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TRANSLATING CULTURES OF SCIENCE

Maeve Olohan

This essay focuses on conceptualisations of science as culture, drawing primarily on research from the field of science and technology studies. It first highlights differences between traditional, Western positivist views of science and more culturally oriented, constructivist perspectives. In doing so, it introduces a conceptualisation of culture that is closely bound up with notions of knowledge-as-practice. It then illustrates how the concept of epistemic cultures can help us to understand how different branches of science are culturally distinct. This is followed by an outline of postcolonial science studies, used as an example to illustrate the kinds of issues that can be addressed when we construe science as culture in global settings. The essay then outlines one way in which scientific discourses construct science, using exclusionary boundaries. These discussions of science are followed by an overview of current trends in research on translating science. Like science studies, translation studies is shifting its attention away from a focus on science as knowledge and scientific discourse as referential and towards a better understanding of the social and cultural importance of scientific translation. The essay concludes by outlining the scope for further research on scientific translation from cultural perspectives.

1. Introduction: Two Cultures, and a Third

C.P. Snow initiated a debate in the 1950s in the UK that has become very well known as the two-cultures debate (Snow 1959; 1963). In a public lecture, later published, Snow posited a 'gulf of mutual miscomprehension' (1959, 4), and indeed a considerable degree of animosity, between scientists and literary scholars, representing the two cultures in question. Snow's ideas sparked further debate, but the question he raised was not new. The relative value of science and literature, or the humanities, for society's understanding of the world had long been discussed, although as Franklin (1995, 166) observes, this particular opposition is perhaps more characteristic of Western scholarly history than of other intellectual traditions. We can observe it, for example, in exchanges between scientist T.H. Huxley and literary intellectual Matthew Arnold in nineteenth-century England (Hultberg 1997), and its precedents include similar disciplinary distinctions in medieval and early modern Europe (Blair 2008).

A physicist turned civil servant and novelist, Snow used his lecture to voice criticism of the lack of esteem or importance attached to scientific knowledge by the British literary intellectuals of the time. He described the two cultures as espousing different value systems and different perspectives on the future – the scientists forward-looking and optimistic and the literary intellectuals more pessimistic. Snow argued that the lack of scientific understanding and the undervaluing of science by society could be damaging for policy making and would require substantial changes in scientific education for it to be overcome.

Revisiting this notion a few years later, Snow posited the emergence of a third culture, in the form of social historians who bridge the scholarly gap. If he had been writing a little later still, Snow might have counted among this group those who were to engage in ground-breaking social studies of science, especially from the 1960s onwards (Van Dijck 2003), and whose thinking on science forms the backbone of this essay.

The publication of Thomas Kuhn's (1962) seminal work on how scientific knowledge advances through different periods of scientific revolution or paradigm shifts and how scientific communities are organised may be taken as marking the start of the wave of social studies of science that flourished during the 1970s. These historical and sociological studies offered a critique of science and scientific culture from outside of science, challenging firmly held, positivist notions of scientific research as disinterested and not driven by personal or institutional agendas. These science studies also challenged the foundations of scientific realism which accorded to science the capability and purpose of producing an accurate reflection or presentation of an existing reality by applying the objective and rational 'scientific method'. It may be noted that the cultural significance of science had been addressed philosophically in various ways in the inter-war years by Whitehead, Fleck and Duhem, among others, and in the post-war period by Merton, Polanyi and others (see Turner (2008) for an overview). However, it is through the development of 'science studies', post Kuhn, and a period of intense critical enquiry into the nature of doing science, and through subsequent examinations of the relations between science and society, that a deeper and more nuanced understanding of science as culture emerges. Some aspects of this understanding of science are elucidated in the following sections.

2. Historical Perspectives: From Knowledge To Situated Practice

The conventional scientific epistemology that was challenged by Kuhn and other post-positivist thinkers included assumptions about science as singular or unitary. According to the conventional Western view, there would be no distinctive differences between different branches of science or between science done in different institutional settings. In challenging this idea, Sandra Harding sums it up as an expectation that society would provide the conditions for scientific work but would not influence the outcome of research 'in any culturally distinctive way' (Harding 1998, 3).

As noted above, the 1970s, in particular, saw the development of approaches to science studies that emphasised the socially constructed nature of science. They did this through a range of conceptualisations, focal points and methods (see Sismondo (2010) for an accessible book-length overview of science and technology studies (STS) and Hackett et al. (2008) for more detailed, essay-length treatment of numerous approaches). Initially there was a focus on the ways in which science is shaped by the interests of relevant social groups (Bloor 2001). Other studies from the late 1970s and during the 1980s examined how knowledge is locally negotiated by scientists in laboratories (Latour and Woolgar 1979; Traweek 1988). Constructivism offered an approach that contrasted strongly with positivism and logical empiricism in focusing on how sciences and cultures are co-constitutive and co-evolving:

> The distinctive ways that cultures gain knowledge contribute to their being the kinds of cultures they are; and the distinctiveness of cultures contributes to the distinctively 'local' patterns of their systematic knowledge and systematic ignorance (Harding 1998, 3).

By emphasising what is local and cultural about scientific practice, these approaches challenged science's claims to universality and unity. As Harding goes on to describe them, constructivist approaches emphasize how

> systematic knowledge-seeking is always just one element in any culture, society, or social formation in its local environment, shifting and transforming other elements – education systems, legal systems, economic relations, religious beliefs and practices, state projects (such as war-making), gender relations – as it, in turn, is transformed by them (*ibid*., 4).

A collection of essays published in 1992 under the title *Science as Practice and Culture* reflects some of the commonalities and divergences of the approaches that emerged during those decades. Andrew Pickering, in his introduction, summarises what was, in his view, the key advance of science studies during the 1980s, namely 'the move towards studying scientific practice, what scientists actually do, and the associated move toward studying scientific culture, meaning the field of resources that practice operates in and on' (Pickering 1992, 3). This particular definition of scientific culture is motivated by an understanding of science as practice. It stands in stark contrast to logical empiricist views of science as knowledge, which would be more likely to define scientific culture as consisting of a field of knowledge and a set of knowledge claims, a conceptual network (*ibid*.). The science-as-practice view instead leads to a less knowledge-dependent view of science, as well as 'a greater appreciation of its thorough enculturation at every layer of the onion' (Franklin 1995, 170).

In a similar vein, David Hess (1995) adopts a broad, anthropological understanding of culture as encompassing not only the intellectual life of a group of people – religion, arts, literature, language, and so on – but also their knowledge and way of life, i.e. 'everything that a group of people has learned', including the social actions of 'rituals, work, trade, political institutions, family and kinship' (*ibid*., 10). Studies that exemplified this approach to culture and science, emphasising the cultural specificity of knowledge practices, included Marilyn Strathern's (1992) and Donna Haraway's (1991) work on kinship which challenged Eurocentric presumptions of notions like parenthood.

Thus, from the starting point of Snow's notion of the culture of science, closely linked to intellectual life and contrasted with literary thought, we can trace a development through science studies towards an understanding of science that is less centred on science as a set of knowledge claims and the pursuit of universal truths but is instead interested in situated knowledge practices, in the doing of science in all its contexts. Culture, previously dismissed as irrelevant to science that was presumed to be disinterested, value-free, objective, unified, universalist and realist, now becomes a key concept. In the next section we explore the kinds of critical issues and topics that arise from this understanding of science and culture as co-constitutive.

3. Critical Issues and Topics: Science as Culture

This section examines what it means to think about science as culture through a series of examples and key concepts. It focuses first on the notion of epistemic cultures, as a way of understanding cultural differences across the sciences and within scientific communities, illustrated by the work of Karin Knorr Cetina and Sharon Traweek. It then considers postcolonial science studies, using Sandra Harding's contributions as a foundation to exemplify strands of theory and research that have shaped and been shaped by thinking about science in cultural terms. The section concludes with consideration of Thomas Gieryn's insights on boundary work, with an example of a recent scientific controversy to illustrate how discursive practices construct the concepts of scientific insiders and outsiders and the culturally contingent characteristics of science itself.

3.1. Epistemic cultures

Bruno Latour's (1987) and Latour and Woolgar's (1979; 1986) pioneering ethnographic studies of laboratory scientists focused on how knowledge is locally produced, using semiotic resources, inscriptions, the enrolling of allies, etc. Karin Knorr Cetina continues this work of laboratory studies (Knorr Cetina 2001) but with a different focus. She is not studying the 'construction of knowledge' but rather 'the construction of the machineries of knowledge production' (Knorr Cetina 1999, 3). She makes use of the notion of 'epistemic cultures' to designate:

> those amalgams of arrangements and mechanisms – bonded through affinity, necessity and historical co-incidence – which, in a given field, make up how we know what we know. Epistemic cultures are cultures that create and warrant knowledge (Knorr Cetina 1999, 1).

In *Epistemic Cultures* (1999) Knorr Cetina studies two branches of science (high energy physics and molecular biology) but she points out that the notion of epistemic cultures can also be applied in other areas of expertise. The shift from consideration of disciplines or specialisations to epistemic cultures or knowledge-related cultures serves to highlight the spaces of knowledge-in-action and to bring out the 'complex texture of knowledge as practiced in the deep social spaces of modern institutions' (*ibid*., 2).

For Knorr Cetina, culture is 'the aggregate patterns and dynamics that are on display in expert practice and that vary in different settings of expertise' (*ibid*., 8). She focuses attention not only on the uniformities of practice but also on ruptures in practices and the rich diversity of practices. Her analyses of epistemic cultures take account of instrumental, linguistic, organisational, theoretical and other frameworks in the intricacies of knowledge construction (*ibid*., 10).

Knorr Cetina is interested in the diversity and disunity of science, and her study highlights the differences in epistemic cultures between the enormous, collaborative experiments of high energy physics with particle colliders and the bench work of small molecular biology laboratories. Hacking (1992, 33) had earlier described the laboratory as 'a cultural institution with a history (or rather histories)'. As conducted by Knorr Cetina, an investigation of the nature of epistemic cultures focuses on the 'epistemic subjects', i.e. the agents in scientific practice and the authors of scientific publications, as traced in the field. In the case of high energy physics, this may be a team of up to two thousand scientists, a detector and discourse integrating machine analysis and human analysis (Knorr Cetina 1999), while molecular biologists work in smaller two-tier teams. Epistemic cultures also concern the objects of knowledge, the spatial arrangements of the places of knowledge, and what are termed 'object-relations regimes', i.e. 'prescribed and presupposed ways of relating to objects of knowledge and of approaching them in research' (Knorr Cetina 2007, 366).

There are parallels here with Hacking's (1992) characterisation of the 'ideas, things and marks' of science. By 'things' he refers to the 'materiel' of an experiment, i.e. the laboratory apparatus, the substances or objects investigated (*ibid*., 32). Surrounding the materiel are, on the one hand, the ideas, i.e. theories, hypotheses, questions and models, and on the other hand, the 'marks' and 'manipulations of marks', i.e. the data, calculations, interpretations of data, and other forms of inscription (*ibid*.). As in Knorr Cetina's examination of epistemic cultures, Hacking points out that science is disunified because of the proliferation of specialisations but also because of the different theories, techniques and phenomena investigated within different specialisations (*ibid*., 57).

Knorr Cetina's (1999) comparative study addressed a major shortcoming of previous laboratory studies by highlighting the cultural diversity of different branches of science. The two settings for her field studies were at CERN in Switzerland and a Max Planck Institute in Germany, and it is interesting to note that diversity of national institutional cultures and linguacultures does not figure in her analyses. By contrast, Sharon Traweek's (1988) comparison of Japanese and US (Stanford) accelerator laboratories, although not permitting a comparison across scientific disciplines, was able to attend to differences in how scientific institutions are set up and run in the US and Japan. As Franklin (1995, 174) notes, those kinds of ethnographic studies of science deal with the 'crossing-over between culture of the lab and the culture of which this culture is a part'. They focus on local strategies of making sense and the embeddedness of local scientific cultures in wider cultural meanings, or how 'technoscientific artifacts make sense in a kind of cultural hyperstack' (*ibid*.)

3.2 Postcolonial science studies

The title of one of Harding's influential contributions (1998) poses the question: *Is Science Multicultural?* There and throughout her work, Harding pursues a parallel line to the post-Kuhnian science studies outlined above, through the territory of postcolonial science and technology studies. She examines the relationships between European and non-European sciences or knowledge systems, and the tensions and balance between 'maximally global and firmly local' elements in scientific accounts (*ibid.* 7). The discredited diffusionist model that was popular in earlier studies of the circulation of scientific knowledge (exemplified by Basalla 1967) conceived of scientific ideas spreading, in one direction, from Europe outwards to other cultures whose knowledge and belief systems were often thought of as falling short of the levels of rationality and objectivity taken as inherent in the conventional scientific method so valued in Europe. In contrast to those earlier imperialist and Eurocentric models, science studies now offers alternative frames of understanding that seek to recognise the interchange of knowledge between cultures and to value the diversity and mutual shaping of knowledge systems, thus also challenging the marginalisation of non-Western knowledge systems. A key aspect of these studies (see also Harding 2011) is also to understand and critique the particular political, cultural and economic factors that have shaped Eurocentric or Northern knowledge production and the consequences of these, including inequalities, global asymmetries, racial and gender bias, and systematic ignorances in science (with due acknowledgement of the difficulties of applying labels such as 'Northern' and 'Southern', used here as shorthand.)

Harding (1998, 56-5) provides useful examples of some of the ways in which science is influenced by cultural factors. Her first example is taken from Needham's (1969) work on Chinese science. Both Needham and Harding argue that the European conception of 'laws' of nature in early-modern Europe drew on both the prevalent Christian religious beliefs and the strength of royal authority. Chinese science, by contrast, conceived of nature as self-governing rather than being ruled by a divine being. Adding Fox Keller's (1985) views to the discussion, Harding points out the different implications of these two different ways of viewing nature in political terms, as laws 'imposed from above and obeyed from below' vs. a notion of patterns of organisation that may emerge in various ways, and not necessarily through imposition.

A second aspect of cultural influence is in the selection of scientific issues to investigate. Harding (*ibid*., 58) argues that European or Northern science has tended to fund and tackle those issues that it conceptualises and deems to be relevant, prioritising expansionist European interests and thus neglecting other issues of more direct relevance to other cultures. Scientific advances can therefore be in the interests of those who control natural resources but detrimental to those who are more marginalised in our societies. This can result, for instance, in relatively little research attention given to the impacts of Northern interventions on the natural resources, people and societies of the global South. Closely linked to this is the notion that the distribution of the benefits of science is also disproportionately to the advantage of the elite and the privileged, and to the disadvantage of others. Thus, postcolonial science theory and history starts not from a European or Northern standpoint, unlike much of the conventional science studies, philosophies and histories of science, but from other, non-Eurocentric perspectives and issues. A recent illustration is Phalkey's (2013) characterisation of the history of science in India as inseparable from the history of imperialism but also heavily constrained by the colonial and postcolonial binary.

3.3 Boundary work and scientific discourse

Constructivist and cultural perspectives on science, widely accepted in science and technology studies or sociology of science, may be less in evidence in other scientific circles. Positivist, essentialist perspectives on science continue to be reflected in much public and professional scientific discourse produced by or about scientists. A notion of scientific objectivity is constructed, for example, through the standardisation of formats and discursive choices of laboratory reports, descriptions of experiments (Hacking 1992, 43) and research articles. Likewise, public scientific discourse or popular science often portrays science as objective and value-free. Arguably, the conceptualisation of 'scientific facts' being 'communicated' or 'disseminated' to the public reflects a prevailing positivist view and an outmoded model of communication, whereby any failure of this one-way communication is ascribed by scientists to journalists' lack of understanding or misrepresentation of ideas or to an inability of the uninformed public, as receivers, to understand (Bucchi 2014, 4). These views also place scientists in the privileged and paternalistic position of being the experts who judge whether scientific ideas have been accurately conveyed or understood. This conception of scientific popularisation is convincingly challenged by Myers (2003, 266) and others who recognise that we, as non-scientists and members of the public, also construct our ideas on science, drawing on representations produced by scientists and science journalists, but in local, cultural spaces in which those ideas interact with our prior knowledge and beliefs and other public discourses.

Thomas Gieryn's (1983; 1995; 1999) notion of 'boundary work' is useful for thinking about how certain characteristics are attributed to the institution of science in order to construct a social boundary between science and non-science. He urges science scholars to 'get constructivism out of the lab' (Gieryn 1995, 440), explaining that our constructivist understanding of scientific facts as locally contingent (as outlined above) needs to be accompanied by a demonstration of how the cultural categories that people then use to interpret and evaluate those claims are also culturally constructed:

> Whatever ends up as inside science or out is a local and episodic accomplishment, a consequence of rhetorical games of inclusion and exclusion in which agonistic parties do their best to justify their cultural map for audiences whose support, power, or influence they seek to enroll (Gieryn 1995, 406).

The concept of boundary work is useful for understanding what happens when the legitimacy or authority of science is contested. As exemplified by Ramírez-i-Ollé's (2015) study of the 'Climategate' controversy of 2009 in which scientists' emails and data were hacked and their practices of selecting and interpreting data were called into question, scientists' boundary work can be studied by examining (i) the attributes that scientists publicly ascribe to science and themselves; (ii) the work they do to define who can or cannot claim authority over the resources and power associated with science (using strategies of expulsion, expansion and protection) and (iii) the professional interests that scientists pursue collectively by demarcating the scientific territory.

Ramírez-i-Ollé analysed press reports about the Climategate controversy written predominantly by scientists. She concluded that the scientists characterised climate science as consensual, with agreement achieved through scrutiny of theories, enabling them to expel climate change deniers, characterised as illegitimate in terms of their scientific credentials or in terms of their departure from the consensus, and also to protect certain areas of climate science from criticism. Social factors were only invoked for behaviour deemed to fall short of scientific ideals (e.g. the need to obtain funding, professional rivalries, time pressures). Otherwise, science was characterised as asocial. Threats to scientific autonomy were perceived as coming from economic, political or ideological interests, and these were mostly associated with the climate change deniers. In agreement with Gieryn (1995), Ramírez-i-Ollé demonstrates that the climate scientists' challenge is to keep their science close enough to politics so that they can legitimate their role in policy decisions but not so close that their 'putative objectivity and neutrality' is undermined (*ibid*.).

The fields of rhetoric and genre analysis provide us with a wealth of studies of the characteristics of scientific genres and the discursive and rhetorical strategies of scientific communication that result in the kinds of inclusion, exclusion or protection of status outlined above. Emanating from the discipline of English for Academic Purposes in particular, much of this research has focused on English and a great deal of it has focused on the prototypical scientific genre, the research article. Seminal work by Bazerman (1988; 1997), Myers (1990) and Swales (1990; 2004) provide a basis for the study of how social actions and relations of the scientific discourse community are reflected in and constituted by discursive and rhetorical choices or moves. For example, by analysing biologists' drafts and published articles, as well as grant proposals and referee reports, Myers highlights key discursive aspects of scientific practice and epistemic cultures, such as the negotiation of knowledge claims and controversies. Other linguists (Halliday and Martin 1993) have studied the language of science in terms of lexicogrammatical characteristics, with Halliday's (2004) analysis of grammatical metaphor providing a useful example of how abstract theoretical entities are constructed through linguistic choices, e.g. nominalisation in English, and can contribute to the exclusionary and elitist nature of professional scientific discourse. Hyland's (2000; 2005; 2008; 2010) notion of metadiscourse, i.e. 'the self-reflective expressions used to negotiate interactional meanings in a text, assisting the writer (or speaker) to express a viewpoint and engage with readers as members of a particular community' (Hyland 2005, 37) provides tools for analysing the interactive and interactional resources used by scientists and others to engage with peers or with the public and how they direct their readers to engage with the propositional content. The usefulness of these tools is amply illustrated by Hyland and others through applications to both professional and popular scientific discourses, mostly in English.

4. Current Contributions and Research on Translating Science

This section focuses on how the translation of science has been approached within translation studies, ranging from textbooks guiding students in translation practice, to studies of scientific translation activities within historical and present-day contexts and analyses of translated scientific discourse. It is worth noting that scientific translation is an area of activity that was very largely neglected by translation researchers in Anglophone contexts for decades. Some attention has been directed at scientific translation in recent years, through conferences and journal special issues (e.g. *The Translator* (2011) and *Meta* (2016) following a themed annual conference of the Canadian Association of Translation Studies in 2013), the addition of a Sciences track in the *Translation Spaces* journal in 2015, and inclusion of scientific translation in key reference works, including this volume but also Baker and Saldanha (2008; forthcoming) and Millán and Bartrina (2013).

The first form of contribution to be considered are books published during the 1960s, 1970s and 1980s, in English, French and German, conceived as practical guides to scientific and/or technical translation (Jumpelt 1961; Maillot 1969; 1981; Finch 1969; Pinchuck 1977; Bédard 1986; 1987). These tended to place a strong emphasis on techniques for achieving terminological accuracy and precision of expression. A focus on the translator's development of conceptual scientific knowledge and understanding can be seen in later works (Hann 1992; 2004), while more recent guides in particular also offer insights into the professional activities of technical communication and technical translation and/or focus on specific technical and scientific genres (Schmitt 1999; Byrne 2006; 2012; Scarpa 2001; 2008; Stolze 2009; Olohan 2016).

A second significant set of contributions on the translation of science are historiographical. A key volume here is Scott L. Montgomery's (2000) analyses of translation activity in several periods. He examines, for example, the history of translating astronomy in the West from antiquity to the Renaissance and the translation of science in Japan from the late medieval period into the twentieth century. A central assumption in his work is that translation is involved in knowledge production at all levels and his case studies serve to illustrate the role of translation in the shaping and reshaping of ideas as they travel between cultural and linguistic contexts. Other historical analyses with a strong focus on translation can be found in the work of Wright (1998; 2000) on how Western chemistry travelled in China in the nineteenth century and Dodson's (2005) study of scientific translation into Indian languages in nineteenth-century colonial India. Further studies of the circulation and construction of knowledge include Lackner et al. (2001) and Lackner and Vittinghoff's (2004) on China, Raj (2007) on South Asia and Europe, and Meade (2011) on early Meiji-era Japan.

The translation of ancient Greek texts into Arabic in the ninth century and translations from Arabic into Latin in the Middle Ages form two periods of translation that have been studied by several historians of science and translation scholars. Researchers such as Saliba (1994; 2007), Burnett (2001; 2005; 2006), Gutas (1998; 2006) and Rashed (2006; 2009) challenge the long-held notion that ancient Greek science, having been previously translated into Arabic, was then re-introduced to Europe in the Middle Ages through translations from Arabic to Latin. That account of translation serving merely as a means of transmission of established scientific ideas failed to recognise the valuable scientific contributions made by Islamic scholars, as translators, who built on the Greek astronomical and mathematical traditions, expanding knowledge. These historical studies thus help to show how translation was part and parcel of scientific practice, and further exemplification and analysis of these two periods are also offered by contributions by translation scholars (Salama-Carr 1991; 2006; Hernando de Larramendi and Fernández Parrilla 1997; Foz 1998; Pym 2000).

Scholars have also focused their attention on case studies of translations of specific texts or works by specific authors, e.g. Darwin's *On the Origin of Species* (Brisset 2002; Vandepitte et al. 2011), or the publishing of Euclid in China (Engelfriet 1998) or translations of Linnaeus' *Systema naturae* into various European languages (Dietz 2016). Examples of culturally and ideologically situated analyses of historical translation practices include Somerset's (2011) study of shifts in ideological orientation in the translation of a seminal popular science work of the nineteenth century. Considering the perspectives of women, Martin's (2011; 2016) focuses on the contributions of women translators of botany in the early nineteenth century and scientific travel writing in the late eighteenth century, while Sánchez (2011; 2014) studies how Borgos used paratextual and textual interventions to challenge the misogyny of a scientific treatise by Möbius when translating it into Spanish.

With a predominant focus on current translation practice, several collected volumes on specialised translation have also dealt with aspects of scientific or technical translation practice (Wright and Wright 1993; Fischbach 1998; Desblache 2001; Gotti and Šarčević 2006), while contrastive text typologies (Göpferich 1995) aim to inform translation practice and pedagogy, and studies such as Krüger's (2015) explore the theoretical interface between scientific translation and cognitive linguistics. The translation of popular science discourse has been analysed from the perspective of metaphor (Shuttleworth 2011; Manfredi 2014) and metadiscursive reader-writer interaction (Liao 2011), among other topics.

A key question in recent years has been that of the dominance of English, described by Swales (1997, 374) as Tyrannosaurus rex, 'a powerful carnivore gobbling up the other denizens of the academic linguistic grazing grounds' and the implications of this dominance for science (Montgomery 2009; Gordin 2015). One area of corpus-based study has been to investigate the possible influence of translation on language change, with a strong focus on popular science discourses (House 2002; 2003; Baumgarten et al. 2004; Malamatidou 2013; House 2013). A second area of enquiry has been initiated by Bennett's analyses of the erosion of non-Anglophone scientific epistemologies through translation. Santos' (1995) uses the term 'epistemicide' to denote the destruction of knowledges by European expansionism and Northern oppression of the South from the sixteenth century onwards (sometimes accompanied by genocide and linguacide). Bennett (Bennett 2007a; 2007b; 2011) draws on this concept to analyse the role of translation in reinforcing the hegemony of English and scientific epistemologies of the Anglophone world and undermining or obliterating non-Anglophone epistemologies.

5. Future Directions

We have seen above how science studies has directed attention towards socio-cultural understandings of science. The interests of translation scholars in scientific translation can also be seen to have shifted from the focus on communication of invariant referential meaning that characterised some initial translation guides to a growing interest in the complexities of how translation and translators figure in the circulation of knowledge. This entails a move away from diffusionist and uni-directional models of communication and more careful consideration of translation and translators in the co-construction of knowledge.

A number of historians of science and historians of scientific publishing are also developing more complex understandings of the transcultural nature of science. Productive approaches include Secord's (2004) work on 'knowledge in transit' and Raj's (2007) conceptualisation of 'sites of intercultural contact'. These approaches are interested in how scientific knowledge and practices circulate and interact and are influenced by both the processes of circulation and the local conditions in which they are entangled. Raj (2010, 517) also suggests that such approaches need to recognise the problematic nature of circulation itself and to understand better how 'localities are constantly constituted within a history of circulation and entanglement between heterogeneous networks of peoples, objects and knowledge practices'. This represents a challenge for translation scholars and historians of science alike; some of the common disciplinary concerns are discussed in more detail in Olohan (2014).

STS's long-held interest in knowledge-in-practice, researched for example through laboratory studies, is one that is relatively new to translation studies but worthy of greater attention. Research conducted at the scientific translator's workplace may be a productive means of understanding what present-day scientific translators do and how they do it. Studies may permit a detailed understanding of how scientific translators and scientists interact in the co-construction of knowledge and enable researchers to analyse a range of aspects of translation practice related to the socialities and materialities of the workplace (see Olohan (forthcoming) for a study of the situated, embodied and materially mediated knowing-in-practice enacted by scientific translators, and Risku (2009), Ehrensberger-Dow (2014) and

Olohan and Davitti (2015) for examples that are not specific to scientific translation but that are illustrative of some approaches and issues). Taking a cue from the notion of epistemic cultures, a greater understanding of the construction of the machineries of knowledge production in the area of translation should also be of interest to translator education and pedagogy.

In addition to the critical sensitivities offered by Bennett's work on epistemicide in translation contexts, translation studies may benefit from other approaches to questions of power inequalities that have emerged in STS scholarship, such as postcolonial science studies and feminist science studies, with scope to extend them to focused analyses of scientific translation practices and policies. This includes analyses of how translation decisions can be used to support or challenge scientific and cultural orthodoxies. Finally, another example of how power inequalities may be approached is offered by Hess and colleagues (Frickel et al. 2010; Hess 2015) who refer to 'undone science' as 'non-knowledge that is systematically produced through the unequal distribution of power in society'. Undone science may arise, for example, where a social reform movement advocating for a particular perspective in the public interest finds that there is no research to support their campaign. Undone science also involves 'the systematic underfunding of a specific research agenda' (*ibid*.) through various mechanisms, from active suppression of scientists or research to more subtle non-selection of areas for research funding. From a translation studies perspective, it may be of interest for us to pay more attention to 'undone translation', past and present, in scientific domains, leading to a better understanding of the exclusion or blocking of access to knowledge entailed in such decisions on what not to translate.

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