



Geographies of science and technology I: Boundaries and crossings

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Abstract

In a world of accelerating environmental crises, global pandemics and seemingly unstoppable datafication of anything that moves, thinks or feels, the politics of science and technology are pervasive. In this first of three progress reports on the geographies of science and technology, I home in on some definitional questions which an account of anything like a new or emerging subfield must necessarily concern itself. I examine how geographers have addressed the spatial effects of the making and unmaking of boundaries between science, technology and their various outsides. While work on historical and contemporary geographies of technoscience has often pulled in slightly different directions, I identify some promising convergences around questions of political economy and on the topic of scale as an emergent property of technoscientific practices. New attention is also falling on the spatial practices through which technoscience gets plugged into wider worlds, such as politics and policymaking, while geographers have also been busy disrupting, in a more experimental mode, conventional boundaries and hierarchies of technoscientific practice. Finally, the report examines recent and welcome efforts to convene new conversations around the geography of technology but cautions against the potential seduction of the new, the innovative and the ‘disruptive’. Important recent work in cultural geography has purposively unsettled assumed hierarchies of ‘high’ and ‘low’ tech, new and old, and suggests that any nascent subfield of ‘geography of technology’ needs to reflexively attend to how boundaries get drawn around ‘technology’, and with what effects.

Keywords

boundary work, science, science–policy interface, technology, technoscience

This is the first time that progress reports have been commissioned on the geographies of science and technology. As Richard Powell noted in his 2007 review of work on science’s geographies, this is a body of work of increasing vibrancy and diversity – so much so that calls to institutionalise a distinctive subfield of ‘geography of science’ might not do justice to the variety of ways in which geographers of various stripes contribute to science (and technology) studies writ-large and to the discipline’s own

understandings of the making of modern life-worlds (Powell, 2007). The diversity and vibrancy identified by Powell has only grown in the intervening years, as has innovative – if rather more scattered – work on the geographies of technology. Furthermore, the invitation to

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appraise literature on the geographies of science and technology is novel, and a prompt for reflection on what unites and divides these two domains. Here we encounter the geographies of two things whose definitions have kept philosophers in long academic careers, while real-world disputes over their boundaries have given much grist to the critical mills of history, sociology and, increasingly, geography. While much of science's history has been marked by struggles over the boundaries and definitions of the enterprise, with powerful actors keen to keep the number of things under the umbrella of 'science' as restricted as possible, 'technology' is, conversely, commonly taken to be a class of objects and practices which permeate lifeworlds almost without limits. While science is strictly circumscribed, technology, we are told, is everywhere. Science retains its authority by limiting the things that can bear that label, while the promiscuousness of 'technology' is part of its ideological force (Kirsch, Forthcoming; León and Rosen, 2020).

I therefore chose 'boundaries and crossings' as the theme for this first report in order to confront these definitional questions and to shine a light on geographical scholarship which examines the spatial consequences of their settlement. But the theme was also a response to the context in which this report was written. The multiple tragedies and injustices of Covid-19 raise urgent new questions, to which geographers and others are already offering provisional answers, most notably in a collection of short essays in *Dialogues in Human Geography*. Focus has fallen, for example, on the geographies of public health infrastructures (Delaney, 2020) and of the technologies of population monitoring (Datta, 2020), the uneven exposures of bodies to aggravating toxicities (Eaves and Al-Hindi, 2020), the political economies of medical knowledge and technology (Blue and Rock, 2020), the relationship between scientific advice and political decision-making (Hulme et al., 2020), the politics of risk, uncertainty

and anticipation (Barry, 2020), and an emerging geo- and bio-politics of what has already been dubbed, in a twist on the Anthropocene, the 'virocene' (Fernando, 2020). Boundaries between science and politics, nature and culture, bodies, technologies and environments, and between gestures of control and of care have long been of central concern to science and technology studies (STS), whether as targets for theoretical deconstruction or for empirical mappings of the traffic across them. Likewise, literatures on the geographies of science and technology have frequently concerned themselves with the fuzzy edges of those things, edges which any account of anything like a 'subfield' within geography must necessarily concern itself.

I Bounding Science

For Beth Greenhough (2006: 225), how geographical work reckoned with science's own boundaries was itself a crucial dividing line between different strands of inquiry. On the one hand, historical geographers tended to offer naturalistic descriptions of the spaces of scientific practice after the fact, once boundaries – both physical and epistemological – had been erected between science and its outsides. By contrast, engagements by geographers with contemporary sciences, most notably the bio- and environmental sciences, were concerned less with the spaces science made for itself, and more with how the spatial boundaries set by scientific practitioners are challenged in practice, and how scientific practices 'serve to question pre-existing understandings of spaces and the social relations sustained within them'. Indeed, the common use of the term 'technoscience' in such work emphasised how the crossing (or even illusion) of boundaries – such as between science and technology, or 'the true and the useful' (Feenberg, 2016: 649) – was a common starting point of inquiry (e.g. Jöns, 2006). While historical work tended towards a critique of universal objectivity by showing how scientific practices

were dependent upon particular spatial arrangements, work on the geographies of early 21st-century technoscience addressed itself towards how science remakes space and spatial relationships beyond its own conventional walls and addressed ‘the spatial possibilities generated by and through [scientists’] work’ (Greenhough, 2006: 225).

We could characterise this as a distinction between a topographical and a topological approach to science’s geographies. And to some extent, it is a distinction that still holds. Historical geographers have continued to produce fascinating accounts of the spatiality of scientific practice and of knowledge circulation, drawing inspiration from earlier scholarship on the social and cultural history of science (Finnegan, 2017; Livingstone, 2014; O’Sullivan, 2019). Meanwhile, geographical work on contemporary sciences has continued to exercise a more topological spatial imagination (Paasi, 2011), making profitable use of various strands of post- or more-than-humanist thought, assemblage theory and feminist and post-colonial science studies to engage with the joint transformations of scientific practice and wider spatial formations (e.g. Davies, 2013; Donovan and Oppenheimer, 2015a; Greenhough, 2011). However, there is also notable work that has crossed over the distinction proposed by Greenhough (2006). For example, Carey et al. (2016), Powell (2017) and Lehman (2020) have used the tools of postcolonial and feminist theory to reappraise both historical and contemporary geographies of environmental science, while efforts have also been made to use what Powell (2007) labelled the socio-spatial approach to history of science to interpret contemporary geographies of geology (Donovan and Oppenheimer, 2015a) and climate science (Mahony and Hulme, 2018). Historical geographers of science have also begun to pay more attention to questions of political economy and class formation (e.g. Vitale, 2017), paralleling wider moves in STS – in which geographers have been notably

involved – to use the analytical tools of political economy to reinterpret contemporary formations of technoscientific power (e.g. Birch and Muniesa, 2020; Tyfield et al., 2017).

Historical geographers of science have long agonised about the temptations of ‘parochialism’ and about falling prey to the ‘lure of the local’ (see the discussion in Naylor, 2010). As Finnegan (2015: 239) notes, studies of science’s local contexts have arguably left under-explored how science gets ‘plugged into’ the wider world and offer little explanation for the success of some forms of knowledge and practice in becoming global. Finnegan offers scale, as an emergent property of scientific practice, as a key notion for geographers of science to grapple with, and it may be that in concertedly addressing questions of scale, geographers taking topographical and topological approaches to science may find some common ground. Jessica Lehman (2020), for example, tackles this issue head-on in her study of oceanography during the 1957 International Geophysical Year. She criticises the focus of much geography of science and STS literature on relatively ‘small’ stories and spaces of scientific practice and contends that the localising tendencies of existing analytics struggle to fully capture the social and political dynamics of scientific practices which address themselves towards, and construct, planetary spaces. Lehman offers a focus on the ‘synoptic geographies’ through which large-scale knowledge-systems – such as those of earth observation (e.g. Edwards, 2010) – have been made. The geopolitical and technical work of planetary-scale science prompts us to broaden the cast of actors that populate our geographical stories – from the central scientists to the technicians, calculators and various ‘locals’ who are enrolled into, and sometimes resist, networks of observation and data collection (also Lehman, 2018). This is a move which may be familiar to historians of science (e.g. Shapin, 1989), but Lehman is right to point out that geographers have occasionally been oddly

silent on the diverse social worlds which exist within and move through the spaces produced for scientific practice.

II Liminal Boundaries

While some geographers have peered into ‘scientific’ spaces – such as geophysical observation networks – and revealed them to be also home to things like politics, interests and values, others have looked more deliberately at the spaces where traffic across the boundaries of science and politics is actively encouraged – albeit in carefully regulated, frequently contested ways. Work on science–policy advisory processes has frequently used a spatial register to interpret the relationships between the social worlds of science and policymaking: ‘interfaces’ (Gluckman, 2016), ‘boundaries’ (Gieryn, 1983; Gustafsson and Lidskog, 2018) and ‘domains’ (Ribes et al., 2019) abound. Yet it is only relatively recently, with inspiration from the heterodox literature on geographies of science, that space has been taken as an active participant in such processes. For example, Palmer et al. (2019) examine the spaces and materialities of scientific advisory processes within the UK government, using the example of departmental Chief Scientific Advisors (CSA). Questions about influence, authority, independence and objectivity – well-worn in interactional traditions of STS inquiry (Jasanoff, 2004) – are addressed here as questions of spatial practice. The image of a CSA lurking by the lifts to try to catch and bend the ear of a minister, or of another jealously watching the chief economist walking to their bigger, better-located office, speak to established lines of inquiry into the social and material constitutions of spaces of scientific practice and expert speech.

Palmer et al. don’t offer a spatially deterministic reading of scientific advisory processes, rather they draw attention to the ‘spatial affordances’ of certain material artefacts – such as

the lift or the office door – which make themselves ‘available to certain uses while constraining others, thereby influencing the extent – and the nature – of the advisory encounters themselves’ (Palmer et al., 2019: 249). There are promising linkages here with work in political geography which emphasises the material assemblages through which practices like diplomacy and policy formation take place (Dittmer, 2017). Political geographers are increasingly paying critical attention to the role of technical and scientific expertise in such assemblages (e.g. Kuus, 2020), although it is only relatively recently that such work has engaged in explicit dialogue with work on the geographies of science. Donovan and Oppenheimer (2015b), for example, argue for the relevance of relational thinking in such contexts, using the case of volcanic risk assessment processes to conceptualise the science–policy interface topologically, as a ‘diffusive’ assemblage in which ‘both science and policy contain multiple overlapping networks of actors, objects and ideas that interact with one another through flows of responsibilities, attribution, identity and interpretation’ (Donovan and Oppenheimer, 2015b: 153). Efforts by scientists and decision makers to define physical boundaries – for example, between zones at risk or not at risk from an eruption – involve the negotiation of conceptual and disciplinary boundaries which are inherently unstable, even chimeric, yet which are powerfully performative as actors struggle for epistemic and social authority.

Amy Donovan’s work on the interaction between boundaries of risk/safety and science/politics has recently expanded to explore how such processes play out in a different kind of liminal space – international borderlands. If volcanoes are a focal point for examining ‘geologic politics’ (Bobbette and Donovan, 2019), and their eruptions ‘geo-events’ that transform human and more-than-human worlds (Shaw, 2012), then international borders can similarly bring into focus how national assemblages of

disaster science and politics interact, conflict with, and learn from each other. Examining a recent eruption on the border of Argentina and Chile, Donovan (2020: 1056) shows how ‘territorial boundaries that define human collectives are resisted and reinforced by the earth, with complex consequences for political agents and for identities’. This is particularly true for scientists and their monitoring technologies, embedded as they are within historically contingent national institutions and political cultures, but enrolled by the geopower (Grosz, 2008) of a volcanic eruption into an assemblage of knowledges, institutions, emergency management protocols and inhuman forces which heightens the liminality both of territorial boundaries, and of any boundaries between science and politics. Volcanic events are one potential source of ‘civic epistemological rupture’, which can fundamentally remake place-based settlements between science and politics (Donovan and Oppenheimer, 2015c).

As well as stressing the liminality of the boundaries of science, geographers have also been at pains to emphasise the existence of multiple science–policy interfaces, and to push back against universalising normative models of how science, policymaking and politics *should* interact. Meehan et al. (2018) mobilise the notion of ‘socio-technical imaginary’ (Jasanoff and Kim, 2015) to explain how and why a model of trans-disciplinary sustainability research developed in North America failed to function as imagined in Colombia. Meehan et al. use the socio-technical imaginary concept in a similar way to Jasanoff’s earlier notion of ‘civic epistemology’, as a way of describing culturally and politically situated norms of making and using technical knowledge, and thus of explaining spatial variation in science–policy processes and outcomes (Jasanoff, 2005). However, while civic epistemology tends to focus on national political cultures, Meehan et al. additionally refer to the political economy of a neo-liberal development paradigm, and its local

instantiations, as part of the particularities against which supposedly universal knowledge practices bump up. They thus describe a ‘geopolitics’ of knowledge mobilisation in these tensions between ‘a plurality of science–policy interfaces produced by local social orders and global hegemonic ideas and practices’ (p. 774). Within this geopolitics, we can view scale as an emergent property of competing science–policy co-productions (cf. Beck et al., 2017), each with their own commitments to where the science/politics boundary should lie.

The work of Katie Meehan and colleagues contributes to a broader set of efforts by geographers to purposively dismantle boundaries and hierarchies which structure technoscientific practice, particularly those which are taken to be obstructive to effective and just responses to conjoined crises of environment and economy. As well as offering criticisms of ossified technoscientific hierarchies, geographers continue to actively experiment in relocating and democratising scientific and technological worlds (Chilvers and Kearnes, 2020).

For example, Jamie Lorimer’s recent work has tracked the emergence of the microbiome as a new epistemic object, alongside an uneven turn in global health discourse away from a Pasteurian, antibiotic ontology of identifiable and eradicable germs to a new set of understandings of human–microbial symbiosis (Lorimer, 2017). The emergence of new communities, often disconnected from formal scientific institutions, concerned with understanding and fostering human–microbe relationships has seen the practices and technologies of microbiology and metagenomics spill out of the lab and circulate among new networks of biohackers and citizen scientists. Lorimer et al. (2019) sought new ways of intervening in this making-public of the biome in order to anticipate the challenges which will be associated with a likely intensification of public microbiology (see also Greenhough et al., 2020). Drawing on Whatmore and Landström’s (2011) experiments in

an ‘apprenticeship’ model of mutual learning across expert/lay dichotomies, the ‘Good Germs, Bad Germs’ project opened up the design and framing of microbiological research to a public which was enthusiastic about the implications of new knowledge of the microbiome in domestic settings, albeit frustrated at the levels of scientific uncertainty involved in mapping the microbiome of their own kitchens. The experiments showed how several decades of germ discourse have cemented a species ontology in public imaginaries of microbiology, which doesn’t sit easily with emergent ecological understandings of the microbiome, nor with the practical scientific challenges of accurately mapping the microbiome down to a species level. In taking microbiology out of the laboratory and into the community centre and the domestic kitchen, Lorimer et al. (2019) illustrate both the challenges and opportunities of democratising the technologies and practices of scientific knowledge making and show how the interests and concerns of various publics may not always chime with those of research funders and mainstream scientists, nor with the commercial entities seeking to use science to identify and exploit new sites of capital accumulation.

III Spacing Technology

Experiments in the convening of new publics and new communities of practice for technoscience parallel recent moves in diverse areas of human geography to reappraise the place of technology in cultural, political and more-than-human worlds. However, while ‘geographies of science’ is a recognised area – if not an institutionalised field – of geographic inquiry, what prospects for ‘geographies of technology’? After all, ‘history of technology’ sits alongside ‘history of science’ as an established subfield of History.

Perhaps for geographers the concept of ‘technology’ itself is problematic. Until the 1940s,

technology was truly an *-ology*, a field of study of the technical arts; it is only relatively recently that the term has come to signify machines and tools, things that you might hold in your hand, build a roof over or climb inside (Schatzberg, 2018). As Scott Kirsch notes, ‘technology’, conceived as a broad set of material-discursive practices, is inherently geographical:

It is in our every communication, our roads, water, health, work, energy, and waste, to name a few of its concrete material settings. It is distributed across the earth’s surface even as it remains a most abstract idea, a word that can be made to stand for many knowledges, processes, capabilities, and things (Kirsch, Forthcoming: 695).

Technology is a ‘brain macerating concept’ (Edgerton, 2019: xii). It’s difficult to conceive of any human geography which isn’t, in some way, a geography of technology and its coproduction with space and power. Nonetheless, important moves have been made to unite geographical work which places technologies of various sorts at the forefront of analysis. The publication of a *Handbook on the Geographies of Technology* (Warf, 2017) represents an important moment in the consolidation of a field of geographical research which has characteristically been spread out across various subfields and lacking a coherent discourse and agenda. The handbook covers an admirable range of technological fields – biotechnology, transport, computation, communications, energy and manufacturing – and draws in large part on research in economic geography which seeks to map and explain geographical patterns of technological innovation and diffusion. Other theoretical perspectives are present, including from STS and feminist critiques of technology (McLean et al 2017), but the handbook is primarily organised around individual technologies or families of technologies, such as radio, the internet or robotics, rather than around conceptual or thematic concerns. The empirical organisation of the volume will undoubtedly

make it a useful teaching aid, and a helpful compendium of reference points for those seeking orientation. But recent conceptual contributions by geographers to the critical study of technology, such as work in new materialist traditions on the agential force of technological artefacts (Barry, 2013; Bergmann et al., 2020), gets less visibility.

It is also worth reflecting on the boundaries drawn around the notion of 'technology' in the *Handbook*. The introductory chapter offers a productively open definition of technologies not as simple *things* but 'systems that enmesh people, objects, knowledge, techniques, procedures, and places into a seamlessly integrated whole' (Warf, 2017: 1). But the handbook subsequently maps a fairly conventional landscape of 'high' technology – for the most part energy-intensive, electronic, and integral to the production systems of advanced capitalism. This reflects how the 'geography of innovation' can channel attention towards the new and the 'disruptive', to the detriment of a fuller understanding of technology in everyday lifeworlds. As the historian David Edgerton pointed out forcefully in *The Shock of the Old*, students of technology have a tendency to be blinded by technologists' own rhetoric of novelty and revolutionary change, and thus miss how economies and societies mostly function through the circulation, maintenance, reuse and repurposing of 'old' and vernacular technologies.

Cultural geographers have recently done important work in unsettling conventional narratives and hierarchies of technological innovation, drawing often on postcolonial and new materialist traditions (Kirsch, 2014). For example, Klocker et al. (2018) conceptualise Tanzanian plastic bag footballs as 'fluid technologies' (de Laet and Mol, 2000) – 'situated cultural geographic accomplishments' which are not inferior to mass-produced, shop-bought balls, but which are purposively and carefully adapted to local physical, social and economic conditions (Klocker et al. 2018:

304). Klocker et al. thus disrupt colonial narratives which position such vernacular technologies as inevitably inferior or imitative of industrial alternatives – as 'creative' responses to poverty and hardship which can be jettisoned as soon as people can afford the real thing. Relatedly, the authors' more-than-human perspective on making, repair and reuse joins a wider current of geographical literature on communities of enthusiasts (Geoghegan, 2013), makers (Carr and Gibson, 2016), apprentices (Patchett, 2017) and restorers (DeLyser and Greenstein, 2017), and their emotional, practiced and embodied entanglements with the material worlds of technological objects. This literature helpfully refuses the image of the maker as an all-powerful actor imposing their will on inanimate matter, and instead emphasises the co-constitution of material and social worlds: of culturally and historically situated communities bound together by relationships of shared interest, care and generosity; and of agential materials temporarily configured 'as things or objects at a singular point in time' (Carr and Gibson, 2016: 302).

IV Concluding Thoughts

Building on such insights, a fuller geography of technology-in-use (cf. Edgerton, 2019) would move beyond the innovation paradigm, with its tendencies towards technological determinism and its tacit support for a political economy that privileges new frontiers of capital accumulation to the direct detriment of the labours of maintenance and care through which social, material and technoscientific worlds are continuously remade (Vinsel and Russell, 2020). Similarly to how geographies of science have emphasised diverse spaces of practise, geographers are showing a greater interest in the spaces of technology use, including how technologies reshape situated lifeworlds, and how users in turn shape or 're-script' technological artefacts (Millner,

2020; Rose et al., 2018). Additionally, geographers have drawn on STS work on the sociology of expectations as well as insights from political economy to critically engage with the rhetoric and discursive practices of technological innovation, and their role in the production of space at local, regional and planetary scales (Bellamy and Palmer, 2019; Porter and Randalls, 2014; Vitale, 2017). If a subfield of ‘geography of technology’ is to exist, we need more of this critical and reflexive engagement with the definition, boundaries and ideological baggage of the concept of ‘technology’ itself, and the work that the concept – and not just the material artefacts it describes – performs in the making of historical and contemporary worlds (Kirsch, Forthcoming). There is much inspiration to be had in the parallel achievements of science studies scholars – including geographers – in this regard, while such work also promises to push research on the liminal spaces between ‘science’ and ‘technology’ in exciting new directions.

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