

Introduction: The languages of scientists

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Abstract

Much of the scholarship in the history of science has undervalued the significance of the debates around language choice and language use. After surveying various historiographical trends characterizing the relationship of science to language, this introduction explores the role of language-choice in nation-building, education, publication and transnational exchanges. It concludes with a brief summary of the four case studies in this special issue, which explore the German, Greek, English and Russian languages in the context of the sciences in nineteenth-century Europe.

Keywords

Scientific languages, language, education, publication, nineteenth-century Europe, Greece, Germany, Britain, Russia

Historiographical trends

Which languages do scientists speak when they communicate as scientists? To say that science depends on communication, or that mobility – of ideas, artefacts, people, techniques – is part of its internal core, is not a novel idea.¹ But could it be that language, the medium of communication itself, somehow shapes the message it carries? Setting aside Whorfian arguments about the ostensible intellectual properties intrinsic to various languages and language families, a more direct question is posed here about what the *choice* of language might indicate as a historical tool. What can be learned by exploring the choices to use a specific language – French instead of Spanish, English instead of Polish

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– in the history of the sciences, especially subsequent to the diversification of linguistic regimes since the early modern period?

The present collection of papers confronts these questions directly. Language has of course been already the focus of scholarly attention, often in an abstract form of ‘language in general’, exploring the registers of language in a philosophical key, or in terms of dialectical variation within a particular language among the various sub-disciplines, as in the choice of various nomenclatures.² More common, however, is for language’s very ubiquity to leave it in the shadows, hidden from plain view much like Edgar Allan Poe’s purloined letter. ‘Science’ is an analytical category, whose historical study includes practices, theories, institutions, norms and values. But it is also an actors’ category, and those actors tended to imbue it with the cultural and ideological trappings of their era. In addition – and this is a principal contention of this collection of papers – it is obviously in this paragraph a word *in English*. The location of the boundaries between ‘science’ in English and *science* in French, *Wissenschaft* in German, *nauka* in Russian, and so on is an important issue that merits further study.³ Thus, for the purposes of these papers, unless stated explicitly otherwise, the authors use the term ‘science’ to refer to the natural sciences in its most common Anglophone usage. How and why, then, do linguistic borders interrelate with the practice of science? How were major scientific languages established as such, and how did they accommodate translations both into and out of each other? How do linguistic practices constrain, contain, or enable the creation and circulation of scientific artefacts, theories and practices? In what ways has language been a cultural, ideological or normative resource for scientists? What tacit assumptions about what scientists did and about what scientists intended to do become apparent in their language use? These are only some of the possible research directions that a historical examination of language use within science brings forth. It is our intention here to contribute to the development of this field.

The existence of an interesting problematic, however, does not necessarily entail that there is a lacuna within the existing scholarship. Language in science, it can be argued, has already come under historiographical scrutiny and an astute reader can surely name at least some of the most famous examples. How then does this specific inquiry on science and language differ from the various analyses already encompassed by current scholarship?

The systematic study of language in relation to science is often traced to what has been called the ‘linguistic turn’ that began in the 1960s. Thomas Kuhn’s famous *Structure of Scientific Revolutions* acted as the catalyst for a reexamination of scientific practice under the lens of the philosophy of language.⁴ Wittgenstein’s language games, the Duhem–Quine thesis, and indeterminacy of translation became part of the theoretical armature brought to bear in understanding science. Historical studies began to show the diachronic validity of these approaches. The great debates between sociologists and philosophers of the late 1970s often used history as ammunition, leading to a number of pioneering historical studies.⁵ Discourse analysis also made a subtle but lasting impact, followed by examinations of the communicative aspect of the public sphere. Even more recently, scholars working on colonialism have pointed out how science has itself been used as a hegemonic tool, a way to enforce colonial power through the lure of modernity.⁶ Language, it would seem, is at the centre of all these developments.

Another relevant line of inquiry that has been especially fruitful is the one known, somewhat nominalistically, as the rhetoric of science. For the purposes of this introduction, by rhetoric of science we mean scholarship that aims to study the literary forms and textual strategies produced by scientific communities, especially the role of texts in creating knowledge, the oratorical techniques used in the public sphere by scientists, and the role played by scientific utterances within different contexts. The most exemplary of the field's historical studies have focused either on pivotal, contentious events such as the Scientific Revolution, or on emblematic spaces and scientists, such as Charles Darwin or Louis Pasteur.⁷ In all such cases, the use of language – in the general sense of discourse, as opposed to a discussion of the choice of specific 'national' or 'ethnic' languages – takes centre stage.

Finally, the last decades have witnessed the emergence of Science and Literature as a distinct area of study. What began as a reexamination of the famous 'Two cultures' thesis proposed by C.P. Snow has now evolved to a vibrant field that attracts scholars from various disciplines.⁸ There are societies, journals, conferences, and book-series devoted to this theme, and the scope of relevant scholarship only increases with time. Historical studies are, if not the majority, then the most significant plurality within the Science and Literature scholarship.⁹ Is the vitality of the Science and Literature field then another sign that language already has its 'paladins' within history of science and needs no other?

Although scholars are indebted to each of these schools of study, something has been overlooked in the intense attention to the activity of language in the general sense, clearly inspired by Ferdinand de Saussure's structuralism. It is almost as though historians of science have attempted to address the hard case (the philosophy of language) before addressing the more straightforward cases of language choice in specific contexts (sociolinguistics).¹⁰ This collection of papers highlights this second domain for particular inquiry. Given that the dynamics of language choice across the global history of science is obviously too large a topic to explore in a single collection, the focus of this set of papers will be on four case studies from nineteenth-century Europe. That restriction is made for a number of reasons. First, the nineteenth century was the moment of professionalization in the sciences, and a strong case can be made that language choice became particularly salient then. Furthermore, the historiography on European science in the nineteenth century has achieved a density and richness of texture that the benefits of the addition of a linguistic focus will be clearer against this background. And, finally, Europe happens to be a relatively small region with well-articulated linguistic diversity – especially in the form of 'standard languages' – by the nineteenth century. Therefore, this is a fruitful starting point for further development of this historiographical direction.

The current project evolves within the historiographical specificity of scientific languages in nineteenth-century Europe. This spatial and temporal restriction will be explored by focusing on a number of themes that also introduce the stakes of the question. These are nation-building, patterns of scientific publication, and the transnational circulation of people and ideas. Of course, it is obvious that these are not independent considerations but facets of the same phenomenon. For example, publishing was circulation in action (in both the local and the international sense), just as nation-building depended on the existence of publishing houses and the emergence of a public sphere.

Scientific identity and authority were contingent on publishing activity and credentials that were often acquired 'abroad'. Yet, in the general literature on European history and also to some degree on the history of science these themes have typically been treated separately and for analytic clarity that practice is continued here. We hope that this collection makes evident the utility of using language as a framework to organize and interconnect all three themes.

Building nations

No account of European history in the nineteenth century can avoid reckoning with the power of nationalism, both as an ideology generating perceived affinities among groups of individuals and as a principle for organizing polities.¹¹ The relevance of nation-building processes in the sciences has been notable both within Europe and outside of it, especially in the process of decolonization, and it immediately brings to light important tensions between the transnational rhetoric and ideology of science as a body of knowledge and the intensely particular and nationalistic institutions through which scientists are organized and their work is funded. In this, 'national' languages share an affinity with 'national' sciences; none of the languages in question for scientific communication are entirely contained within the borders of any single state – indeed, transnational communication requires some degree of bilingualism – yet languages are intimately connected with conceptions of national belonging. It is this affinity that we explore here.

Historians of science have been equally adept at exploring the nuances of individual cases, focusing on how the superstructure of ideological invocations of nationhood and the base of social transformation of institutions interact with the epistemological aspects of scientific research. In the same vein, the way that sciences contribute to the emergence of a national identity and to the establishment and perpetuation of a well-defined state has also received scrutiny in recent years.¹² The emphasis here on nineteenth-century Europe is designed not so as to restrict attention to classic cases of nation-state formation (typically on the model of France or Germany), but rather also to point to the significance of debates over nationalist frameworks in multinational empires to the East (Russian, Habsburg and Ottoman) and decolonizing states (such as Greece and Bulgaria). The diversity of political formations indicates that a straightforward generalization along that axis is likely to remain elusive, but language provides a way to point to commonalities in the nation-building process in the sciences.

There are many ways for a group to construct an 'imagined community': a common geography (as in Switzerland); a perceived common ethnos (the norm in Central and Eastern Europe); a shared history (Ireland and Poland); and/or a shared language. In the case of the Czechs, for example, in the absence of political autonomy or even shared geography or history – given the ubiquitous presence of self-identified Germans in what were historically named the 'Czech Crown Lands' – the Czech language came to assume outsized importance in the process of creating a national identity. Theatre, poetry, national literature: this was the stuff of building a nation fit to break off from Austria-Hungary.¹³ Across Europe in the nineteenth century, intellectuals furiously worked to craft what linguists term 'standard languages': grammatically and orthographically regular idioms that served to standardize communication across dialectical zones within a

perceived imagined community. In France, this was done by a national academy; in many other countries, the task was the product of the educational system and the publishing industry.¹⁴

Education was thus the field *par excellence* where language, nation-building and science have often come together. The nineteenth century especially was an era of major educational upheavals and reforms all over Europe. State controlled public school systems, secondary education and the modern university are only some of the institutions that appeared during this period. Education was also fiercely and publicly debated in almost all European states, and was seen as the key for a variety of national goals and aims.¹⁵ It is thus surprising how often the influence of education on scientific practice has been historically marginalized.¹⁶ Scientists by the end of the nineteenth century were seen as highly trained specialists and a panoply of institutional and vocational practices emerged to enable the awarding of such credentials. Most scholarship has focused on what today is called higher education, such as universities, polytechnic schools and Écoles.¹⁷ However, secondary education was also important, both as a vocational outlet and as the main venue through which science reached a general public.¹⁸ Assumptions about language choice were vital in both establishing and maintaining the disciplinary apparatus of modern science.

Educational demands also guided the emergence of a number of scientific artefacts. Textbooks arose from pedagogical practices but shaped decisively the disciplinary contours of the sciences they were meant to describe. Textbooks time and again have proved to be not passive vehicles for the propagation of science, but rather potent objects that restructure scientific practice.¹⁹ Scientific instruments would be another case in point. In the antebellum USA, for example, the need for scientific instruments in the classroom led to the establishment of native communities of instrument makers, which in turn facilitated the creation of college and university laboratories.²⁰ It appears that in many cases, linguistic endeavours acted as the blueprints for scientific activities. It is well-established that the research seminars that gave the research university its name first appeared in philological circles in Halle. German scientists initially adopted them for their own purposes and they then became a hallmark of the scientific ethos worldwide.²¹ In the same vein, the norms of scientific education borrowed heavily from language pedagogy. Friedrich Bessel worked in close cooperation with the pedagogue Johann Friedrich Herbart in Königsberg in order to develop a new way of teaching physics. Herbartian pedagogy went on to conquer the Western world, while many of the educational innovations this collaboration induced – such as framing textbook problems to be solved by students – became staples of science education for decades to come.²² Much like the generalized process of nation-building, therefore, the specific example of educational transformation drew heavily on changes within publishing in individual contexts.

Publishing

The proliferation of detailed studies on the dynamics of scientific publication has been one of the most striking developments in the historiography of nineteenth-century European science. The landscape of publication was different in every national or regional context, often exhibiting strongly local features – it mattered that an individual

was published by *that* press in *this* city, for example, rather than the one in the neighbouring metropolis to the south. To highlight the relationship with language, therefore, it is necessary to be specific, and so the focus here will be on only one national context to illustrate the scope of the question, albeit the particular context that has been driving much of the recent scholarship.²³

The national context referred to is, of course, Victorian Britain. It will suffice to point to three domains of the current historiography. First, consider the vibrant debates about science recounted in James Secord's *Victorian Sensation*, which blossomed among monographs, review journals, the popular press and the reading public.²⁴ The remarkable achievement of that study – perhaps unreplicable, given the almost unparalleled wealth of sources about individuals' reading practices of the era – was how a particular book, Robert Chambers's *Vestiges of the Natural History of Creation*, was appropriated by different communities. All those communities, it goes (literally) without saying, were readers of the English language, an attribute that characterized the majority but certainly not all the denizens of the British Isles in the mid-nineteenth century. (The speakers of Cornish were long gone, but Welsh, Scots-Gaelic, Irish, and other tongues were in good evidence, alongside émigré communities who took advantage of Britain's liberal publication laws.) By taking such a wider view on top of Secord's already exhaustive approach, we see even within a particular national community the heterogeneity of networks that come from engagement with a particular source base framed by one particular language.

Research publication in the sciences almost always compresses to a small set of dominant languages, as has been extensively documented by the sociological literature cited earlier, and in the rise of scientific journals (to invoke a second, and growing, area of the scholarly historiography) the dominance of English as the currency of naturalist communication within Britain is obvious.²⁵ Most North American scientists could engage this material as it stood, but Continental readers often had to peruse the publications of these journals either through the original language (of which many were capable) or by following particular articles as they were picked up and transmitted through the surprisingly efficient translation system elaborated by scientific journals across Europe, as described by Christoph Meinel.²⁶

In such a fashion, English, French, and German came to dominate elite scientific communication, but popularization may very well tell a different story. Bernard Lightman has recently published an extensive study of the Victorian popularizers who wrote in English, further opening up the question of scientific communication to a broader body of readers.²⁷ In multilingual nations on the continent, however, such as Austria-Hungary, more scholarship is needed that explores the process of popularization into other languages, such as Hungarian, Czech, Yiddish, Romanian, and Polish, let alone attempts to develop research publications in those languages.²⁸

The problems of developing a publishing culture were ramified for languages with non-Latin scripts – as with Russian, Ottoman Turkish, or Greek – for in those instances it was simply not possible to import typefaces from abroad. Even that way of framing the issue oversimplifies the historical developments, as can be observed in the case of Greek printing. Greek publishing began before there was a Greek state, in rich and prosperous Greek-speaking communities all across Europe. During the eighteenth century, Venice

and Vienna, not Athens, Thessaloniki, or Syros, were the main publishing sites for Greek textbooks of natural philosophy. This was not a case of scientific publishing starting 'abroad': Greek populations existed within and outside the Ottoman Empire, and the Greek-speaking scholars in both cases were equally eager to craft the new national identity that was coming into being. Vienna, for Greek scholars, was no more 'abroad' than Syros. From the 'internationally national' Greek publishing of the eighteenth century, a local publishing industry arose during the nineteenth century within the rapidly consolidating Greek state, drawing scholars' attention to transnational circulation and the negotiation of scientific practice. Thus, language, science and circulation seem to be, at least in some cases, inexorably intertwined.

Cosmopolitanism and scientific identity

Recent historiography of science has taken a markedly global and spatial turn. A number of ground-breaking studies have shown that scientific practice was decisively affected by its location and that theories, artefacts and tacit skills did not circulate unproblematically among spaces. Ideas were brokered, networks emerged, and actors negotiated and redefined their roles across disciplines and boundaries. Historians are beginning to bring to light whole scientific traditions previously dismissed as marginal and their innovative focus on processes of circulation unravels how tentative notions of scientific peripheries and centres really are.²⁹

And yet once more, the role of language is so ubiquitous that it fades into its own shadow. Networks of scientific exchange emerged when actors communicated and thrived exactly because a common linguistic base had been established. Problems of translation and interpretation are not only philosophical considerations but actual historical events: the collection of specimens, the consolidation of data and the conglomeration of nomenclature presuppose linguistic interactions at their most basic level. The same held true for scientists themselves: before science became global, scientists had to become cosmopolitan.³⁰ The most visible form of this cosmopolitanism was the vigorous translation of scientific texts both within Europe (as alluded to earlier) and between Europe and colonial and imperial outposts, which has been the subject of interesting recent scholarship. In translation, language choice reflected not so much abrupt nineteenth-century transformations but rather a continuous problem of transfer of scientific language that stretched back to antiquity.³¹

Cosmopolitanism entails border crossing by definition. During the nineteenth century – and it could be argued before and after as well – scientists crossed borders in many ways. They went abroad to study, they formed networks with their peers and they came together in scientific congresses. Each of those practices decisively established a scientific ethos. At the same time, each of these practices contained a linguistic act as a basic component. Knowledge of a specific language by scientists defined reciprocally not only the nature of their audiences, but also where they would study and what literature they would have access to. Current historiography has gone to great lengths to show how science was a locally negotiated phenomenon. Language and its multifaceted use was the interface where the local became transnational. In many cases, linguistic hegemony facilitated scientific hegemony. An example would be French science textbooks, which

were in wide circulation long after French science ostensibly declined, as the case of Ganot's Physics textbook clearly shows.³² Accordingly, multilingualism was a way for a variety of often invisible actors to appear in scientific practice, women being a prime example. (Madame Lavoisier's translation of English and Italian chemical works for her husband would be a case in point.)³³

Talking about language during the nineteenth century

Even under such strict spatial and temporal restrictions, the current collection of papers necessarily leaves many very significant cases out. Nineteenth-century Europe, whether culturally or geographically defined, was a tumultuous, diverse space. Thus, we could not hope to cover all possible linguistic and scientific communities. Instead, we chose to address two of the most common scientific languages of the era, German and English, as well as two linguistic communities that did not have a Latin-derived genealogy, Russian and Greek.³⁴ Perceptive readers will note how such a linguistic division also echoes several other historiographical dichotomies: East–West; Centre–Periphery; and Developed–Developing. This underscores the significance of adopting this approach as a point of analysis.

Denise Phillips' paper sets the tone of this collection by looking deeper into the meaning of the supposedly 'untranslatable' word *Wissenschaft* and its differences from 'science'. By asking why and how specific concepts became markers of national identity, she describes how a polemical critique of Francis Bacon by Justus Liebig in the 1860s incited a furious debate over the relationship between German and English science. Phillips carefully disentangles the negotiation of Bacon among several groups of German scientists and, in the process, describes how different terms were applied to distinguish epistemological, cultural and institutional perspectives. In the end, as she succinctly puts it,

when we leave *Wissenschaft* in German, thus reminding ourselves that it does not mean "science" in our contemporary sense, it is also worth remembering that "science" often did not mean "science" in nineteenth-century English either. In their broad understanding of the term, nineteenth-century German intellectuals were in fact not that peculiar.

Kostas Tampakis' paper turns to the linguistic activities of the Greek scientific community from the 1830s to the dawn of the twentieth century. By showing the intricate intertwining of nation and identity that accompanied the Greek 'language question' during the nineteenth century, Kostas Tampakis' paper argues that Greek scientists used linguistic strategies to define a public role for themselves and for the scientific disciplines in general. Moreover, Greek scientists regularly became embroiled in debates around matters of language and its use within their own disciplines. Thus, language comes across not as a passive vehicle of communication, but rather as an integral component of a Greek scientific *modus operandi*.

In his paper, Bernard Lightman tackles a well-known story from an unusual angle. He considers the linguistic considerations of famous British naturalists like Charles Darwin and Thomas Henry Huxley and the physicist John Tyndall not in the sense of metaphor,

but in terms of concrete decisions about language choice. Lightman's paper systematically traces the engagement of these men in introduction, use and translation of vital evolutionary terms across a plethora of publishing and narrative activities. This work happened in both directions: first, Huxley and Tyndall engaged extensively in translating foreign scientific works into English, as a step in a reform programme to revitalize British science; then, once they were established, they took just as much care in selecting translators who would render their latest work into other tongues. Especially given the general apathy towards works in foreign languages by today's Anglophone scientists, the highlighting of Huxley and Tyndall's intense concern with linguistic transfer helps displace unstated historiographical assumptions. By focusing on the use of language and translation, Lightman argues, not only new dimensions are added to well-known scientific stories, but new actors, such as female translators and laboratory assistants, come to the fore.

Finally, Michael Gordin narrates in his paper the creation of a chemical nomenclature in Russian, in the wake of the Lavoisierian transformation of inorganic chemistry. He shows how in nineteenth-century Russia, while French was often the language of the elite, German frequently took centre stage as the language of science, at least in chemistry. Professors lamented the poor linguistic skills of their students (and themselves) and saw the deficit as a central impediment to being a good scientist. Vice versa, Russian chemists embarked on their own nomenclature in tandem with their Western peers. At each stage, the central issue of standardization (of nomenclature) and resistance to standardization (in living languages in general) come up, both for the historical actors and for the historian attempting to reconstruct their concerns.

Conclusion

In the beginning of this introduction, we stated that this collection of papers represents an attempt to see how languages, as skills and as lived practices, have shaped the scientific messages they have been used to carry. It is obvious that most of the possible research directions such a question entails have neither been identified nor answered. But we hope that this special issue persuades the reader that they cannot remain bracketed. Scientists during the nineteenth century stated in no uncertain terms that their role as language actors was crucial to how they approached the scientific enterprise and its paraphernalia. In letters and speeches, in articles and textbooks, scientists from the Thames to the Volga and from the Aegean to the North Sea were preoccupied with which languages to learn, from which languages to translate and how to accurately describe what they were doing in their own native language and in those of others. Furthermore, linguistic communities within the sciences transcended national borders and national communities, while serving as a strong element in defining those very borders and communities. Greek and Russian scientists alike argued using German and French, even as they worked vigorously to create a national scientific nomenclature appropriate for the new era. Greek and English scientists appropriated from poetry and literature the norms that would help redefine their own practice within the ideologically laden atmosphere of the nineteenth century. In all these examples, vividly described in the papers of this volume, language was not something used unthinkingly, passively, but something actively

harnessed and deployed. It remains to be seen what could be discovered, redefined or realized if the language(s) of scientists are studied across larger spatial and temporal contexts.

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Notes

1. For science as communication, see James Secord, 'Knowledge in transit', *Isis*, 95, 2004, pp. 654–72. The scholarship on circulation and scientific practice is vast. A good start would be Kapil Raj, 'Beyond postcolonialism ... and postpositivism: Circulation and the global history of science', *Isis*, 104, 2013, pp. 337–47; Lissa Roberts, 'Situating science in global history: Local exchanges and networks of circulation', *Itinerario* 33, 2009, pp. 9–30; and Sujit Sivasundaram, 'Sciences and the global: On methods, questions, and theory', *Isis*, 101, 2010, pp. 146–58.
2. A subset of this latter category includes debates about the adoption of linguistic sources for particular nomenclatures. Linnean taxonomy is based on Latin, for example, but when invoking *Drosophila melanogaster*, a name is usually used as a noun within English, or French, or Japanese. That is, it is a loan-word of Latin origin. The choice of origin languages for loan-words is, it stands to reason, not neutral, and the privileging of Latin over Caribbean languages is explored in Londa Schiebinger, *Plants and Empire: Colonial Bioprospecting in the Atlantic World* (Cambridge, MA: Harvard University Press, 2004), chapter 5.
3. See, for example, Denise Phillips, *Acolytes of Nature: Defining Natural Science in Germany, 1770–1850* (Chicago, IL: University of Chicago Press, 2012); and Sydney Ross, 'Scientist: The story of a word', *Annals of Science*, 18(2), 1962, pp. 65–85.
4. Thomas S. Kuhn, *Structure of Scientific Revolutions*. 2nd ed. (Chicago, IL: University of Chicago Press, 1968).
5. A polemical but detailed description can be found in John Zammito, *A Nice Derangement of Epistemes: Post-Positivism in the Study of Science from Quine to Latour* (Chicago, IL: University of Chicago Press, 2004). A straightforward historical analysis of the language of chemistry can be found in Maurice P. Crosland, *Historical Studies in the Language of Chemistry* (Cambridge, MA: Harvard University Press, 1962). Seminal historical works which utilize linguistic concepts are Mario Biagioli, *Galileo, Courtier: The Practice of Science in the Culture of Absolutism* (Chicago, IL: University of Chicago Press, 1993) and Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago, IL: University of Chicago Press, 1997).
6. A discussion of the importance of discourse for scientific practice can be found in Jan Golinski, 'Language, discourse and science', in G.N. Cantor, J.R.R. Christie, M.J.S. Hodge, and R.C. Olby (eds), *Companion to the History of Modern Science* (London/New York: Routledge, 1996), pp. 110–21. For the relation between science, reason and colonialism, see Sandra Harding (ed.), *The Postcolonial Science and Technology Studies Reader* (Durham, NC: Duke University Press, 2011); and Gyan Prakash, *Another Reason: Science and the Imagination of*

- Modern India* (Princeton, NJ: Princeton University Press, 1999).
7. Important studies along these lines can be found in Peter Dear (ed.), *The Literary Structure of Scientific Argument: Historical Studies* (Philadelphia, PA: University of Pennsylvania Press, 1991); Richard Harris (ed.), *Landmark Essays on Rhetoric of Science: Case Studies* (Mahwah NJ: Hermagoras Press, 1997); Marcelo Pera and William R. Shea (eds), *Persuading Science: The Art of Scientific Rhetoric* (Canton, MA: Science History Publications, 1991); and Allan Gross, *Starring the Text: The Place of Rhetoric in Science Studies* (Carbondale, IL: Southern Illinois University Press, 2006). Archetypal historical studies are also Bruno Latour, trans. Alan Sheridan and John Law, *The Pasteurization of France* (Cambridge, MA: Harvard University Press, 1988); Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, NJ: Princeton University Press, 1985); and David Livingstone, *Dealing with Darwin: Place, Politics, and Rhetoric in Religious Engagements with Evolution* (Baltimore, MD: Johns Hopkins University Press, 2014).
 8. See Charles P. Snow, *The Two Cultures and the Scientific Revolution* (Cambridge, UK: Cambridge University Press, 1960). For an overview of the field see Gillian Beer, 'Science and literature', in G.N. Cantor, J.R.R. Christie, M.J.S. Hodge and R.C. Olby (eds), *Companion to the History of Modern Science* (London/New York: Routledge, 1996), pp. 783–98; and Bruce Clarke and Manuela Rossini (eds), *The Routledge Companion to Literature and Science* (London/New York: Routledge, 2010).
 9. Some notable examples are Marjorie Nicolson, *Newton Demands the Muse: Newton's Opticks and the Eighteenth Century Poets* (Princeton, NJ: Princeton University Press, 1966); Laura Otis, *Literature and Science in the Nineteenth Century: An Anthology* (Oxford: Oxford University Press, 2009); and Adelene Buckland, *Novel Science: Fiction and the Invention of Nineteenth-Century Geology* (Chicago, IL: University of Chicago Press, 2013).
 10. As in, for example, Ulrich Ammon (ed.), *The Dominance of English as a Language of Science* (Hawthorne, NY: Mouton de Gruyter, 2001); and Michael D. Gordin, *Scientific Babel: How Science Was Done Before and After Global English* (Chicago, IL: University of Chicago Press, 2015).
 11. The significance of the topic makes the literature equally copious. For a classic account and a more recent intervention, see Benedict R. Anderson, *Imagined Communities: Reflections on the Origins and Spread of Nationalism* (London: Verso, 1983); and Anthony D. Smith, *Nationalism: Theory, Ideology, History*. 2nd ed. (Cambridge: Polity Press, 2010).
 12. See, for example, Ann Johnson and Carol Harrison (eds), *National Identity: The Role of Science and Technology, Osiris 24* (Chicago, IL: University of Chicago Press, 2009); Suzanne Zeller, *Inventing Canada: Early Victorian Science and the Idea of a Transcontinental Nation* (Toronto, ON: University of Toronto Press, 1987); Mitchell Ash and Jan Surman (eds), *The Nationalization of Scientific Knowledge in the Habsburg Empire, 1848–1918* (New York, NY: Palgrave Macmillan, 2012); and Robert Fox, *The Savant and the State: Science and Cultural Politics in Nineteenth-Century France* (Baltimore, MD: John Hopkins University Press, 2012).
 13. Peter Bugge, *Czech Nation-Building, National Self-Perception and Politics 1780–1914* (PhD dissertation, University of Aarhus, 1994).
 14. Matthias Hüning, Ulrike Vogel, and Olivier Moliner (eds), *Standard Languages and Multilingualism in European History* (Amsterdam: John Benjamins, 2012); and W. Haas (ed.), *Standard Languages: Spoken and Written* (Manchester: Manchester University Press, 1982).
 15. For a general overview, see James Bowen, *A History of Western Education: The Modern West* (New York: Methuen and Co, 1981); Andy Green, *Education and State Formation: Europe, East Asia and the USA* (London: Palgrave Macmillan, 2013); and Andy Green, *Education and State Formation: The Rise of Education Systems in England, France and the U.S.A.* (New York, NY: St Martin's Press, 1990).

16. A seminal study is Owen Hannaway, *The Chemist and the Word: The Didactic Origins of Chemistry* (Baltimore, MD: Johns Hopkins Press, 1975). A novel approach is that of Andrew Warwick and David Kaiser, 'Conclusion: Kuhn, Foucault, and the power of pedagogy', in David Kaiser (ed.), *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA: MIT Press, 2005), pp. 393–409; and Suman Seth, *Crafting the Quantum: Arnold Sommerfeld and the Practice of Theory, 1890–1926* (Cambridge, MA: MIT Press, 2010). An overview of the history of science education is John Rudolph, 'Historical writing on science education: a view of the landscape', *Studies in Science Education*, 44(1), 2008, pp. 63–82.
17. See, for example, William Brock, 'Breeding chemists in Giessen', *Ambix*, 50(1), 2003, pp. 25–70; William Clark, *Academic Charisma and the Origins of the Research University* (Chicago, IL: University of Chicago Press, 2007); Viktor Karady, 'Educational qualifications and university careers in science in nineteenth century France', in R. Fox and G. Weisz (eds), *The Organization of Science and Technology in France 1808–1914* (Cambridge: Cambridge University Press, 1980), pp. 95–104; and Andrew Warwick, *Masters of Theory: Cambridge and the Rise of Mathematical Physics* (Chicago, IL: University of Chicago Press, 2003).
18. See Peter Lundgreen, 'Education for the science based industrial science? The case for nineteenth century Germany', *History of Education*, 13, 1984, pp. 59–67; Kathryn Olesko, 'Physics instruction in Prussian secondary schools before 1859', *Osiris*, 5, 1989, pp. 94–120; and Kathryn Olesko, 'Tacit knowledge and school formation', *Osiris*, 8, 1993, pp. 16–29. For a comparative view see Kostas Tampakis, 'The unrecognized mechanism: History of science education in the 19th century', *Almagest*, 2(2), 2011, pp. 80–101. Especially for Greece, see Kostas Tampakis, 'Science education and the emergence of the specialized scientist in nineteenth century Greece', *Science & Education*, 22(4), 2013, pp. 789–805.
19. For textbooks and their influence see, for example, Antonio Garcia-Belmar, José Ramon Bertomeu and Bernadette Bensaude-Vincent, 'The power of didactic writing: French chemistry textbooks of the nineteenth century', in David Kaiser (ed.), *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA: MIT Press, 2005), pp. 219–51; Anders Lundgren and Bernadette Bensaude-Vincent (eds), *Communicating Chemistry: Textbooks and Their Audiences* (Canton, MA: Science History Publications, 2000); and Kostas Tampakis and Constantin Skordoulis, 'The many faces of textbooks: Science, education and science education in the early Greek state (1838–1931)', *Archives Internationales d'Histoire des Sciences*, 60(164), 2010, pp. 93–116.
20. Deborah Warner, 'Commodities for the classroom: Apparatus for science and education in Antebellum America', *Annals of Science*, 45(4), 1988, pp. 387–397.
21. William Clark, 'On the dialectical origins of the research seminar', *History of Science*, 27(76), 1989, pp. 111–154.
22. See, for example, Kathryn Olesko, *Physics as a Calling: Discipline and Practice in the Königsberg Seminar for Physics* (Ithaca, New York: Cornell University Press, 1991), pp. 25–43.
23. There is, of course, a debate of longer standing concerning print and science that focuses on the early modern period, which forms the background for much of this scholarship on the nineteenth century. Although those studies critically engage with the force of written and spoken language in shaping scientific developments, the issue of language choice is secondary to their arguments. For contrasting views, see Elizabeth Eisenstein, *The Printing Press as Agent of Change* (Cambridge: Cambridge University Press, 1982); and Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, IL: University of Chicago Press, 1998).
24. James Secord, *Victorian Sensation: The Extraordinary Publication, Reception, and Secret Authorship of Vestiges of the Natural History of Creation* (Chicago, IL: University of Chicago Press, 2003).
25. See, for example, Melinda Baldwin, *Making Nature: The History of the Scientific Journal* (Chicago, IL: University of Chicago Press, 2015). See also the account of the *Chemical*

- News in W.H. Brock, *William Crookes (1832–1919) and the Commercialization of Science* (Aldershot: Ashgate, 2008).
26. Christoph Meinel, 'Die wissenschaftliche Fachzeitschrift: Struktur- und Funktionswandel eines Kommunikationsmediums', in Christoph Meinel (ed.), *Fachschritftum, Bibliothek und Naturwissenschaft im 19. und 20. Jahrhundert* (Wiesbaden: Harrassowitz, 1997), pp. 137–55. For an English case study, see Maeve Olohan, 'Gate-keeping and localizing in scientific translation publishing: The case of Richard Taylor and scientific memoirs', *British Journal for the History of Science* 47, 2014, pp. 433–50.
 27. Bernard Lightman, *Victorian Popularizers of Science: Designing Nature for New Audiences* (Chicago, IL: University of Chicago Press, 2009).
 28. See, for example, Jan Surman, 'Science and its publics: Internationality and national languages in Central Europe', in Mitchell G. Ash and Jan Surman (eds), *The Nationalization of Scientific Knowledge in the Habsburg Empire, 1848–1918* (Basingstoke: Palgrave Macmillan, 2012), pp. 30–56
 29. Simon Schaffer, Lissa Roberts, Kapil Raj and James Delbourgo (eds), *The Brokered World: Go-Betweens and Global Intelligence, 1770–1820* (Sagamore Beach, MA: Science History Publications, 2009).
 30. A vigorous discussion on the role of cosmopolitanism in science and its association with language has appeared in recent years. For a discussion of language and cosmopolitanism in the case of Sanskrit, see Sheldon Pollock, *The Language of the Gods in the World of Men: Sanskrit, Culture, and Power in Premodern India* (Berkeley, CA: University of California Press, 2006). An argument influenced by postcolonial studies is given in Arun Bara, *The Dialogue of Civilizations in the Birth of Modern Science* (New York: Palgrave Macmillan, 2006). Finally, an attempt at a more precise treatment of the term cosmopolitanism can be found in Ken Alder, 'Scientific Conventions: International assemblies and technical standards from the republic of letters to global science', in Mario Biagoli and Jessica Riskin (eds), *Nature Engaged: Science in Practice from the Renaissance to the Present* (New York: Palgrave Macmillan, 2012), pp. 19–40.
 31. For the former point, see Marwa Elshakry, *Reading Darwin in Arabic, 1860–1950* (Chicago, IL: University of Chicago Press, 2013); for the latter, see Scott L. Montgomery, *Science in Translation: Movements of Knowledge Through Cultures and Time* (Chicago, IL: University of Chicago Press, 2000).
 32. Josep Simon, *Communicating Physics: The Production, Circulation and Appropriation of Ganot's Textbooks in France and England, 1851–1887* (London: Pickering and Chatto, 2011).
 33. Jean-Pierre Poirier, *Lavoisier: Chemist, Biologist, Economist*, trans. by Rebecca Balinski (Philadelphia, PA: University of Pennsylvania Press, 1998); and Marco Beretta, 'Italian translations of the *Méthode de nomenclature chimique* and the *Traité élémentaire de chimie*: The case of Vincenzo Dandolo', in Bernadette Bensaude-Vincent and Ferdinando Abbri (eds), *Lavoisier in European Context: Negotiating a New Language for Chemistry* (Canton, MA: Science History Publications, 1995), pp. 225–47.
 34. Obviously missing from this collection is French. As it happens, the political and scientific importance of the French language has been the most well studied from the point of view of language choice – the framework here – and therefore there is other scholarship to turn to for comparison. Regarding the dominance of French in the eighteenth century (in general, not only in science), from which point it seemed to enter a gradual decline vis-à-vis especially English and German, see Marc Fumaroli, *When the World Spoke French*, trans. by Richard Howard (New York: New York Review of Books Publications, 2011). For later developments, see David C. Gordon, *The French Language and National Identity (1930–1975)* (The Hague: De Gruyter, 1978). For a variety of perspectives on French as a language of science, see Conseil de la langue française, Gouvernement du Québec, *Le français et les langues scientifiques de demain: Actes du colloque tenu à l'Université du Québec à Montréal du 19 au 21 mars 1996* (Quebec: Government of Quebec, 1996).