical work, we know quite a lot about the way the emergence of the Internet and the use of ICT has affected some aspects—but not others—of the process of knowledge production and circulation.

With some exceptions (to which we will turn later), most scholarly work about the Internet and/or informatization of academic research can be sorted in these three types of literature: impact talk, deconstruction of impact talk, and detailed empirical description. All three have produced interesting work that may be relevant to a large variety of audiences. All three have also displayed distinct intellectual problems or "deep troubles" (Collins, 2001).

Perhaps the most impressive "impact talk" analysis of informatization in science has been published by Nentwich (2003). His book is based on a large set of interviews with practicing researchers, combined with a review of the literature about the future of academic work in cyberspace. The analysis has basically reproduced actor's impact talk, placed within the context of trying to assess the potential of the Internet for science. To his credit, the author does not claim that the potential and the actual are identical but leaves this question open to follow-up empirical research. To support this research, the book proposes a three-step impact model. In the first step, ICT has an impact on the scholarly communication system. "I explain how ICT is actually shaping the move away from traditional science and research while, at the same time, developing further not least influenced by the development it has originally initiated" (Nentwich, 2003: 63–64). In the second step, these "ICT-induced changes," which together have led to "cyberscience" as qualitatively distinct from "traditional science," influence academia at large. This leads to changes in actors, structures, processes, and products. The third step consists of "indirect consequences" in the substance of research via three routes: methodology, work modes, and representation (Nentwich, 2003: 64). This model leads to a qualitative "trend extrapolation" (Nentwich, 2003: 480), in which the substitution, i.e., the more or less complete replacement of old ways of doing things by new cyber-tools, is expected across the board. To sum up,

cyberscience is already a fact, and a deep one. "I hold that the increasing use of ICT in academia impacts on the very substance of what science and research produces" (Nentwich, 2003: 486). In the end, we have a linear storyline of increasing "cyberscience-ness."³

The problem with deconstruction of impact talk, on the other hand, can perhaps be characterized as "unworldliness." If both the woman in the street and eminent scientists agree that the Internet has made a huge difference for them, it may come across as snobbery and elitism to insist on the opposite on purely philosophical grounds.⁴ Perhaps more importantly, this approach tends to draw attention away from the role of technology in research practices to such an extent that mediation technologies have become invisible in many STS analyses, even though mediation has been central to STS theorizing. This invisibility tends to be reproduced in STS textbooks (Jasanoff et al., 1995; Fuller, 1997; Sismondo, 2004).

However, there is a growing body of work that pays specific attention to the role of mediating technologies in scientific practice. For example, Cummings and Kiesler have found that the use of communication technology was not particularly useful in the coordination of multi-organizational research projects, although e-mail was used a lot and Web sites were common⁵ (Cummings & Kiesler, 2005).⁶ They conclude that new types of tools are needed. Shrum (2005) has developed a series of projects about science in "distant lands" and has recently called for more research on this. Bohlin (2005) has produced an analysis of scientific communication through the lens of the sociology of technology, emphasizing interpretative flexibility and variation across disciplines (see also Lazinger et al., 1997). Differences between disciplines is also a key theme of the work of the late Rob Kling (Kling & Lamb, 1996; Kling & McKim, 2000; Kling et al., 2003; Kling et al., 2002). Information infrastructures and databases have been studied with a focus on their construction in, and implications for, scientific practice (Fujimura & Fortun, 1996; Bowker & Star, 1999; Star, 1999; Van Horn et al., 2001; Bowker, 2005). The role of mediation technologies has also been the topic of historical research (e.g., Shapin & Schaffer, 1985).

Still, much work on the use of these technologies in scientific communities has been performed outside of STS, especially in the fields of social network analysis (Wasserman & Faust, 1994; Haythornthwaite, 1998; Matzat, 2004; Wellman, 2001), Internet studies (Jones, 1995; Howard, 2002), information science⁷ (Barabási, 2001, 2002; Börner et al., 2005; Huberman, 2001; Thelwall, 2002a,b, 2003, 2005; Scharnhorst 2003), computer-supported collaborative work (Galegher & Kraut, 1992; Sharples, 1993), social informatics (Suchman, 1987; Hakken, 1999, 2003; Kling, 1999), and communication sciences (Jankowski, 2002; Jankowski et al., 2004; Lievrouw & Livingstone, 2002).

These studies, independently of how informative they are, often have a different theoretical ambition from STS. Although they teach us a lot about the past and present of, say, scientific publishing or the use of networked on-line microscopy, we do not necessarily gain much insight into what they mean for our understanding of knowledge making and the politics of research. This is a reason that we abstain in this

chapter from an overview of what we presently know about the way new media and the Internet are being mobilized in scientific and scholarly practices. We instead try to make links between different bodies of work about the interaction between new media and academic work and the role of information and the Internet therein, to circumscribe and address particular theoretical and methodological concerns. This, we hope, will also enable us to discuss scholarly work that has moved beyond the impact/deconstruct/describe triad mentioned earlier.

THEORY AND THE INTERNET

Theoretically, the Internet and the Web seem the almost perfect materialization of key concepts in the constructivist tradition of STS, such as "seamless network," "translation," and "hybrid socio-technical networks." STS scholars may therefore be encouraged to keep using these concepts, since their empirical references have only become more visible and hence plausible. This is indeed promising but at the same time perhaps too easy. In fact, the near-perfect fit between the Internet and a variety of analytical concepts⁸ should encourage us to question these concepts, the more so since they are also mobilized in the building of new sociotechnical infrastructures (Beaulieu & Park 2003). What are the implications of the use of STS concepts in the design of new infrastructures and practices for the politics of STS and indeed for the role of STS itself?

These are questions about the intersection of method and theory in STS. Charis Thompson's (2005) characterization of STS is relevant here. According to Thompson, an interest in the deep interdependence of nature and society is the most unifying element of the field. This is accompanied by a common methodological orientation.

Despite a good deal of reflexivity on the nature of data and its interpretation, there is a valorization of empirical data collection either by ethnography and participant observation, or by original contemporary or historical archival and document research . . . Synthetic, a priori, and purely interpretative methods, for example, are all viewed suspiciously if they are not bolstered by empirical work. Versions of empiricism and positivism, thought of as not requiring any interpretation (as advocated in some natural and social science methodologies), are viewed as equally suspect . . . STS thus opts for empirical methodologies that are nonetheless assumed to be interpretative. Because of the tight knit between methodological and theoretical concerns, STS often reads like empirical philosophy or an empirical case study that has been trotted out to make a theoretical point. (Thompson, 2005: 32)

This view has important implications for the study of mediation technologies in scholarly and scientific practice. If both actor and analyst perform their research in and through new digital media, this may affect not only actor practice (the topic of impact talk) but also, though perhaps less visibly, shape the theory-method intersection for the analyst. According to Timothy Lenoir, this amounts to a new epistemic regime:

Media inscribe our situation. We are becoming immersed in a growing repertoire of computer-based media for creating, distributing, and interacting with digitized versions of the world, media

that constitute the instrumentarium of a new epistemic regime. In numerous areas of our daily activities, we are witnessing a drive toward the fusion of digital and physical reality; not the replacement by a model without origin or reality as Baudrillard predicted, but a new playing field of ubiquitous computing in which wearable computers, independent computational agent-artifacts, and material objects are all part of the landscape. (Lenoir, 2002: 28)

This comment has methodological consequences because new media are not transparent. "Media not only participate in creating objects of desire, they are desiring machines that shape us . . . Media inscribe our situation: it is difficult to see how we can teleport ourselves to some morally neutral ground" (Lenoir, 2002: 46). The same is true for the analyst. Since we cannot be teleported to unmediated ground, reflexive analysis of the implications of new media for our production of knowledge about the new media in knowledge creation is perhaps the only way to pay due attention to the new shapes of mediation in scholarly practices.

This sensitivity to mediation informs our exploration of two questions. First, what can we learn from emerging e-science practices for the study of science and scholarly practice and for theory and method in STS? Second, how can these insights be included in a critical interrogation of e-science? We therefore try to address the possibility of speaking about e-science and informatization while systematically breaking down the reification that is the continuing product of this speaking.

In the next, second, section we discuss the notion of scientific labor as a useful point of departure for the analysis of scientific practice. We distinguish two dimensions: labor as the source of user-value and labor as the source of exchange value. We specify these dimensions with respect to work in the context of e-science and the Internet. This brings us to the discussion, in the third section, of epistemic culture.

We think that this concept provides a productive framework to study emerging knowledge practices. We discuss to what extent e-research leads to a redefinition of our understanding of epistemic cultures. We also explore the implications for the notion of epistemic culture itself. The fourth section shifts from labor to the institutionalization of scientific labor in disciplinary formations and the role of information infrastructures therein. This brings us to disciplinary differences in the uptake of communication and information technologies. While disciplinary differences may seem rather commonsensical and old-fashioned, it is important to revisit them because of the universalizing aspects of e-science as an ideology. Disciplines, infrastructures, and institutions are also the basis for the reproduction of scientific labor and the generation of the identity of researchers and scholars. The last section will draw conclusions for a critical interrogation of informatization and e-science.

RESEARCH AS LABOR

In an industry first, Chemical Abstracts Service (CAS) demonstrated the delivery of chemical information, including structure, via live interaction using Blackberry and other handheld devices at the CAS European conference in Vienna this week. More than 20 handheld devices were used simultaneously by conference participants to retrieve hundreds of literature references

as well as molecular structure and related data for specific substances in real time. CAS will be making this new mobile route to scientific databases, called CAS Mobile, available through its STN and SciFinder services in the near future.

This is certainly worthy of attention, but I hope to heaven that it doesn't mean we have to now make handheld device client software available to our patrons and support it as well! On the other hand, perhaps it means that it will all be Web compatible! (e-mail exchange, STS-L list, 20 January 2006)

This e-mail exchange contains in a nutshell some key problems of e-science with respect to the organization of scientific and technical labor. Before sketching the potential of taking labor as analytical point of departure, we need to become more intimate with the way e-science is being defined. In other words: what and where is it? This will lay the ground for a discussion of two different but perhaps complementary approaches to science as labor.

The term e-science is most popular in the United Kingdom, continental Europe, Australia, and some other parts of Asia. In the United States, other parts of Asia, and other parts of the Americas, the concept of cyberinfrastructure for research is more common. The difference between these terms is interesting. One stresses the practice of research, the other the infrastructural condition for that practice, but both concepts are understood to refer to a shared view of computationally intensive research as a qualitatively novel way of doing research. Since 2003–2004, the concept of e-research as the more generic capture of ICT-driven change of the organization and nature of research has become popular with most actors involved, sometimes in combination with the concept of cyberinfrastructure (see, for example, Goldenberg-Hart, 2004).

The UK E-Science Programme defines its topic as follows:

What is meant by e-Science? In the future, e-Science will refer to the large scale science that will increasingly be carried out through distributed global collaborations enabled by the Internet. Typically, a feature of such collaborative scientific enterprises is that they will require access to very large data collections, very large scale computing resources and high performance visualization back to the individual user scientists. The Grid is an architecture proposed to bring all these issues together and make a reality of such a vision for e-Science. (U.K. Research Councils, 2001)

This concept of e-science stresses computational research, processing of huge data sets, video-conferencing, and collaborative research relying on digital communication channels. In terms of disciplines, physicists, computer scientists, life scientists, and some computational social sciences are dominant in e-science (Wouters & Beaulieu, 2006). Yet, the prospect of e-research has spread out across the entire scholarly community, including the interpretative social sciences and humanities. On October 15, 2004, over 100 leaders from higher education, libraries, and information technology gathered in Washington, D.C., at a forum entitled "E-Research and Supporting Cyberinfrastructure: A Forum to Consider the Implications for Research Libraries & Research Institutions," which was cosponsored by the Coalition for Networked Information (CNI) and by the Association of Research Libraries (ARL). The forum was addressed by

Atkins, author of a crucial 2003 NSF Blue Ribbon Report (Atkins et al., 2003). According to the report,

a new age has dawned in scientific and engineering research, pushed by continuing progress in computing, information and communication technology . . . The capacity of this new technology has crossed thresholds that now make possible a comprehensive "cyberinfrastructure" on which to build new types of scientific and engineering knowledge environments and organizations and to pursue research in new ways and with increased efficacy.

At the December 2004 ARL Forum, the chairperson of the Coalition for Networked Information, Clifford Lynch, stated that massive changes in scholarly practice are occurring across all disciplines. He argued that new practices, products, and modes of documenting and communicating research will have far-reaching implications for all organizations involved in managing the scholarly record and supporting the ongoing enterprise of scholarship, and that libraries in particular play a central role because they manage the record across time and across disciplines. These changes in scholarly practice will create profound changes throughout the entire system of scholarly communication, and a failure to put into place effective new support structures in response to these changes would pose tremendous risk to the enterprise of research and scholarship. "This is what is at stake when we consider how to lead our institutions in addressing these new needs," Lynch said at the Forum (Goldenberg-Hart, 2004).

Note how similar this future vision is to the prospected trajectory of cyberscience in Nentwich (2003). The implications of e-science as a prospective technology have been analyzed by Vann and Bowker (2006), building on Brown's analysis of the role of promise in science and technology policy (Brown & Michael, 2003). In the same book (Hine, 2006), an interrogation of future visions contrasting e-science as computational research with women's studies use of ICT has been developed by Wouters and Beaulieu (2006). We will come back to these issues in the last section, in which we try to sketch the outline of a critique of e-science. What concerns us here is the impact of emerging e-research investments, practices, and infrastructures on the organization of labor. The fact that librarians, researchers, information technology experts, and new hybrids such as bioinformaticians, neuroinformaticians, and visualization experts are all heavily involved, points to an important, not yet well studied phenomenon: a re-definition of what type of labor is needed to sustain these scientific and scholarly practices (but see Doing, 2004).

It is common for practitioners in science studies to refer to science as labor and to use the terms "work" and "labor" interchangeably to highlight the concrete actions undertaken by subjects in a process of knowledge creation—indeed, the process of knowledge creation itself. While science as labor in this specific sense is certainly an important sociological and historical category, it may be insufficient to the task of theorizing the mediated character of science. Instead, the distinction between two different standpoints may prove fruitful. In its attempt to emphasize the historical and social contingency of scientific knowledge, and of nature itself, much of the work on science in STS over the past three decades has been concerned to look at science as a

"practice" (cf. Pickering, 1992; Star, 1992; Clark & Fujimura, 1992). STS research on practice, also often referred to as "the nitty gritty of scientific work," has highlighted the centrality of tools to knowledge production process. Here, the hope was to build an ecology of the contents of scientific knowledge as well as of the conditions of its production (Clark & Fujimura, 1992). As a concrete, situated activity, scientific work was taken to be highly mediated by the objects that enabled specific orientations to the scientists' tasks at hand. This emphasis on science as labor also had important implications for the methodologies and approaches to research in STS. Ethnographic approaches and detailed case studies of work done in particular locations became core tools for STS. Even issues of circulation of knowledge were posed in terms of adaptation to local conditions of work.

Although looking at scientific labor as practice in this sense is important and crucial to the development of methodologies that could grasp its mediated character, it is only one of its faces. In other words, the category of the "nitty gritty" of scientific labor as epistemic practice is only one dimension of scientific knowledge production as commodity-determined labor. Indeed, exclusive focus on the "nitty gritty" of scientific labor may reflect a "technicist" model of labor, which diverts researchers' attention from questions about the economic valorization of laboring action (Vann, 2004).⁹ A second perspective is therefore important that enables scientific activity to be construed as a social process through which the market values of specific knowledge-producing efforts are achieved. Here, the labor of scientists emerges as an object of market exchange that is constructed through highly mediated cultural and institutional processes of qualification and inscription (cf. Callon et al., 2002; Vann, 2004). In other words, scientific labor is not only a process of constructing knowledge of objects; it is itself the result of objectification of its own practices through processes of market exchange. From the standpoint of this latter dimension of labor, which value-form theoretic Marxists refer to as its "exchange-value," the study of scientific practice would entail study of how scientific practice—as a valorized object of institutional knowledges—is itself produced (Vann & Bowker, 2006).

STS scholars are increasingly turning their attention to the ways in which information infrastructures enable the visibility and invisibility of "concrete" work in institutional settings to emerge (Star, 1999; Bowker & Star, 1999). Although much of this work does focus on the "informal, nitty gritty of largely invisible articulation work," it also brings our attention to the processes and politics of institutional coding, the ways in which the identities of institutional subjects are themselves constructed through modes of infrastructural recognition. This strand of STS literature is distinguishable from that strand which emphasizes science as epistemic practice because it actually has important affinities with another tradition of science studies from which studies of science as epistemic cultures distanced themselves: studies of scientific accounting and of scientific disciplines as labor market sectors.

Given these analytical transversals, the contemporary proliferation of digitally mediated scientific labor presents even more difficult analytical challenges than those which aim to explicate how digitization mediates "the nitty gritty of scientific

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Given these analytical transversals, the contemporary proliferation of digitally mediated scientific labor presents even more difficult analytical challenges than those which aim to explicate how digitization mediates "the nitty gritty of scientific

practice." Indeed, when we intersect the analytical points made above with the capacities of digital techniques for mediating knowledge production, new challenges emerge for the study of the production and accountability of the identities of scientific laborers. In contexts in which technological interfaces and social and digital networks are increasingly broader and longer, many dialectical relationships, such as those of visibility and invisibility and of expert and nonexpert work, may be altered. Taking our hunches from those aspects of Marx's work that dealt with the commodity-determined labor as a duality of use-value and exchange-value, we can begin to orient ourselves to forms of implicit analytical reductionism in STS and to pursue new methodological vocabularies that bring us closer to the textures of contemporary digitally mediated scientific practice—both as site of knowledge production and as site of knowledge about production. This chapter therefore entails the methodological idea that the study of science as a process mediated by new information technologies requires a synthesis of conceptual resources that zoom in on labor in each of its dimensions because qualitatively different forms of mediation occur in each.

EPISTEMIC CULTURES IN E-SCIENCE

The notion of epistemic culture focuses on the machinery of knowledge production (Knorr Cetina, 1999). It emphasizes configurations of persons and objects rather than institutions or concepts. This approach has the advantage of making research practices and epistemic objects, rather than digital technology, central to the analysis. Research instrumentation is nevertheless important, since epistemic cultures and ensembles of research technologies define one another (Hackett, 2005: 822 note 4). The long tradition of studying the role of research instruments in STS is therefore a fruitful perspective to incorporate in the study of emerging e-science practices (Edge & Mulkay, 1976; Fleck, 1979; Fujimura, 1987; Clark & Fujimura, 1992; Fujimura, 1992; Fujimura & Fortun, 1996; Rheinberger, 1997; Benschop, 1998; Joerges & Shinn, 2001; Hackett et al., 2004; Price, 1984; Traweek, 1988; Zeldenrust, 1988).

An "epistemic cultures approach" enables an understanding of the multiple ways new technologies can be taken up, without foreclosing possibilities based on existing technological promises (Lenoir, 1997, 2002; Cronin, 2003). This approach therefore provides ways of addressing knowledge creation as varying configurations of practices around epistemic objects. Of particular value in Knorr Cetina's (1999) characterization is the inclusion of material, symbolic, and subjective worlds in her exploration of practice. Knorr Cetina carries out her task of redefining practice by the notion of knowledge objects as epistemic—as productive generators of activity, continually opening up and revealing new knowledge. This concept draws on Rheinberger's epistemic things, which Knorr Cetina defines as "any scientific objects of investigation that are at the centre of a research process and in the process of being materially defined." These objects are productive because of their defining characteristic, their "... changing, unfolding character... lack of object-ivity and completeness of being" (Knorr Cetina, 1999: 181).

As a framework to "work up" ethnographic analysis, three main categories are central in analyzing epistemic cultures. These correspond to concern with empirical, technological, and social aspects of an epistemic culture. The first typifies the way the empirical is brought in as an object of study, the second focuses on the performance of relations to the object through instruments, and the social dimension brings to the fore the emergence of relations between units in a field of knowledge (i.e., laboratories, individual researchers). In digitization, there is a reconfiguration of the object that results from repeated de-contextualization and re-contextualization steps, which feed on each other. Both decontextualization and recontextualization require work. To maintain globalized knowledge networks is particularly labor intensive—one reason for the renewed debate about the most appropriate funding model for scientific and scholarly work. Digitization affects all three dimensions of epistemic cultures through this process of de- and re-contextualization.

Epistemic cultures have been studied through "laboratory studies" involving observation, interviews, as well as the analysis of technical instruments and documents. This methodology can be adapted to the study of e-science. For example, the distributed aspects of e-science resemble the set-up of high-energy physics experiments studied by Knorr Cetina in which e-mail seemed to play an important coordinating role and computing and networked access to data are clearly present (see also Wouters & Reddy, 2003). The analyst can shape her approach based on these features of the epistemic practice, so that an "intermittently absent observer can always link up with the e-mail network, as physicists do" (Knorr Cetina, 1999: 23). The challenge of studying a center with outposts active at different times can also be met by a "scaling up" of ethnography, from one to many participant-observers. Other adaptations of traditional laboratory studies are likely to be needed, to deal not only with scale but also with mediation of laboratory work (Beaulieu, 2005; Hine, 2002), scientific communication (Fry, 2004; Hellsten, 2002), and interaction via and about infrastructure and knowledge circulation.

While it is worthwhile to use epistemic cultures to question the notion of e-science (Wouters, 2004, 2005; Wouters & Beaulieu, 2006), the framework of epistemic cultures itself may also be interrogated, in relation to e-science. It may be necessary to interrogate the concepts of epistemic cultures and see how the contexts of knowledge are shaped across cultures.

One way of investigating this issue is to consider the distinction that is foundational to Knorr Cetina's framework. Epistemic objects are not the same as the experimental systems that embed them into broader fields of scientific culture.¹⁰ Furthermore, the relations between experiments and laboratories can be articulated in a variety of ways (via correspondence to the world, intervention in the world, or processing of signs) (Knorr Cetina, 1992). E-science may require a revisiting of these relations, since it troubles the distinction between technological objects and epistemic objects. Rheinberger states that the first are stable and black-boxed, whereas the second produce unexpected results when interrogated (Rheinberger, 1997). An object can also move (historically) from the first to the second category, so that what was once a discovery becomes a

routine technique that enables other objects to be interrogated. In e-science, infrastructures for experiments can be databases, "grid" applications, or models for example. Bowker and Star have noted that electronic infrastructures may offer more flexibility with regard to the way data have to be aggregated in order to be managed (Bowker & Star, 1999). The following questions arise: Does it become more difficult to distinguish experimental objects from technological objects when they are in a similar medium, when the technologies and their content are continuous? How are such distinctions maintained?

Given the importance of this distinction between experiment and lab and its implications for methodological approaches, it is worth reflecting on the ways the case of e-science might or might not be covered by Knorr Cetina's typology of relations. In the archetypal laboratory of experimental science, the laboratory signals independence from the field, and the reconfiguration of the object as to what it is (or what can stand in for it), when it occurs, and where. When there is more "epistemic infrastructure" for experiments (modeling, data repositories, search capabilities; see Van Lente & Rip, 1998), the relation to the experiment may be different. For example, if the laboratory can be thought of as the removal from the field, it seems that the Internet can serve as both field and laboratory because of the mediating aspects of interactions on the Net (i.e., the Internet as place where people act, talk, etc., in a "natural" field but where these interactions also leave traces, so that they can be manipulated/measured/modeled as though they were taking place in a lab). This possible shift, between epistemic object and "setting" for experimentation can be seen as a complex version of the tension between an epistemic object and a technical object. Whereas Rheinberger argues that objects may move (historically) from one category to the other, Knorr Cetina argues for an unsettled status of technical objects as well (Knorr Cetina & Bruegger, 2000). Neither of these perspectives, however, fully accounts for the complex ways in which objects may shift, from technical to epistemic object and back again. Such shifts seem to characterize e-science work, where the distinctions between tool and object are not clear-cut. The ways in which these shifts occur, and the points of stabilization, are therefore important elements in understanding e-science.

The ongoing nature of shifts between technical and epistemic objects was particularly visible in a recently studied e-science project: a distributed database of genetic and epidemiological data (Ratto & Beaulieu, in press 2007). As the project team worked through the ethical, scientific, and technical issues involved in setting up this data infrastructure, new questions emerged. These questions, on such matters as bioinformatics techniques, methods of preservation of "wet" materials, and the best way to make disparate kinds of data comparable (e.g., comparing life style data to genotyped information) blended scientific and technical issues. Seen in this light, the work is less the application of technical tools to epistemic objects and more what Norris has called "tinkery business" (Norris, 1993) and Fujimura has characterized as the searching out of "doable problems" (Fujimura, 1987). Importantly, as the project progressed, the stabilization of various aspects of the database as either "scientific" or "technical" could be read as part of the disciplinary organization of the project (e.g., that the database

infrastructure is a technical task for the bioinformaticians, whereas the composition of individual database records is the job of the genetic epidemiologists). This analysis points to the complex linkages between technical and epistemic objects and, as noted above, indicates that the choices about how to distinguish between them have important ramifications for the valuing of certain kinds of scientific labor. In addition, the stabilization of certain kinds of problems as "technical" was also related to the delegation of particular questions of trust or authority to various parts of the overall infrastructure, in some cases preempting other systems of due diligence. The tensions (and importance) of these choices were made obvious when technical systems such as password managers and public key encryption techniques were evaluated as possible additions to scientific oversight committees and informed consent procedures. While these technologies were not seen as replacing such systems, the possibility of such delegation is indicative of the transformation of a scientific (and social) problem into a technical issue that can have vast ramifications for the way science is carried out as well as ethically guided (Ratto & Beaulieu, in press 2007).

The social dimension of epistemic cultures is also useful for understanding possible shifts in the practice of science. The relations between units in a field have to do with the social structures in scientific work. For example, these relations can be exchanges of expert services between individuals, competition between laboratories or collaboration in experiments. One way in which relations between units have been mediated consists in the use of texts (articles and books). The status of texts as key units of scientific knowledge may be challenged in e-science, for example, when contributions to knowledge become constructions of or additions to databases or infrastructures (Bowker, 2000; Van House, 2002; Cronin, 2003). The economy of credit—for example, attribution of authorships of publications or their citation (Scharnhorst & Thelwall, 2005)—is likely to be different in e-science than in traditional sciences because social relations in e-science are also affected by the change from face-to-face to mediated communication/textuality (Hayles, 2002).

It is here that the issues involved in studying epistemic cultures bring us to questions about the institutionalization of scientific work. As noted above, the institutional configuration of e-science involves a great deal of mediation, and thus we need to pay attention to the effects of such mediation on the epistemics of representation, proof, the issue of trust, and the kinds of work that e-sciences involve, enable, distribute, emphasize, and conceal. Tracing the dimensions of scientific work requires linking the cognitive and associated practices of scientists "on the ground" to the particular institutional settings that both create and are created by them.

SCIENCE WITHOUT DISCIPLINE?

The previous section focuses on scientific practice through the lens of epistemic cultures. However, some of the issues it raises relate to the problem of disciplining scientific labor in academic institutions: "the structural and organizational conditions of scientific production" (Fuchs, 1992). The concept of the scholarly discipline is useful

for exploring these issues in e-research, such as new modes of dissemination, the allocation of intellectual property, concentration of resources to leverage new forms of science, mutual dependencies, task uncertainty, and variation in work practices. Thus, the discipline as an analytic unit also introduces a comparative lens for understanding practice.

The concept of the scholarly discipline is useful for this exploration. Disciplines provide for the stabilization of heterogeneous and localized practices through an economy of practices (Lenoir, 1997). As Becher (2000) points out, the concept of academic discipline is not straightforward. Its study is a long-standing, although intermittently performed, tradition in STS (Becher, 1989; Heilbron, 2004; Lemaine et al., 1976; Weingart et al., 1983; Weingart, 2000; Whitley, 2000). The exploration of the performance of e-science labor as a professional activity may be enhanced by revisiting the notion of discipline and interdisciplinarity. This is particularly relevant, since e-science not only claims to be interdisciplinary but also promises to transform the core idea of disciplinarity. While the idea that e-science exists "beyond disciplines" might characterize the discourse about e-science better than its practice, transdisciplinarity is a strong element of e-research. In a way, it is the defining rationale of the cyberinfrastructure that must make e-science possible. The philosophy behind the Grid is crucial here (figure 14.1).

Presently, the user-scientist often has problems navigating the confusing mix of tools, data, interfaces, and protocols that make up current on-line computational and archival resources. Resolving this issue is one of the primary claims of e-science. By providing a single interface (typically Web-based) that "automatically" translates diverse databases and other informational resources through the use of a common middle layer of software often called "middleware," many e-science projects hope to standardize this diversity without losing track of the productive disciplinary and technical differences that create it. Thus, in these projects the idea of "middleware" is extended from being a purely technical solution to being seen as one possible answer to the problems to multidisciplinary. Indeed, we can argue that an important selling point for e-science will be the extent to which complex problems can be tackled by research teams that are much more hybrid than currently possible:

In order to achieve the best results research depends increasingly on worldwide collaboration between scientists and use of distributed resources. The complexity of the science often requires multidisciplinary teams. Such collaborations of distributed scientists, brought together in a common solution-oriented goal, have been named 'Virtual Organizations (VO)'. Thus, the Grid has also been defined as an enabler for Virtual Organizations: Given the barriers to collaborative working without such technology, it is immediately clear that the quality of the e-Science environment available to such distributed teams is vital to their ability to collaborate and perform good science (Berg et al., 2003: 7).

However, this begs the question of how e-science visions and the technical possibility of sharing resources will relate to diverse research practices: common problem formulation, shared socio-cognitive styles, a shared scientific and technical language, and

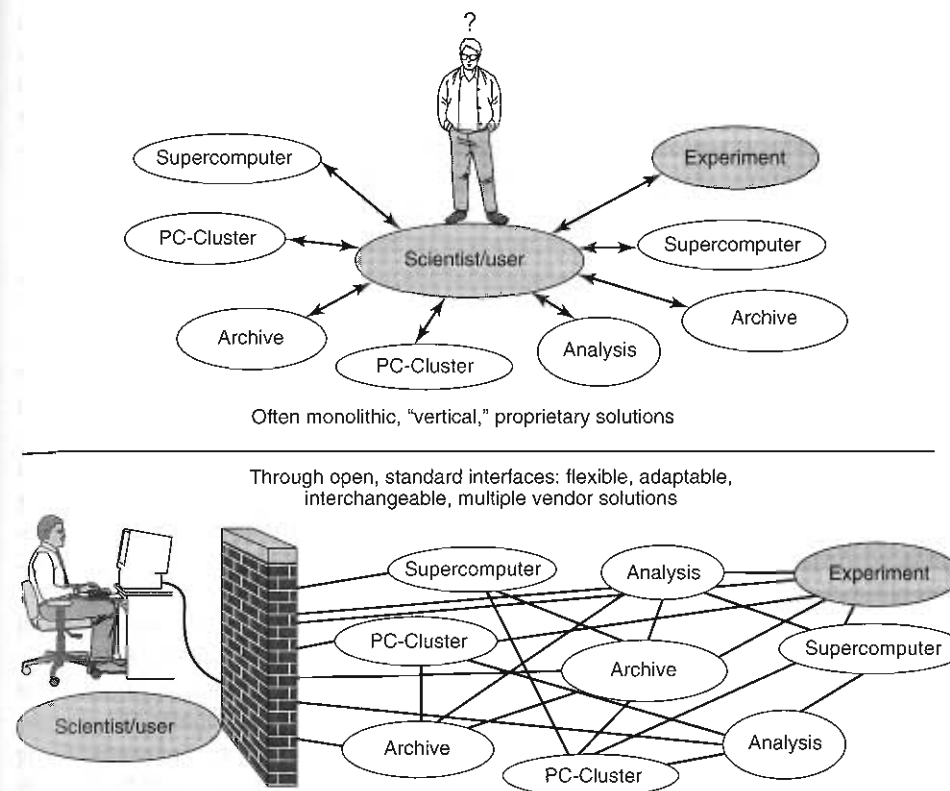


Figure 14.1
The future of e-research, from Berg, A., C. Jones, A. Osseyran, & P. Wielinga (2003) *e-Science Park Amsterdam* (Amsterdam: Science Park Amsterdam). Available at: <http://www.wtcw.nl/nl/projecten/eScience.pdf>.

enough commonality in reputational control mechanisms to allow researchers seriously to invest in collaboration and the creation and testing of new infrastructures. The rich STS tradition of the study of the institutionalization of research, mechanisms of reputational control, and the emergence and stabilization of disciplinary structures is relevant here. This body of work may be helpful to e-researchers, either in the natural or in the social sciences, who might otherwise run the risk of being end-users of an infrastructure, and its related diffusion model, imbued with a set of assumptions relating to what constitutes valid practice in one particular scientific tradition, namely, high-energy physics, that does not necessarily translate across epistemic cultures. To STS researchers, this perspective may clarify the potential of older elements of its theoretical and methodological tradition and protect against a progressivist model of STS methodology in which only the latest "turn" is worthy of attention.

Questions about reputation, communication, and new modes of authorship and authority are paramount in such explorations of disciplinarity and of e-science as labor. According to Whitley (2000), two main factors influence the reputational control over scientific labor: the degree of horizontal concentration of employment units, resources, audience, and reputations; and the vertical integration of goals, problems, and techniques. Vertical integration relates to the community-wide practices in epistemic cultures, whereas horizontal concentration relates to resource and accountability infrastructures. Reputational control determines how identities of scientific labor force are produced and can be highly influential in legitimating or marginalizing scientific labor.

A concrete example is the role of informal technical communication in technologically driven intellectual work. Knorr Cetina's notion of technical gossip provides one way of understanding the construction of researcher identities through reputational networks around the object of research. She describes technical gossip as an evaluative and personal discourse that interweaves "report, commentary and assessment regarding technical objects and regarding the relevant behavior of persons" (Knorr Cetina, 1999: 205). Reproducing a "personalized ontology" that transcends organizational boundaries such as experiments, experimental groups, and institutions, technical gossip is an informal infrastructure for development of interpersonal recognition. This is obviously not limited to intellectual communities that are organized around experimental or laboratory apparatus. Reflecting on the generation of new insights by geographers, Passmore (1998) stresses the centrality of gossip to the development of new ideologies. He observes that in geography, rumor communicated through the structure of personal networks is influential in building reputations and determining the position an individual holds in relation to the research front of a field. On the Internet, technical gossip may become embodied in specialized forms of communication such as Weblogs, Wikipedia, and collaboratories by which it may become more visible and perhaps acquire new roles (Hine, 2002; Mortensen & Walker, 2002; Thelwall & Wouters, 2005).

New modes of communication and quality control that challenge the traditional scientific communication system, such as digital preprint archives¹¹, open-access journals, and open peer review have emerged within a handful of disciplines whose work organization fits their perceived benefits. For example, Knorr Cetina's (1999) notion of technical gossip and of confidence pathways may explain saturation in the uptake of computer-mediated communication technologies for informal communication within the high-energy physics community, which has not been mirrored in other physical science disciplines, such as chemistry (Walsh & Bayma, 1996). Technical gossip and confidence pathways in experimental high-energy physics, albeit often formalized in collaboration-based quality control mechanisms (Traweek, 1988), create a high degree of interpersonal recognition that has partly displaced traditional forms of peer review. In intellectual fields where mutual dependence between scientists is not a necessary factor in making valid contributions to science and interpersonal recognition is a function of the formal publication system, rather than informal

mechanisms such as "technical gossip" and "confidence pathways," open-access models of communication can be perceived as a threat to intellectual property (Fry, 2006b). Furthermore, data repositories, which are increasingly becoming linked to the submission of articles in visions of e-science knowledge management, threaten the notion of both authorship and ownership. This would explain why Kling et al. (2002) observed resistance to the digital preprint model of publishing by workers in medicine (see also Bohlin, 2004).

More generally, the role of e-journals and digital forms of scholarly communication and publication varies strongly by field (Kling & McKim, 2000; Fry, 2006a). This holds for the use of ICT in research as such. E-science is not oblivious to these disciplinary variations. On the contrary, because e-science represents a particularly capital-intensive mode of research, it is even more susceptible to the disciplinary and local regimes of control over resources and reputations.

In short, the role of scientific and scholarly disciplines and subdisciplines will become more rather than less important in the development of informational infrastructures. This makes a revisiting of older STS work on disciplines perhaps pertinent although we will have to devote more attention to the disunity of science (Lenoir, 1997).

INTERROGATING INFORMATIZATION AND E-SCIENCE

E-science is clearly not a unified phenomenon. On the one hand, it is a specific, local process emerging from cooperative work in computer science, physics, and hardware production. It makes possible new computational forms of research on huge and diverse data sets. This goal requires massive standardization of software tools, information infrastructures and databases, and embedded digital research instruments. It attempts to formalize information structures and operations in knowledge fields. E-science is highly capital intensive. It is supported by a discourse coalition of widely different actors. Its prospects are promoted in a future-oriented discourse and logic even in the face of, and perhaps precisely because of, its repeated shortcomings (Lewis, 2000; Vann & Bowker, 2006). It can be analyzed as a creative, yet colonizing movement occupying new territories in the sciences, social sciences, and humanities. On the other hand, e-science is embedded in a context of very diverse initiatives taken by individual scholars, librarians, artists, and amateurs. The boundary between e-science and this diffuse array of informatization action is fuzzy. This brings us back to the beginning of this chapter: in what ways are scholars actually incorporating the Internet and ICT in their practices?

One way to answer this question is to list the forms that e-research and cyber-stuff take. Our list includes Web-accessible databases; digital libraries; virtual research instruments; virtual reality objects; simulations; multi-sited games; Web surveys; videoconferencing; CUSeeMe cameras; speech technology; search engines; crawlers; network analysis tools; Web pages; annotated Web pages; Web site analysis; MUDs and MOOs; Wikipedia; Weblogs; Weblog analysis software; maps and map overlays; Google

Earth; Geographical Information Systems; semantic Web structures; portals; e-mail lists; multimedia publications; traditional publications as pdf files; history repositories; on-line digitized collections; clinical trial databases; Crackberry databases; specialized databases of annotated and standardized raw research data; ontologies; robotic agents; text parsing; artificial life forms; monitoring systems logging every action in cyberspace; spyware; podcasts; and standards, standards, standards.

Another way is to consider the way different fields have taken up the Internet either in their methodology or in their theoretical or topical research agendas. The most obvious move, of course, is to look at sciences that take Internet-related phenomena as research objects. This has been done on a truly huge scale in the social sciences, information and computer science, and the humanities. According to the editors of *Academia and the Internet*:

The Internet and its impact on society has been a matter, quite appropriately, of focus by scholars across disciplines. We are not here assessing *whether* the Internet has had impact; it is a starting assumption of this book *that* it has had a substantial impact and has already affected people, societies and institutions. (Nissenbaum & Price, 2004: xi)

This expectation of impact has stimulated an increasing body of work with a huge variety of conceptualizations of the Internet, theoretical frameworks, and analytical questions.¹² This work includes, among others, studies of on-line social networks, virtual communities, identity formation in virtuality, the construction and analysis of the digital divide, trust and civic involvement (Barry, 2001), surveys of Internet use and time spent on-line, e-commerce and on-line auctions, the political economy of information (Mosco & Wasko, 1988; Shapiro & Varian, 1999; Lyman & Varian, 2000; David, 2004), distance learning, gender relationships, science in developing countries (Shrum, 2005), data practices, the World Wide Web and cultural theory (Herman & Swiss, 2000), on-line eroticism, and flex working. There is actually no good way to group this expanding work together except by the somewhat superficial observation that somehow something called or related to the Internet is involved in the research topic.

A more interesting question is whether the new topics of investigation resulting from the inclusion of Internet in everyday life have also influenced the conceptual or theoretical structure or apparatus of research fields studying them. This is far less clear. Obviously, the Internet has been taken up in the sociological theories of the information society (Webster, 1995; Castells, 1996; Slevin, 2000; Castells, 2001; Poster, 2001). In economics, there is a debate about the economics of information with a new emphasis on public goods and the commons (Mosco & Wasko, 1988; David, 2004). In cultural theory, scholars have taken the Web as the embodiment of postmodernism. Overall, the literature points to an incorporation of Internet issues within existing disciplinary structures instead of a proliferation of new fields (with Internet research as a possible exception although it is not yet clear whether this can be called a field in the traditional sense). "Throughout, however, accommodation and change occurred within traditional disciplines, and research concerning the Internet and its impact on

society was established, to a greater or lesser extent, within existing debates, existing structures, and existing thematic approaches" (Nissenbaum & Price, 2004: x). Nissenbaum and Price go so far as to claim that the increased attention to the Internet has led to "a retreat back into disciplinary folds" compared with the interdisciplinary wave of work in the 1990s. This may also point to the resilience of existing disciplinary paradigms.

Researchers do report, however, an uptake of the Internet as platform for new social science and humanities methodologies. Early adopters were quick to establish the potential of the Internet for qualitative data collection. This may even be one of the defining elements of the field of Internet research: a shared fascination with the methodological potential of the Internet and/or the World Wide Web. It may explain how it is that the Association of Internet Research has come to bring together postmodernists focusing on intertextuality with social network analysts aiming to explain causal relationships in human networks, a rather unusual combination (Consalvo et al., 2004). Two examples may make this clear. Writing on hypertextuality, George Landow has proposed that digital text as a technology represents the embodiment of postmodernist theory (Landow, 1992). This perspective has been influential in cultural theories of the Internet and the Web, ranging from literary theories to explorations of aesthetics (Hjort, 2004). Landow sees hypertext as "the natural fulfillment" of postmodern literary theory. The literary theorist Marie-Laure Ryan takes a subtly different position. She does not see the convergence as a form of media determinism but as a reminder that "available technologies affect the use as well as the theorizing of already available technologies" (Ryan, cited in Hjort, 2004: 211). In other words, hypertext might be put to very different uses in a world in which the literary elite would value "plot, character and coherence." The key question is how scholarly and scientific methodologies are being influenced by mediating technologies. The second example embodies this in a different way. The Pew Internet and American Life project has surveyed the use of the Internet in the United States since March 1, 2000. It monitors the use, penetration, and appreciation of media in society. Methodologically, the project is innovative in its scale. By using the Internet as channel for the data collection, the project succeeds in collecting large representative samples with a diversity that enables a meaningful breakdown by gender, age, and Internet experience (Jankowski et al., 2004). Because it uses a daily sample design, the survey allows respondents to register fresh experiences and is therefore seen as more accurate than conventional surveys. Comparable use of the Internet as both a source of new data and a new source of old types of data has been reported in virtually all fields of the social sciences, information science, and the newly emerging field of Webometrics (Almind & Ingwersen, 1997; Aguillo, 1998; Ingwersen, 1998; Thelwall, 2000, 2004, 2005; Björneborn & Ingwersen, 2001; Scharnhorst, 2003; Scharnhorst et al., 2006).

To sum up, we can take it as empirically established that mediating technologies are influencing scholarly and scientific methodologies (see also Reips & Bosnjak, 2001). For example, Kwa has found that despite its uncertainties, modeling techniques have caught on in climate research because by use of these techniques climate can be

visualized so effectively (Kwa, 2005). This claim is no “creeping technological determinism” (Lenoir, 2002), because the influence of technology on methods is driven by interaction embedded in practices. It would be too simple, however, to claim that new media need new methodologies, which would also amount to a form of method-oriented technological determinism. Most modifications in methodology, however interesting or promising, are based on already existing research designs and methods (Jankowski et al., 2004).

This brings us back to e-science in the more restricted sense. Methodological innovation is the central promise that e-science seems to hold for social scientists and humanists. A new body of work, sometimes labeled as e-social science and e-humanities, is currently being created. In 2005, the first International Conference on E-Social Science took place in Manchester, U.K., and it promises to become a yearly happening and showcase. In the United States and elsewhere, coalitions have formed to create new interactions between humanists and the digital,¹³ trying to combine critical deconstruction with constructive development of new ways of performing scholarship (Ang & Cassity, 2004). Although the critical element is lively and well (e.g., Woolgar, 2002a), this body of work is dominated by tool development and infrastructure building (Proceedings, 2005; Anon., 2005b).

How can STS interact with this social science and humanities agenda, given its strength in empirically grounded theoretical work? We have tried to sketch some key questions that may inform a developing research agenda for STS.

Perhaps we should first point to the value of disrespecting the boundaries around e-science. By insisting on contextualized analysis and not accepting a narrow definition of e-science, STS may help infuse the debates about e-social science and e-humanities with discourses and experiences that would otherwise not become part of those debates. We think that it is also pertinent for STS inquiry itself that its agenda in this area is not restricted by dominant views on e-science and the future of research. In other words, let us keep things messy.

Second, we have tried to sketch some emerging analytical lines of work that may be of value here. We have shown how the concept of epistemic culture helps us to ask crucial questions about the networked practices that are increasingly bundled together under the notion of e-science. By paying attention to the role of epistemic objects and experimental settings, the core business of collectively producing inscriptions in scientific and scholarly research is highlighted. The notion of epistemic culture is a powerful one because it may bridge the analysis of day-to-day practice with the study of the processes of institutionalization that are based on and constrained by these practices. We also drew on the notion of disciplines as conservative institutions that carry a tension between the need to produce novel results on the one hand and the stability required to monopolize knowledges as markets. Digitally mediated knowledge practices seem to invite us to see both epistemic culture and discipline as two intertwined analytical perspectives, a stance that is not very common in STS—if only because the notion of epistemic culture has been developed on the basis of a critique of the notion of the discipline (Knorr Cetina, 1981).

We have also focused on the analysis of scientific labor, which includes *inter alia* the labor of technicians and support staff. On the one hand, we wish to zoom in on the *net-work*: the work that produces the networks and maintains them. The production as well as circulation of inscriptions is key here. In this analysis we find the epistemic culture a productive analytical device. On the other hand, renewed attention to the value production by scientific labor seems pertinent. Analyzing science as a value-producing and circulating process is especially productive because it enables the analysis of the creation and sustenance of markets for scientific results, expertise, and, not least, scientific labor itself.

This approach also relates to the analysis of inscription. Inscriptions do not move by themselves, nor are they self-producing. They are the product of labor. But it is in inscriptions that labor manifests itself, both in its capacity of producing use-value and in its capacity of producing exchange value. Increasingly, these traces are embedded in a digital medium that is itself composed of the same type of inscriptions, produced by similar labor at an earlier point in time. Therefore, institutionalization is itself the product of labor, and digital institutions are nothing but recurring patterns of circulation of inscription. Seen in this light, e-science may invite us to take a step beyond the received STS analysis of science as inscription activity (for a more extended discussion of this point, see Wouters, 2006). In Latour and Woolgar's (1979) analysis of the laboratory, scientists were obsessed by the frantic production of inscriptions. Research instruments were created to enable the large-scale, routinized production of these traces. Yet, the scientists themselves and their institutions were still separate from these inscriptions, although they derived their meaning and identity from them.

Informatization can be interpreted as the reflexive reinscription of research in and on itself. All actors are literally embodied in bundles of inscriptions that perform highly circumscribed operations on each other (Lenoir, 2002). We would like to stress that this is different from the notion of dematerialization. Neither human nor animal nor machine bodies disappear as performing work. On the contrary, the reflexive self-inscription has huge implications for what it means to be implicated in knowledge production. This attention to the semiotics of information, labor, and its material forms in digital practices and tools is, we think, an interesting emerging line of work in the history and sociology of science (Lenoir, 1997, 2002; Rheinberger, 1997; Kay, 2000; Thurtle & Mitchell, 2002; Beaulieu, 2003; Mitchell & Thurtle, 2004) that may inform ethnographic and historical case study work in STS.

Interaction between media and methodology is complex. It is not simply that new media need new methods. However, the new mediation technologies do influence methods and ways of working, including our own methods and work. We have tried to exemplify this by discussing how our analysis speaks back to the notion of epistemic culture. We have discussed how a crucial distinction in that analytical framework seems undermined in digital media: the distinction between epistemic object and experimental system. Perhaps more importantly, we suggest that this mode of analysis may help us understand better the interplay between scholarly identity, research infrastructures, and practice in and through the organization of labor. This

may be a productive basis for critically interrogating informatization and e-research as both promising practice and problematic ideology.¹⁴

Notes

1. The Virtual Knowledge Studio is a research center of the Royal Netherlands Academy of Arts and Sciences, based in Amsterdam. This chapter was written by Paul Wouters, Katie Vann, Andrea Scharnhorst, Matt Ratto, Iina Hellsten, Jenny Fry, and Anne Beaulieu. E-mail: paul.wouters@vks.knaw.nl. Since November 2005, Fry has been at the Oxford Internet Institute, Oxford, U.K.
2. For a critical discussion of impact talk and a plea to focus rather on implications, see Woolgar (2002a).
3. An additional problem with generic impact talk is noted by Hakken (2003: 187): "Indeed, specialization is so extensive as to make very difficult any meaningful discourse on general knowledge creation."
4. John Zammito has characterized this as a problem for the value of empirical research in STS by quoting Willard Quine in his critical analysis of STS constructivism: "To disavow the very core of common sense, to require evidence for that which both the physicist and the man in the street accept as platitudinous, is no laudable perfectionism; it is a pompous confusion" (Zammito, 2004: 275).
5. The experience that there are at least as many technology-related impediments to knowledge creation as stimuli has also been noted by Hakken (2003: 203).
6. The role of ICT in scientific communication has been a focus in both STS and information studies. See, for example, Voorbij (1999), Cronin and Atkins (2000), Kling and McKim (2000), Borgman and Furner (2002), Fry (2004), Bohlin, (2004), Heimeriks (2005) and the Annual Review of Information Science and Technology (ARIST) series.
7. In information science, we can differentiate between analyses about the "impact" of ICT on traditional scholarly practices (collaboration, publishing behavior [Lawrence 2001, Wouters & de Vries 2004]), the emergence of new scholarly practices (e-mail, chat, on-line peer review), and new ways of studying scholarly practices (both using Web data [hyperlinks] as well as digitized bibliometric data [Chen & Lobo 2006]).
8. In a similar way, postmodern literary researchers were encouraged by the invention of hypertext (Landow, 1992). Social network analysts tend to see the Internet as a new source of social network data (Park, 2003) and sociologists claim that the Internet is both embodiment and proof of the thesis of the network society (Castells, 2001).
9. Vann (2004) has identified a similar "technicism" and analytical reduction on the part of some contemporary theorists of "immaterial" and/or "emotional" labor, and discusses its affinities with a particular strand of Marxian theory.
10. The interaction between the broader fields and locally configured action is not worked out fully by Knorr Cetina, but others have suggested how this might be investigated (Lynch, 1990; Beaulieu, 2005).
11. For an example, see the "endorsement policy" of the physics preprint archive (<http://arxiv.org/new/>) (17 January 2004):

ArXiv was developed to be, and remains, a means for specific communities of scientists to exchange information. Moderators and the arXiv administrative team have worked behind the scenes to ensure that content is appropriate to the user communities. The growth in number of submissions to arXiv necessitates an automated endorsement system. Current members of arXiv scientific communities will have the opportunity to endorse new submitters. This process will ensure that arXiv content is

relevant to current research while controlling costs so we can continue to offer free and open Web access to all.

12. Recent reviews and exemplary cases of this work can be found in Wellman and Haythornthwaite (2002), Nissenbaum and Price (2004), Miller and Slater (2000), Abbate (1999), Slevin (2000), Bakardjieva and Smith (2001), Barnett et al. (2001), Castells (2001), DiMaggio et al. (2001), Poster (2001), Bar-Ilan and Peritz (2002), Henwood et al. (2002), Van Zoonen (2002), Barjak (2003), and Chadwick and May (2003). Only a relatively small part of this work has happened to come together in the series of conferences by the Association of Internet Researchers (AoIR) (Jones, 1995, 1999).

13. In the United States, the Humanities, Arts, Science, and Technology Advanced Collaboratory (HASTAC, pronounced "haystack") aims to promote the creative use of technology in the humanities and arts (<http://www.hastac.org/>). In Europe, several "computing and humanities" research centers have developed in the past decades, although with varying degrees of success. See for recent overviews of this approach in the literature Breure et al. (2004) and the Proceedings of the XVI Conference of the Association for History and Computing, 2005 (Anon., 2005b).

14. For example, the consequences of e-research for time management and speed control in research may be an interesting area of normatively oriented STS research. See Pels (2003) for a plea for "unhastening science."

References

- Abbate, J. (1999) *Inventing the Internet* (Cambridge, MA: MIT Press).
- Aguillo, I. F. (1998) "STM Information on the Web and the Development of New Internet R&D Databases and Indicators," in *Proceedings Online Information Meeting 98, London, Learned Information 1998*: 239–43.
- Almind, T. & Ingwersen, P. (1997) "Informetric Analyses on the World Wide Web: Methodological Approaches to 'Webometrics,'" *Journal of Documentation* 53: 404–26.
- Ang, I. & E. Cassidy (2004) *Attraction of Strangers: Partnerships in Humanities Research* (Sydney: Australian Academy of the Humanities).
- Anon. (2004a) "Making Data Dreams Come True," *Nature* 428: 239.
- Anon. (2004b) "Virtual Observatory Finds Black Holes in Previous Data," *Nature* 429: 494–95.
- Anon. (2005a) "Let Data Speak to Data," *Nature* 438: 531.
- Anon. (2005b) *Humanities, Computers & Cultural Heritage*, Proceedings of the XVI Conference of the Association for History and Computing, Amsterdam.
- Arzberger, P., P. Schroeder, A. Beaulieu, G. Bowker, K. Casey, L. Laaksonen, D. Moorman, P. Uhler, & P. Wouters (2004) "Science and Government: An International Framework to Promote Access to Data," *Science* 303: 1777–78.
- Atkins, D., K. Droegemeier, S. I. Feldman, H. Garcia-Molina, M. L. Klein, D. G. Messerschmitt, P. Messina, J. P. Ostriker, & M. H. Wright (2003) "Revolutionizing Science and Engineering Through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure" (Washington, DC, National Science Foundation). Available at: <http://dlist.sir.arizona.edu/897/>.
- Bakardjieva, M. & R. Smith (2001) "The Internet in Everyday Life—Computer Networking from the Standpoint of the Domestic User," *New Media & Society* 3(1): 67–83.

- Barabási, A.-L. (2001) "The Physics of the Web," *Physics World*, July, Available at: <http://physicsweb.org/articles/world/14/7/9/1>.
- Barabási, A.-L. (2002) *Linked: The New Science of Networks* (Cambridge, MA: Perseus Publishing).
- Bar-Ilan, J. & B. C. Peritz (2002) "Informetric Theories and Methods for Exploring the Internet: An Analytical Survey of Recent Research Literature," *Library Trends* 50(3): 371-92.
- Barjak, F. (2003) *The Internet in Public Science* (Brussels: SIBIS).
- Barnett, G. A., B. Chon, H. Park, & D. Rosen (2001) "An Examination of International Internet Flows: An Autopoietic Model," presented at the annual conference of International Communication Association, May 2001, Washington, DC.
- Barry, A. (2001) *Political Machines: Governing a Technological Society* (London: Athlone Press).
- Beaulieu, A. (2001) "Voxels in the Brain: Neuroscience, Informatics and Changing Notions of Objectivity," *Social Studies of Science* 31(5): 635-80.
- Beaulieu, A. (2003) "Review of Semiotic Flesh: Information and the Human Body," by Philip Thurtle & Robert Mitchell. Resource Center for Cyberculture Studies. Available at: <http://rccs.usfca.edu/bookinfo.asp?ReviewID=271&BookID=217>
- Beaulieu, A. (2004) "From Brainbank to Database: The Informational Turn in the Study of the Brain," *Studies in History and Philosophy of Biological and Biomedical Sciences* 35(2): 367-90.
- Beaulieu, A. (2005) "Sociable Hyperlinks: An Ethnographic Approach to Connectivity" in C. Hine (ed), *Virtual Methods: Issues in Social Research on the Internet* (Oxford: Berg): 183-98.
- Beaulieu, A. & H. Park (eds) (2003) "Internet Networks: The Form and the Feel," *Journal of Computer Mediated Communication* 8(4), special issue. Available at: <http://jcmc.indiana.edu/vol8/issue4/>.
- Becher, T. (1989) *Academic Tribes and Territories: Intellectual Inquiry and the Culture of Disciplines* (Buckingham, U.K.: SHRE & Open University Press).
- Benschop, R. (1998) "What Is a Tachistoscope? Historical Explorations of an Instrument," *Science in Context* 11(1): 23-50.
- Berg, A., C. Jones, A. Osseyran, & P. Wielinga (2003), *e-Science Park Amsterdam* (Amsterdam: Science Park Amsterdam). Available at: <http://www.wtcw.nl/nl/projecten/eScience.pdf>.
- Berman F., G. Fox, & T. Hey (eds) (2003) *Grid Computing: Making the Global Infrastructure a Reality* (Chichester, West Sussex, U.K.: Wiley): 9-50.
- Bijker, W. E., T. P. Hughes, & T. Pinch (eds) (1989) *The Social Construction of Technological Systems* (Cambridge, MA: MIT Press).
- Björneborn, L., & P. Ingwersen (2001) "Perspectives of Webometrics," *Scientometrics*, 50(1): 65-82.
- Blumstein, A. (2000) "Violence: A New Frontier for Scientific Research," *Science* 289: 545.
- Bohlin, I. (2004) "Communication Regimes in Competition: The Current Transition in Scholarly Communication Seen Through the Lens of the Sociology of Technology," *Social Studies of Science* 34(3): 365-91.
- Borgman, C. & J. Furner (2002) "Scholarly Communication and Bibliometrics," *Annual Review of Information Science and Technology* 36: 3-72.
- Börner, K., L. Dall'Asta, W. Ke, & A. Vespignani (2005) "Studying the Emerging Global Brain: Analyzing and Visualizing the Impact of Co-Authorship Teams," *Complexity* 10(4): 57-67.
- Bowker, G. (2000) "Biodiversity Datadiversity," *Social Studies of Science*, 30(5), 643-84.

- Bowker, G. (2005) *Memory Practices in the Sciences* (Cambridge, MA: MIT Press).
- Bowker, G. & S. L. Star (1999) *Sorting Things Out: Classification and its Consequences* (Cambridge, MA: MIT Press).
- Breure, L., O. Boonstra, & P. Doorn (2004) "Past, Present and Future of Historical Information Science," *Historical Social Research/Historische Sozialforschung* 29(2): 4-132.
- Brown, N. & M. Michael (2003) "A Sociology of Expectations: Retrospecting Prospects and Prospecting Retrospects," *Technology Analysis & Strategic Management* 15(1): 3-18.
- Callon M., C. Méadel, & V. Rabeharisoa (2002) "The Economy of Qualities," *Economy and Society* 31(2): 194-217.
- Castells, M. (1996) *The Rise of the Network Society* (Cambridge, MA: Blackwell).
- Castells, M. (2001) *The Internet Galaxy: Reflections on the Internet, Business, and Society* (Oxford: Oxford University Press).
- Cech, T. (2003) "Rebalancing Teaching and Research," *Science* 299: 165.
- Chadwick, A. & C. May (2003) "Interaction between States and Citizens in the Age of the Internet: e-Government in the United States, Britain, and the European Union," *Governance* 16(2): 271-300.
- Chen, C. & N. Lobo (2006) "Analyzing and Visualizing the Dynamics of Scientific Frontiers and Knowledge Diffusion," in C. Ghaoui (ed), *Encyclopedia of Human-Computer Interaction* (Hershey, PA: Idea Group Reference): 24-30.
- Clark, A. & J. Fujimura, (1992) *The Right Tools for the Right Job: At Work in 20th-Century Life Sciences* (Princeton, NJ: Princeton University Press).
- Cohen, J. (2005) "New Virtual Center Aims to Speed AIDS Vaccine Progress," *Science* 309: 541.
- Collins, R. (2001) *The Sociology of Philosophies: A Global Theory of Intellectual Change* (Cambridge, MA: Belknap Press of Harvard University Press).
- Colwell, R. (2002) "A Global Thirst for Safe Water: The Case of Cholera," 2002 Abe Wolman Distinguished Lecture, National Academies of Science, 25 January 2002, Washington, DC.
- Consalvo, M., N. Baym, J. Hunsinger, K. B. Jensen, J. Logie, M. Murero, et al. (2004) *Internet Research Annual: Selected Papers from the Association of Internet Researchers Conferences 2000-2002 (Digital Formations, 19)* (New York: Peter Lang Publishing Group).
- Cronin, B. (2003) "Scholarly Communication and Epistemic Cultures, Keynote Address, Scholarly Tribes and Tribulations: How Tradition and Technology are Driving Disciplinary Change" (Washington, DC: ARL).
- Cronin, B. & H. B. Atkins (2000) *The Web of Knowledge: A Festschrift in Honor of Eugene Garfield* (Medford, NJ: Information Today).
- Cummings, J. & S. Kiesler (2005) "Collaborative Research Across Disciplinary and Organizational Boundaries," *Social Studies of Science* 35(5): 703-22.
- David, P. (2004) "Economists and the Net: Problems of a Policy for a Telecommunications Anomaly," in M. E. Price & H. Nissenbaum (eds), *The Academy & the Internet* (New York: Peter Lang Publishing Group): 142-68.
- De Boer, H., J. Huisman, A. Klemperer, B. van der Meulen, G. Neave, H. Theisens, et al. (2002) *Academia in the 21st Century: An Analysis of Trends and Perspectives in Higher Education and Research* (Den Haag, Netherlands: Adviesraad voor het Wetenschaps-en Technologiebeleid).

- DiMaggio, P., E. Hargittai, W. R. Neuman, & J. P. Robinson (2001) "Social Implications of the Internet," *Annual Review of Sociology* 27: 307–36.
- Doing, P. (2004) "'Lab Hands' and the 'Scarlet O': Epistemic Politics and (Scientific Labor)," *Social Studies of Science* 34(3): 299–324.
- Drott, C. M. (2006) "Open Access," *Annual Review of Information Science and Technology* 40: 79–109.
- Dutton, W. H. (1996) *Information and Communication Technologies: Visions and Realities* (Oxford: Oxford University Press).
- Edge, D. O. & M. J. Mulkay (1976) *Astronomy Transformed: The Emergence of Radio Astronomy in Britain* (New York: Wiley).
- Esanu, J. & P. Uhlir (2003) *The Role of Scientific and Technical Data and Information in the Public Domain* (Washington, DC: National Academies Press).
- Fleck, L. (1979) *Genesis and Development of a Scientific Fact* (Chicago: University of Chicago Press).
- Fry, J. (2004) "The Cultural Shaping of ICTs within Academic Fields: Corpus-based Linguistics as a Case Study," *Literary and Linguistic Computing* 19(3): 303–19.
- Fry, J. (2006a) "Coordination and Control across Scientific Fields: Implications for a Differentiated e-science," in C. Hine (ed), *New Infrastructures for Knowledge Production: Understanding e-science* (Hershey, PA: Idea Group).
- Fry, J. (2006b) "Scholarly Research and Information Practices: A Domain Analytical Approach," *Information Processing & Management* 42: 299–316.
- Fuchs, S. (1992) *The Professional Quest for Truth: A Social Theory of Science and Knowledge* (Albany: State University of New York Press).
- Fujimura, J. (1987) "The Construction of Doable Problems in Cancer Research," *Social Studies of Science* 17(2): 257–93.
- Fujimura, J. (1992) "Crafting Science: Standardized Packages, Boundary Objects, and Translation," in A. Pickering, *Science as Practice and Culture* (Chicago and London: University of Chicago Press): 168–211.
- Fujimura, J. & M. Fortun (1996) "Constructing Knowledge Across Social Worlds: The Case of DNA Sequence Databases in Molecular Biology," in L. Nader, *Naked Science: Anthropological Inquiry into Boundaries, Power and Knowledge* (New York: Routledge): 160–73.
- Fuller, S. (1997) *Science* (Minneapolis: University of Minnesota Press).
- Galegher, J. & R. Kraut (1992) *Computer-mediated Communication and Collaborative Writing: Media Influence and Adaptation to Communication Constraints*, Computer Supported Cooperative Work (Toronto: ACM Press).
- Giles, J. (2005) "Online Access Offers Fresh Scope for Bud Identification," *Nature* 433: 673.
- Goldenberg-Hart, D. (2004) "Libraries and Changing Research Practices: A Report of the ARL/CNI Forum on E-Research and Cyberinfrastructure," Associations of Research Libraries (ARL) Bimonthly Report No. 237.
- Gunnarsdóttir, K. (2005) "Scientific Journal Publications: On the Role of Electronic Preprint Exchange in the Distribution of Scientific Literature," *Social Studies of Science* 35(4): 549–80.
- Hackett, E. (2005), "Essential Tensions. Identity, Control and Risk in Research," *Social Studies of Science* 35(5): 787–826.
- Hackett, E., D. Conz, J. Parker, J. Bashford, & S. DeLay (2004) "Tokamaks and Turbulence: Research Ensembles, Policy and Technoscientific Work," *Research Policy* 33(5): 747–67.

- Hakken, D. (1999) *Cyborgs@Cyberspace? An Ethnographer Looks to the Future* (New York, Routledge).
- Hakken, D. (2003) *The Knowledge Landscapes of Cyberspace* (New York, Routledge).
- Hauben, R. & M. Hauben (1997) *Netizens: On the History and Impact of Usenet and the Internet* (New York: Wiley).
- Hayles, N. K. (2002) "Material Metaphors, Technotexts, and Media-specific Analysis" in *Writing Machines* (Cambridge, MA: MIT Press): 18–33.
- Haythornthwaite, C. & B. Wellman (1998) "Work, Friendship, and Media Use for Information Exchange in a Networked Organization," *Journal of the American Society for Information Science* 49(12): 1101–14.
- Heilbron, J. (2004) "A Regime of Disciplines: Towards a Historical Sociology of Disciplinary Knowledge," in C. Camic & H. Joas (eds), *The Dialogical Turn: New Roles for Sociology in the Postdisciplinary Age* (Lanham, MD: Rowman & Littlefield), 23–42.
- Heimeriks, G. (2005) "Knowledge Production and Communication in the Information Society: Mapping Communications in Heterogenous Research Networks," PhD diss., University of Amsterdam.
- Hellsten, I. (2002) *The Politics of Metaphor: Biotechnology and Biodiversity in the Media* (Tampere, Finland: Acta Universitatis Tampereensis; 876, Tampere University Press).
- Henwood, F., S. Wyatt, A. Hart, & J. Smith (2002) "Turned on or Turned off? Accessing Health Information on the Internet," *Scandinavian Journal of Information Systems* 14(2): 79–90.
- Herman, A. & T. Swiss (eds) (2000) *The World Wide Web and Contemporary Cultural Theory* (New York and London: Routledge).
- Hey, T. & A. E. Trefethen (2002) "The UK e-Science Core Programme and the Grid," *Future Generation Computer Systems* 18(8): 1017–31.
- Hine, C. (2002) "Cyberscience and Social Boundaries: The Implications of Laboratory Talk on the Internet," *Sociological Research Online* 7(2), U79–U99.
- Hine, C. (ed) (2006) *New Infrastructures for Knowledge Production: Understanding e-science* (Hershey, PA: Idea Group).
- Hjort, M. (2004) "Aesthetic Approaches to the Internet and New Media," in M. E. Price & H. Nissenbaum (eds), *The Academy & the Internet* (New York: Peter Lang Publishing Group): 229–61.
- Howard, P. (2002) "Network Ethnography and the Hypermedia Organization: New Organizations, New Media, New Methods," *New Media & Society* 4(4): 551–75.
- Huberman, B. A. (2001) *The Laws of the Web: Patterns in the Ecology of Information* (Cambridge, MA: MIT Press).
- Ingwersen, P. (1998) "The Calculation of Web Impact Factors," *Journal of Documentation* 54(2): 236–43.
- Ito, M. (1996) "Theory, Method, and Design in Anthropologies of the Internet," *Social Science Computer Review* 14(1): 24–26.
- Jankowski, N., S. Jones, K. Foot, P. Howard, R. Mansell, S. Schneider, & R. Silverstone (2004) "The Internet and Communication Studies," in M. E. Price & H. Nissenbaum (eds), *The Academy and the Internet* (New York: Peter Lang Publishing Group): 197–228.
- Jankowski, N. W. & O. Prehn (eds) (2002) *Community Media in the Information Age: Perspectives and Prospects* (Cresskill, NJ: Hampton Press).
- Jasanoff, S., G. Merkle, J. Petersen, & T. Pinch (eds) (1995) *Handbook of Science and Technology Studies* (Thousand Oaks, CA: Sage).

- Joerges, B. & T. Shinn (2001) *Instrumentation Between Science, State, and Industry* (Dordrecht, Netherlands: Kluwer Academic Publishers).
- Jones, S. G. (1995) *Cybersociety* (London: Sage).
- Jones, S. (1999) *Doing Internet Research: Critical Issues and Methods for Examining the Net* (Thousand Oaks, CA: Sage).
- Kaiser, J. (2003) "NIH Sets Data Sharing Rules," *Science* 299: 1643.
- Kay, L. E. (2000) *Who Wrote the Book of Life? A History of the Genetic Code* (Stanford, CA: Stanford University Press)
- Kling, R. (1999) "What is Social Informatics and Why Does It Matter?" *D-lib Magazine* 5(1). Available at: <http://www.dlib.org/dlib/january99/kling/01kling.html>.
- Kling, R. & R. Lamb (1996) "Analyzing Visions of Electronic Publishing and Digital Libraries," in G. B. Newb & R. M. Peek (eds), *Scholarly Publishing: The Electronic Frontier* (Cambridge, MA: MIT Press): 17-54.
- Kling, R. & G. McKim (2000) "Not Just a Matter of Time: Field Differences and the Shaping of Electronic Media in Supporting Scientific Communication," *Journal of the American Society for Information Science* 51(14): 1306-20.
- Kling, R., G. McKim, & A. King (2003) "A Bit More to IT: Scholarly Communication Forums as Socio-technical Interaction Networks," *Journal of the American Society for Information Science and Technology* 54(1): 47-67.
- Kling, R., L. Spector, & G. McKim (2002) "Locally Controlled Scholarly Publishing via the Internet: The Guild Model," *Journal of Electronic Publishing* 8(1). Available at: <http://www.press.umich.edu/jep/08-01/kling.html>.
- Knorr Cetina, K. (1981) *The Manufacture of Knowledge: An Essay on the Constructivist and Contextual Nature of Science* (Oxford: Pergamon).
- Knorr Cetina, K. (1992) "The Couch, the Cathedral, and the Laboratory: On the Relationship between Experiment and Laboratory Science," in A. Pickering (ed), *Science as Practice and Culture* (Chicago and London: University of Chicago Press): 113-38.
- Knorr Cetina, K. (1999) *Epistemic Cultures: How the Sciences Make Knowledge* (Cambridge, MA: Harvard University Press).
- Knorr Cetina, K. & U. Bruegger (2000) "The Market as an Object of Attachment: Exploring Postsocial Relations in Financial Markets," *Canadian Journal of Sociology* 25(2): 141-68.
- Koslow, S. H. (2002) "Sharing Primary Data: A Threat or Asset to Discovery?" *Nature Reviews Neuroscience* 3(4): 311-13.
- Kwa, C. (2005) "Local Ecologies and Global Science: Discourses and Strategies of the International Geosphere-Biosphere Programme," *Social Studies of Science* 35(6): 923-50.
- Landow, G. P. (1992) *Hypertext 2.0: The Convergence of Contemporary Critical Theory and Technology* (Baltimore and London: Johns Hopkins University Press).
- Latour, B. & S. Woolgar (1979) *Laboratory Life: The Social Construction of Scientific Facts* (Beverly Hills, CA: Sage).
- Latour, B. & S. Woolgar (1986) *Laboratory Life: The Construction of Scientific Facts*, 2nd ed. (Princeton, NJ: Princeton University Press).
- Lawrence, S. (2001) "Online or Invisible?" *Nature* 411: 521.

- Lazinger, S., J. Bar-Ilan, & B. Peritz (1997) "Internet Use by Faculty Members in Various Disciplines: A Comparative Case Study," *Journal of the American Society for Information Science* 48(6): 508-18.
- Lemaine, G., R. MacLeod, M. Mulkay, & P. Weingart (1976) *Perspectives on the Emergence of Scientific Disciplines* (The Hague: Mouton-Aldine).
- Lenoir, T. (1997) *Instituting Science: The Cultural Production of Scientific Disciplines* (Stanford, CA: Stanford University Press).
- Lenoir, T. (2002) "The Virtual Surgeon," in P. Turtle & P. Howard (eds), *Semiotic Flesh: Information and the Human Body* (Seattle: University of Washington Press): 28-51.
- Lewis, M. (2000) *The New New Thing: A Silicon Valley Story* (New York, Norton).
- Lievrouw, L. & S. Livingstone (2002) *The Handbook of New Media: Social Shaping and Consequences of ICTs* (London: Sage).
- Lyman, P. & H. R. Varian (2000) *How Much Information?* Available at: <http://www2.sims.berkeley.edu/research/projects/how-much-info-2003/>.
- Marris, E. (2005) "Free Genome Databases Finally Defeat Celera," *Nature* 435: 6.
- Marshall, E. (2002) "DATA SHARING: Clear-Cut Publication Rules Prove Elusive," *Science* 295: 1625.
- Matzat, U. (2004) "Academic Communication and Internet Discussion Groups: Transfer of Information or Creation of Social Contacts?" *Social Networks* 26(3): 221-55.
- Merali, Z. & J. Giles (2005) "Databases in Peril," *Nature* 435: 1010-11.
- Miller, D. & D. Slater (2000) *The Internet: An Ethnographic Approach* (Oxford and New York: Berg).
- Mitchell, R. & P. Thurtle (eds) (2004) *Data Made Flesh. Embodying Information* (New York: Routledge)
- Molyneux, R. E. & R. V. Williams (1999) "Measuring the Internet," *Annual Review of Information Science and Technology* 34: 287-339.
- Mortensen, T. & J. Walker (2002) "Blogging Thoughts: Personal Publication as an Online Research Tool," in A. Morrison (ed), *Researching ICTs in Context* (Oslo, Norway: Intermedia, University of Oslo): 249-79.
- Mosco, V. & J. Wasko (eds) (1988) *The Political Economy of Information* (Madison: University of Wisconsin Press).
- National Research Council (NRC) (1997) *Bits of Power: Issues in Global Access to Scientific Data* (Washington, DC: National Academies Press).
- National Research Council (NRC) (1999) *A Question of Balance: Private Rights and the Public Interest in Scientific and Technical Databases*. (Washington, DC: National Academies Press).
- Nentwich, M. (2003) *Cyberscience: Research in the Age of the Internet* (Vienna: Austrian Academy of Sciences Press).
- Nissenbaum, H. & M. Price (eds) (2004) *Academia and the Internet* (New York: Peter Lang Publishing Group).
- Norris, K. S. (1993) *Dolphin Days: The Life and Times of the Spinner Dolphin* (New York: Avon Books).
- OECD (1998) *The Global Research Village* (Paris: OECD).
- Park, H. W. (2003) "What Is Hyperlink Network Analysis? New Method for the Study of Social Structure on the Web," *Connections* 25(1): 49-61.
- Passmore, A. (1998) "Geogossip," *Environment and Planning A* 30(8): 1332-36.

- Pels, D. (2003) *Unhastening Science: Autonomy and Reflexivity in the Social Theory of Knowledge* (New York: Routledge).
- Pickering, A. (1992) *Science as Practice and Culture* (Chicago: University of Chicago Press).
- Porter, D. (1997) *Internet Culture* (London: Routledge).
- Poster, M. (2001) *What Is the Matter with the Internet?* (Minneapolis: University of Minnesota Press).
- Price, D. J. de Solla (1984) "The Science/Technology Relationship: The Craft of Experimental Science, and Policy for the Improvement of High Technology Innovation," *Research Policy* 13(1): 3–20.
- Proceedings of the First International Conference on e-Social Science, Manchester, 22–24 June 2005. Available at: <http://www.ncess.ac.uk/events/conference/2005/papers/>.
- Ratto, M. & A. Beaulieu (in press 2007) "Banking on the Human Genome Project," *Canadian Review of Sociology and Anthropology/Revue Canadienne de Sociologie* 44(2).
- Reips, U.-D. & M. Bosnjak (eds) (2001) *Dimensions of Internet Science* (Langerich, Germany: Pabst Science Publishers).
- Rheinberger, H.-J. (1997) *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford, CA: Stanford University Press).
- Rheingold, H. (1994) *The Virtual Community: Homesteading on the Electronic Frontier* (New York: HarperPerennial, or <http://www.rheingold.com/vc/book/>).
- Santos, C., J. Blake, & D. J. States (2005) "Supplementary Data Need to Be Kept in Public Repositories," *Nature* 438: 738.
- Scharnhorst, A. (2003) "Complex Networks and the Web: Insights from Nonlinear Physics," *Journal of Computer-Mediated Communication* 8(4). Available at: <http://jcmc.indiana.edu/vol8/issue4/scharnhorst.html>.
- Scharnhorst, A. & M. Thelwall (2005), "Citation and Hyperlink Networks," *Current Science* 89(9): 1518–23.
- Scharnhorst, A., P. Van den Besselaar, & P. Wouters (eds) (2006) "What Does the Web Represent? From Virtual Ethnography to Web Indicators," *Cybermetrics* 10(1). Available at: <http://www.cindoc.csic.es/cybermetrics/articles/v10i1p0.html>.
- Schilling, G. (2000) "The Virtual Observatory Moves Closer to Reality," *Science* 289: 238–39.
- Shapin, S. & S. Schaffer (1985) *Leviathan and the Air Pump: Hobbes, Boyle and the Experimental Life* (Princeton, NJ: Princeton University Press).
- Shapiro, C. & H. R. Varian (1999) *Information Rules: A Strategic Guide to the Network Economy* (Boston: Harvard Business School Press).
- Sharples, M. (ed) (1993) *Computer Supported Collaborative Writing* (London: Springer-Verlag).
- Shoichet, B. (2004) "Virtual Screening of Chemical Libraries," *Nature* 432: 862–65.
- Shrum, W. (2005) "Reagency of the Internet, or How I Became a Guest for Science," *Social Studies of Science* 35(5): 723–54.
- Sismondo, S. (2004) *An Introduction to Science and Technology Studies* (Malden and Oxford: Blackwell Publishing).
- Slevin, J. (2000) *The Internet and Society* (Cambridge: Polity Press).
- Smith, M. R. & L. Marx (eds) (1994) *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, MA: MIT Press).

- Star, S. L. (1992) "Craft vs. Commodity, Mess vs. Transcendence: How the Right Tool Became the Wrong One in the Case of Taxidermy and Natural History," in A. Clark & J. Fujimura (1992) *The Right Tools for the Right Job: At Work in 20th-Century Life Sciences* (Princeton, NJ: Princeton University Press): 257–86.
- Star, S. L. (1999) "The Ethnography of Infrastructure," *American Behavioral Scientist* 43(3): 377–91.
- Suchman, L. A. (1987) *Plans and Situated Actions: The Problem of Human-Machine Communication* (Cambridge: Cambridge University Press).
- Sugden, A. (2002) "Computer Dating," *Science* 295: 17.
- Thelwall, M. (2000) "Web Impact Factors and Search Engine Coverage" *Journal of Documentation* 56(2): 185–89.
- Thelwall, M. (2002a) "A Comparison of Sources of Links for Academic Web Impact Factor Calculations," *Journal of Documentation* 58: 60–72.
- Thelwall, M. (2002b) "The Top 100 Linked Pages on UK University Web Sites: High Inlink Counts Are Not Usually Directly Associated with Quality Scholarly Content," *Journal of Information Science* 28(6): 485–93.
- Thelwall, M. (2003) "Can Google's PageRank Be Used to Find the Most Important Academic Web Pages?" *Journal of Documentation* 59: 205–17.
- Thelwall, M. (2004) "Scientific Web Intelligence: Finding Relationships in University Webs," *Communications of the ACM* 48(7): 93–96.
- Thelwall, M. (2005) *Link Analysis: An Information Science Approach* (San Diego: Academic Press).
- Thelwall, M. & P. Wouters (2005) "What's the Deal with the Web/Blogs/the Next Big Technology: A Key Role for Information Science in e-Social Science Research?" *Lecture Notes in Computer Science* 3507: 187–200.
- Thompson, C. (2005) *Making Parents: The Ontological Choreography of Reproductive Technologies* (Cambridge, MA: MIT Press).
- Thurtle, P. & R. Mitchell (eds) (2002) *Semiotic Flesh. Information and the Human Body* (Seattle: University of Washington Press).
- Traweek, S. (1988) *Lifetimes and Beamtimes: The World of High Energy Physics* (Cambridge, MA: Harvard University Press).
- Turkle, S. (1995) *Life on the Screen: Identity in the Age of the Internet* (New York: Simon & Schuster).
- U.K. Research Councils (2001) *About the UK e-Science Programme*.
- Van Horn, J. D., J. S. Grethe, P. Kostelec, J. B. Woodward, & J. A. Aslam (2001) "The Functional Magnetic Resonance Imaging Data Center (fMRIDC): The Challenges and Rewards of Large-scale Databasing of Neuroimaging Studies," *Philosophical Transactions of the Royal Society of London B: Biological Sciences* 356(1412): 1323–39.
- Van House, N. A. (2002) "Digital Libraries and Practices of Trust: Networked Biodiversity Information," *Social Epistemology* 16(1): 99–114.
- Van Lente, H., & A. Rip (1998) "Expectations in Technological Developments: An Example of Prospective Structures to Be Filled in by Agency," in C. Disco & B. E. van der Meulen (eds), *Getting New Technologies Together* (Berlin and New York: Walter de Gruyter): 203–29.
- Vann, K. (2004) "On the Valorisation of Informatic Labour," *Ephemera: Theory and Politics in Organization* 4(3): 242–66.

- Vann, K. & G. C. Bowker (2006) "Interest in Production: on the Configuration of Technology-bearing Labors for Epistemic IT," in C. Hine (ed), *New Infrastructures for Knowledge Production: Understanding e-science* (London: Information Science Publishing): 71-97.
- Van Zoonen, L. (2002) "Gendering the Internet: Claims, Controversies and Cultures," *European Journal of Communication* 17(1): 5-23.
- Vasterman, P. & O. Aerden (1995) *De context van het nieuws* (Groningen, Netherlands: Wolters Noordhoff).
- Voorbij, H. (1999) "Searching Scientific Information on the Internet: A Dutch Academic User Survey," *Journal of the American Society for Information Science* 50(7): 598-615.
- Walsh, J. P. (1999) "Computer Networks and The Virtual College," *OECD STI Review* 24: 49-77.
- Walsh, J. & T. Bayma, (1996) "Computer Networks and Scientific Work," *Social Studies of Science* 26: 661-703.
- Walsh, J., C. Cho, & W. Cohen (2005) "The View from the Bench: Patents, Material Transfers and Biomedical Science," *Science* 309: 2002-3.
- Wasserman, S. & K. Faust (1994) *Social Network Analysis: Methods and Applications*, vol. 8 (Cambridge: Cambridge University Press).
- Webster, F. (1995) *Theories of the Information Society* (New York: Routledge).
- Weingart, P. (2000) "Interdisciplinarity: The Paradoxical Discourse," in P. Weingart & N. Stehr (eds), *Practising Interdisciplinarity* (Toronto: University of Toronto Press): 25-45.
- Weingart, P., L. R. Graham, & W. Lepenies (eds) (1983) *Functions and Uses of Disciplinary Histories: Sociology of the Sciences Yearbook*, vol. VIII (Dordrecht, Netherlands: Reidel).
- Wellman, B. (2001) "Computer Networks as Social Networks," *Science* 293: 2031-34.
- Wellman, B. & C. Haythornthwaite (2002) *The Internet in Everyday Life* (Malden, MA: Blackwell).
- Wheeler, Q. D., P. H. Raven, & E. O. Wilson (2004) "Taxonomy: Impediment or Expedient?" *Science* 303: 285.
- Whitley, R. (2000) *The Intellectual and Social Organization of the Sciences* (Oxford: Oxford University Press).
- Woolgar, S. (2002a) "Five Rules of Virtuality," in S. Woolgar (ed.) *Virtual Society? Technology, Cyberbole, Reality* (Oxford: Oxford University Press): 1-22.
- Woolgar, S. (2002b) *Virtual Society? Technology, Cyberbole, Reality* (Oxford: Oxford University Press).
- Wouters, P. (2000) "Cyberscience: The Informational Turn in Science," lecture at the Free University, Amsterdam, 13 March.
- Wouters, P. (2004) *The Virtual Knowledge Studio for the Humanities and Social Sciences @ the Royal Netherlands Academy of Arts and Sciences* (Amsterdam: Royal Netherlands Academy of Arts and Sciences).
- Wouters, P. (2005) *The Virtual Knowledge Studio for the Humanities and Social Sciences*, Proceedings of the First International Conference on e-Social Science, Manchester, June 22-24.
- Wouters, P. (2006) "What Is the Matter with e-science? Thinking Aloud about Informatisation in Knowledge Creation," *Pantaneto Forum*, July 2006. Available at: <http://www.pantaneto.co.uk/issue23/wouters.htm>.
- Wouters, P. & A. Beaulieu (2006) "Imagining e-science Beyond Computation," in C. Hine (ed), *New Infrastructures for Knowledge Production: Understanding e-science* (London: Information Science Publishing): 48-70.

- Wouters, P. & R. de Vries (2004) "Formally Citing the Web," *Journal of the American Society for Information Science and Technology* 55(14): 1250-60.
- Wouters, P. & C. Reddy (2003) "Big Science Data Policies," in P. Wouters & P. Schröder (eds) (2003), *Promise and Practice in Data Sharing* (Amsterdam: NIWI-KNAW): 13-40.
- Wouters, P. & P. Schröder (eds) (2000) *Access to Publicly Financed Research: The Global Research Village III* (Amsterdam: NIWI-KNAW).
- Wouters, P. & P. Schröder (eds) (2003) *Promise and Practice in Data Sharing* (Amsterdam: NIWI-KNAW).
- Wyatt, S. (1998) "Technology's Arrow: Developing Information Networks for Public Administration in Britain and the United States," PhD diss., University of Maastricht.
- Wyatt, S., G. Thomas, & T. Terranova (2002) "They Came, They Surfed, They Went Back to the Beach: Conceptualizing Use and Non-Use of the Internet," in S. Woolgar, *Virtual Society? Technology, Cyberbole, Reality* (Oxford: Oxford University Press): 23-40.
- Wyatt, S., F. Henwood, N. Miller, & P. Senker (2000) *Technology and Inequality: Questioning the Information Society* (London: Routledge).
- Zammuto, J. H. (2004) *A Nice Derangement of Epistemes: Post-positivism in the Study of Science from Quine to Latour* (Chicago: University of Chicago Press).
- Zeldenrust, S. (1988) *Ambiguity, Choice, and Control in Research* (Amsterdam: Amsterdam University Press).