Chapter 5

Circumventing the 'Elusive Quarries' of Popular Science: The Communication and Appropriation of Ganot's Physics in Nineteenth-Century Britain

Josep Simon[1]

Adolphe Ganot (1804–87) published two physics textbooks in Paris that went into a large number of successive editions in France and other countries through translation into Spanish, English and other languages. During the second half of the nineteenth century, these made a decisive contribution to physics and its teaching on an international scale.[2] Ganot's motivations as an author and publisher were driven by his position as a teacher preparing mainly medical students for the *baccalauréat-ès-sciences* examination and his earlier involvement in courses for artisans organized by the Association Philotechnique.

His books were often characterized as 'popular', and Ganot certainly had an educational and social agenda as an author and teacher. But their actual readership was particularly diverse, including elite practitioners of science, booksellers, students, teachers, instrument makers, journal reviewers and compilers, theological writers and leisure readers in different countries. Their characterizations of the books were also particularly diverse and encompassed the realms of the popular, leisure and entertainment, pedagogy and research.

When confronted with this case study, one struggles to find clear answers from a general survey of secondary literature on 'science popularization'. Despite the numerous contributions to this field in recent decades, it is easy to feel that it currently suffers from a certain ontological, epistemological and methodological disorientation.[3]

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1 I am grateful to Jon Topham for fruitful discussions that helped clarify my insights and improve my conception of this paper.

2 Josep Simon, *Adolphe Ganot (1804–1887) and his textbooks of physics* (Oxford, 2004), unpublished MSc thesis, and 'La famille Baillière et l'introduction du *Traité de Physique* de Ganot en Angleterre', in Danielle Gourevitch and Jean-François Vincent (eds), *J.-B. Baillière et fils, éditeurs de médecine* (Paris, 2006).

3 See Chapter 1 by Jon Topham in this volume.

Peter Burke defined the study of popular culture as an 'elusive quarry', acknowledging the double difficulty in having to deal with past cultures that are different to our own and using indirect means and sources.[4] As argued by Jon Topham in this volume, 'science in popular culture' and 'science popularization' are intersecting subjects, which could be made part of a wider context of scholarship by conceptualising 'popularization' through a historical framework centred on 'communication'. The history of popular culture, education theory, the history of reading, the history of technology, and science communication studies are already helping to foster a move from the context of knowledge production to its context of use, and conceptualising communication as an interactive and multidirectional phenomenon.

In this sense, Roger Chartier has remarked that the pretension of defining popular culture by the distribution of objects or texts in society is misleading, as there are in fact no objects that are 'popular' *per se*. It is the way of using these products that really characterizes what is popular. Thus, we should focus on studying the ways in which these are appropriated – the different ways in which culture is actively used and given meanings by individuals.[5] In relation to texts, these are often different from the ones assigned to them by actors such as the author, the printer and the bookseller;[6] hence the relevance of studying not only the social topography of the practice of science, but also the communicative and appropriative processes shaping it.

'Appropriation' is also a useful concept for tackling the study of the international communication of knowledge,[7] a topic whose relevance has been emphasized by James Secord's historiographical proposal of bringing 'communication' to the centre of our analysis and narratives.[8] In recent decades, the major efforts pushing the historiography of science in an international direction have often fallen under the labels of studies on 'science and empire' and on 'centre and periphery'.[9] Interestingly, the models of communication traditionally used in these research areas on a macroscopic level are afflicted by the same problems as those

[4] Peter Burke, *Popular Culture in Early Modern Europe* (London, 1978).

[5] Roger Chartier, 'Culture as Appropriation: Popular Cultural Uses in Early Modern France', in S.L. Kaplan (ed.), *Understanding Popular Culture: Europe from the Middle Ages to the Nineteenth Century* (Berlin, 1984), pp. 229–53, on p. 233.

[6] Jonathan R. Topham, 'Scientific Publishing and the Reading of Science in Nineteenth-Century Britain: A Historiographical Survey and Guide to Sources', *Studies in History and Philosophy of Science*, 4/31 (2000): 559–612.

[7] K. Gavroglu, M. Patiniotis, F. Papanelopoulou, A. Simoes, A. Carneiro, M.P. Diogo, J.R. Bertomeu Sánchez, A. García Belmar and A. Nieto-Galan, 'Science and Technology in the European Periphery. Some historiographical reflections', *History of Science*, 46/2 (2008): 153–75.

[8] For more details see Chapter 1 by Jon Topham in this volume. James A. Secord, 'Knowledge in Transit', *Isis*, 95/4 (2004): 654–72.

[9] See Gavroglu, 'Science and Technology in the European Periphery'.

traditionally used – on a microscopic level – in the study of popular culture and science popularization. In this sense, Secord's proposal can certainly be useful for establishing links between the practices of science in local contexts, and those performed across national and international boundaries.

In this chapter I intend to problematize 'science popularization' through a case study analysing the 'communication' of Ganot's textbooks from France to Britain, and their 'appropriation' in the latter. Before proceeding with my case study, I will introduce my approach through my reading and appropriation of the work on the structure of society and scientific practice by Edward Shils and Ludwik Fleck, respectively, and my assessment of the centre/periphery divide as represented by the work of Joseph Ben David. I will argue that the central role that Shils and Fleck give to communication helps to clarify the processes involved in science popularization, and can be used to bring together the study of knowledge circulation in local, national and international contexts.

Focusing on the Processes: Centre and Periphery vs Communication and Appropriation

As I argue in this section, by abandoning a centre/periphery model for a focus on communication and appropriation, the study of Adolphe Ganot's textbooks makes it possible to cross the boundaries that in the history of science traditionally divide the popular, education and research, and the local, the national and the international.

In Europe and the Americas, the nineteenth century was characterized by the rise of secondary education and the introduction – on a systematic basis – of science in the secondary school and university curriculum. Concomitantly, this period was critical for the rise of nation states.[10] Furthermore, it was also the time of the constitution of distinct scientific disciplines such as physics.[11]

In this context, scientists and education administrators observed their foreign peers from their national standpoints. The rhetorical use of the virtues of the other was often used as a political strategy to gain social and professional status, and the organization of education was considered to be a critical matter in ensuring the formation of a professional community and its associate disciplinary identity.[12]

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[10] A. Anderson, 'The Idea of the Secondary School in Nineteenth-Century Europe', *Paedagogica Historica*, 40/1 and 2 (2004): 93–106; A. Green, *Education and State Formation. The Rise of Education Systems in England, France and the USA* (Basingstoke and London, 1990); E. Roldán Vera, *The British Book Trade and Spanish American Independence: Education and Knowledge Transmission in Transcontinental Perspective* (Aldershot, 2003).

[11] Iwan Rhys Morus, *When Physics Became King* (Chicago, 2005).

[12] Robert Fox and George Weisz, 'Introduction: The institutional basis of French science in the nineteenth-century', in Fox and Weisz (eds), *The Organization of Science*

By the mid-nineteenth century, reference to the serious consequences of the low status of scientific practice in England, in contrast with the virtues of the organization of scientific research and teaching in France and Germany, had a permanent position in rhetorical discourses of British scientists and educators.[13] Contemporarily, French books and periodicals had a wide readership in Britain.[14] In subjects such as physics, English schools and university colleges, teachers and students were highly dependent on French textbooks such as those by Adolphe Ganot. These books were the fruit of a mature system of scientific education developed over the previous half century. By contrast, scientific education in England only started to be instituted on a solid and general basis from the 1860s.[15]

The question of the relative scientific status of France, Britain and Germany during the nineteenth century has traditionally been tackled through the work of Joseph Ben-David.[16] His comparative study of scientific production in the aforementioned countries and the USA contributed to promoting in history of science the use of a centre/periphery model introducing biases in the national and international study of science in a historical perspective. In focusing especially on structural aspects and not giving analytical relevance to how knowledge circulates across national borders, the dynamics of Ben-David's model are rather static. Furthermore, his centre/periphery model has favoured the use of unconceptualized national boundaries and the contraction of the international dimension of our discipline.

On the other hand, in local contexts, Ben-David's use of Kuhn's concepts of 'paradigm' and 'revolution' led him to restrict the production of science to an elite

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and Technology in France, 1800–1914 (Cambridge, 1980); Agustí Nieto-Galan, 'The Images of Science in Modern Spain', in K. Gavroglu (ed.), *The Sciences in the European Periphery During the Enlightenment* (Dordrecht, Boston, London, 1999); Graeme Gooday, 'Lies, Damned Lies and Declinism: Lyon Playfair, the Paris 1867 Exhibition and the Contested Rhetorics of Scientific Education and Industrial Performance', in I. Inkster et al. (eds), *The Golden Age. Essays in British Social and Economical History, 1850–1870* (Aldershot, 2000), pp. 105–20; Rudolf Stichweh, *Zur Entstehung des modernen Systems wissenschaftlicher Disziplinen: Physik in Deutschland* (Frankfurt, 1992).

13 Gooday, 'Lies Damned Lies and Declinism'; Matthew Arnold, 'Schools and Universities on the Continent', in R.H. Super (ed.), *The Complete Prose Works of Matthew Arnold* (Ann Arbor, MI, 1964), vol. IV.

14 Josep Simon, 'The Baillières: The Franco-British Book Trade and the Transit of Knowledge', in Robert Fox and Bernard Joly (eds), *Franco-British Interactions in Science Since the Seventeenth Century* (Paris, 2008).

15 D.P. Newton, 'A French influence on nineteenth- and twentieth-century physics teaching in English secondary schools', *History of Education*, 12/3 (1983): 191–201; Robert Fox, 'The Context and Practices of Oxford Physics, 1839–77', in Robert Fox and Graeme Gooday (eds), *Physics in Oxford, 1839–1939. Laboratories, Learning and College Life* (Oxford, 2005), pp. 24–79.

16 Joseph Ben-David, *The Scientist's Role in Society: A Comparative Study* (Englewood Cliffs, 1971), pp. 1–15, 186–7; Fox and Weisz, 'Introduction'.

occupying the esoteric circle of scientific practice, and to limit its communication with other parts of society to extraordinary occasions. Hence, quantifiable research was the driving criterion in his scientific international ranking, and other practices such as education and popularization that could be alternative indicators of the relevance of science in culture and society were dismissed.

Ben-David tried to find a political compromise in the ranking arising from his analysis. Thus, the succession of France, Germany and the USA as centres could be complemented by assigning to Britain a regular second influential position and a brief emergence to the centre in the transit from French to German hegemony. As I have suggested, a somewhat different picture emerges if we focus on education, popularization and international communication. Defining historically the 'centre' and the 'periphery' is – like deciding what is the 'popular' – not a simple matter. It depends on historical perceptions of the self and the other held by scientific practitioners, on national and international historiographies, and on the forms of transnational circulation of science. Conceptualizing this historical problem involves the use of an analytical framework based on communication and appropriation.

In this sense, the work of Edward Shils and Ludwik Fleck offers interesting tools to conceptualize 'communication'. As the editor of *Minerva*, Edward Shils decisively contributed to the promotion of the centre/periphery model in the history of science through the publication of works such as that by Ben-David.[17] However, his own work focused on a centre/periphery model applied to society in a more local perspective.

Shils characterized society as structured by a centre and a periphery, not located in spatial or geographical terms but in relation to a system of symbols, values and beliefs. The centre is structured by the actions of the elites, who are beheld with authority and are responsible for propounding, pursuing and affirming the 'central value system' in society. The latter is the central zone of society not only because it is espoused by the elites, but also because of its intimate affinity to what society holds to be sacred.[18] In fact, the 'central value system' is configured through consensus. Consensus is possible both because and when individuals being part of society can successfully interact through communication, which happens in turn when a common value system is shared.[19]

[17] I am indebted to Roy MacLeod, who drew my attention to the relevance of Shils in this context through the presentation of his research in two seminars at Manchester and Leeds in 2006.

[18] Edward Shils, 'Center and Periphery', in *Center and Periphery: Essays in Macrosociology* (Chicago and London, 1975), pp. 3–16.

[19] Edward Shils, 'Society: the Idea and its Sources', in *Center and Periphery*, pp. 17–33.

Shils's macro social model shared many characteristics with the social model of scientific practice proposed by Ludwik Fleck, whose work he had read.[20] Despite the different aims and scale of their approaches, their models have a similar geometry, structuring society in concentric areas occupied by elites and ordinary citizens, respectively. They also have similar dynamics, driven by communication across these areas, and they acknowledge that there is no absolutely privileged direction in this communication.

Fleck's conceptualization of scientific practice through 'thought collectives' configuring and constrained by a 'thought style', and their subdivision into small 'esoteric circles' and large 'exoteric circles', stressed, like Shils's centre/periphery model, the transformative and multidirectional role of communication. Furthermore, it suggested that communication was a fundamental driving agent that shapes science both in local contexts and across national boundaries.[21] Thus, the boundaries that have traditionally been used to separate the elite and the laity and the local and national and the international can be challenged through a more accurate conceptualization based on the study of communication and appropriation.

In addition, Fleck offered a useful characterization of the carriers of scientific knowledge and agents of scientific communication through the definition of three major genres. According to him, a 'thought style' is represented by 'vademecum science', as the carrier of common expert knowledge and the tool binding a 'thought collective'. It is opposed to 'journal science' in that it is comprehensive and consensus-based. It differs from 'popular science' in that it is critical and organized. However, the character of the vademecum is also determined by the fact that every communicative action – including those leading to its configuration – makes knowledge more exoteric.[22] Thus, communication always transforms knowledge, and it acts towards the constitution of 'thought styles' based on social and intellectual consensus. 'Appropriation' is performed through communication, made possible and constrained by a 'central value system', or a 'thought style' and, at the same time, contributing to its configuration.

In the following sections I consider the appropriation and communication of Adolphe Ganot's textbooks and its movement between esoteric and exoteric circles in France and Britain. I will first briefly present the books and their French readers, and will discuss Ganot's own appropriations. Then, I will consider the communication of Ganot's physics in nineteenth-century Britain through six case studies analysing their appropriation by various readerships, including the publisher, the translator, the reviewer, the science teacher, the theological reader, the researcher and the instrument maker, respectively. I will expose the complexity

[20] Thomas S. Kuhn, 'Foreword', in Ludwik Fleck, *Genesis and Development of a Scientific Fact* (Chicago, 1979), pp. vii–xi.

[21] On Fleck see also Jon Topham's Chapter 1 in this volume. Fleck, *Genesis and Development*, pp. 39, 41, 51, 98–9, 105–7, 109, 112–13.

[22] Ibid., pp. 114, 124.

of defining distinct genres and labelling of scientific writing and publishing by showing that Ganot's physics can be viewed not only as 'textbook science', but also as 'popular science' and 'vademecum science'. And I will argue that the wide diversity of processes of communication and appropriation to which Ganot's textbooks were central contributed to giving them the quality of representing a thought style or a central value system defined by Franco-British communication.

The Genesis and Readers of Ganot's *Physique*

Adolphe Ganot was the author of two physics textbooks, the *Traité élémentaire de physique expérimentale et appliquée* (1851) and the *Cours de physique expérimentale à l'usage des personnes étrangères aux connaissances mathématiques* (1859). From 1850, he taught physics and directed a private school in Paris, preparing for the *baccalauréat-ès-sciences* examination controlling access to scientific, medical and engineering studies in France.[23]

As a private secondary school teacher, he was not part of the French scientific elite. However, the pedagogical practices developed in schools like his had an essential role in the configuration of French scientific education, a fact admitted by the elite.[24] Ganot's textbooks were the result of the communication and appropriation processes involving, in the context of the Parisian *Quartier Latin*, an exoteric circle composed of private teachers, printers, booksellers, journal compilers and instrument makers, and an esoteric circle formed by the French scientific elite linked to the state university administration. The pedagogical practices created by the former were subsequently appropriated by the latter, and, in parallel, Ganot's textbooks expanded their context of use by travelling from the exoteric circle of private education to the esoteric circle of state secondary education.[25] Subsequently, as we will see, they were successfully communicated to and appropriated into a larger geographical context of an international character.

In the preface to the *Traité*, Ganot stated that he had designed his book as the complement to his physics cabinet and lectures. The book's subtitle targeted students preparing for the *baccalauréat-ès-sciences*, the final year examination of the School of Medicine, and the entrance examinations for the École Polytechnique and the

[23] Bruno Belhoste, Claudette Balpe and Thierry Laporte (eds), *Les sciences dans l'enseignement secondaire français. Textes officiels* (Paris, 1995).

[24] Jean Baptiste Dumas, 'Rapport sur l'état actuel de l'enseignement scientifique dans les collèges, les écoles intermédiaires et les écoles primaires', ibid., pp. 207–23.

[25] Anon., 'Ganot et Maneuvrier: Traité Élémentaire de Physique (22e édition)', *Revue Générale des Sciences Pures et Appliquée*, 1/15 (January 1904): 746; Simon, *Adolphe Ganot*.

École de Saint-Cyr.[26] A contemporary advertisement[27] added that some parts could also appeal to readers interested in physics for other purposes. From its second edition, a more general public was targeted, including all French secondary and higher education establishments.[28] Designing potential audiences and targeting the widest set of readers was a usual task in the work of nineteenth-century publishers.[29] The *Traité* had large print runs and numbers of editions,[30] only comparable to certain pedagogical treatises, and only surpassed by almanacs, periodicals, trade catalogues or successful novels of the time.[31] Most of Ganot's school customers were students of medicine and pharmacy; only a few of them were science and engineering students.[32] However, in France the book also had readers who were not centrally defined in its subtitle, belonging both to 'esoteric' and 'exoteric' circles: practitioners of science becoming part of the elite of the Académie des Sciences such as Léon Foucault, journal editors such as the ex-Jesuit François-Napoléon-Marie Moigno, instrument designers such as Zénobe Gramme and military engineers such as Arthur-Constantin Krebs. As I will show, Ganot combined his experience as a teacher and 'journal science' reader to produce books that readers confronted not only as textbooks, but also as 'popular science' and as science vademecums.

In writing his second textbook, the *Cours*, he appropriated his first book, the *Traité*.[33] Ganot took special care to explicitly state that the *Cours* was a different book, as his interest was to widen his publishing market by targeting new audiences. However, he certainly re-read and appropriated the *Traité* in order to prepare the *Cours*.

The *Cours*'s subtitle addressed the 'gens du monde', female students involved at different levels in the higher ranks of the French primary education system, and in general, readers who were not familiar with mathematics. The first term – originally coined to designate the leisure aristocratic class – was subsequently

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26 Adolphe Ganot, *Traité Élémentaire de Physique Expérimentale et Appliquée et de Météorologie* (Paris, 1851).

27 Inserted in a copy of its first edition.

28 Ganot, *Traité* (Paris, 1853).

29 Bernardette Bensaude-Vincent, Antonio García-Belmar and José Ramón Bertomeu-Sánchez, *L'émergence d'une science des manuels: les livres de chimie en France (1789–1852)* (Paris, 2003), pp. 123–8, and James Secord, *Victorian Sensation* (Chicago, 2000), p. 53.

30 The 18th edition of the *Traité* (1880) had a print run of 20,000 copies (Archive of the House of Longman, *Atkinson File*). By then Ganot claimed to have produced 204,000 copies of the book since 1851. Ganot, *Traité* (Paris, 1880).

31 Fréderic Barbier, 'Les marchés étrangers de la librairie française', in H.J. Martin (ed.), *Histoire de l'édition française* (Paris, 1985), pp. 269–81.

32 Adolphe Ganot, *A messieurs les membres du jury de l'expropriation pour cause d'utilité publique* ... (Paris, 1856).

33 This idea was developed by Secord in relation to successive editions of a book. However, here I will concentrate on Ganot's appropriation of his first book in preparing the *Cours*. See Secord, *Victorian Sensation*, pp. 78, 385–93.

appropriated to designate those who were not constrained by a formal education course, and who could read a book or attend a lecture for leisure purposes.[34]

Ganot argued that because physics was one of the most interesting and current subjects, it should also be one of the most 'popular' and better known to the public. Unfortunately – according to him – this was not the case; not only among the laity, but also among the 'literary class'. The reasons were the expenditure required to acquire scientific instruments, and the common use in treatises of algebraic language, which constrained the communication of physics to most of the readers. This had created the misleading impression that it could only be studied by an exclusive set of people.[35] Indeed, mathematics, closely linked to the training of the French elite at the École Polytechnique, possessed the highest social prestige among the sciences. Only during the second half of the century did experimental physics progressively challenge this intellectual and social hierarchy.[36]

Thus, Ganot's *Cours* intended to make physics accessible to everyone by reducing the presence of mathematical formulae, unnecessary – in his opinion – to explain many physical phenomena, and by introducing a good number of high-quality illustrations representing experiments at the moment of their performance (being able to substitute them when instruments were not available)[37] – see Figures 5.1 and 5.2.

As for the *Traité*, the *Cours* widened in the course of its life the public targeted by its subtitle, including students of the secondary school classical curriculum.[38] Ganot's second book also had large print runs and numbers of editions, although both inferior to those of the *Traité*.[39]

According to Ganot, the *Cours* was a completely different book from the *Traité*, especially because of its illustrations and its composition.[40] Most illustrations were new, and they showed instruments being manipulated by human figures, often in domestic and social environments (see Figure 5.1). In contrast, in the *Traité*, only hands emerging from the white of the page appeared (see Figure 5.2), although some experiments were also located outside the classroom.

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[34] See Émile Littré, *Dictionnaire de la langue française* (Paris, 1863–69), and the online lexicographic corpus FRANTEXT <http://www.frantext.fr/> (accessed 21 October 2007).

[35] Advertisement inserted in Adolphe Ganot, *Cours de physique purement expérimentale, à l'usage des personnes étrangères aux connaissances mathématiques* (Paris, 1859).

[36] Claudette Fournier-Balpe, *Histoire de l'enseignement de la physique dans l'enseignement secondaire en France au XIXe siècle* (Paris, 1994).

[37] Advertisement in Ganot, *Traité* (Paris, 1859).

[38] Ganot, *Cours* (Paris, 1872).

[39] In 1881, the eighth edition of the *Cours*, the last prepared by Ganot, had a print run of 13,000 copies. According to him, since 1859, 64,500 copies of the book had been produced. Ganot, *Traité* (Paris, 1880).

[40] Ganot, *Cours* (Paris, 1859).

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d'une bobine à deux fils : l'un gros, n'ayant que 3 à 4 mètres de longueur; l'autre fin, enroulé sur le premier et d'une longueur de 500 à 600 mètres (fig. 372). Ces fils sont non-seulement recouverts de soie avec soin, mais d'un vernis à la gomme laque destiné

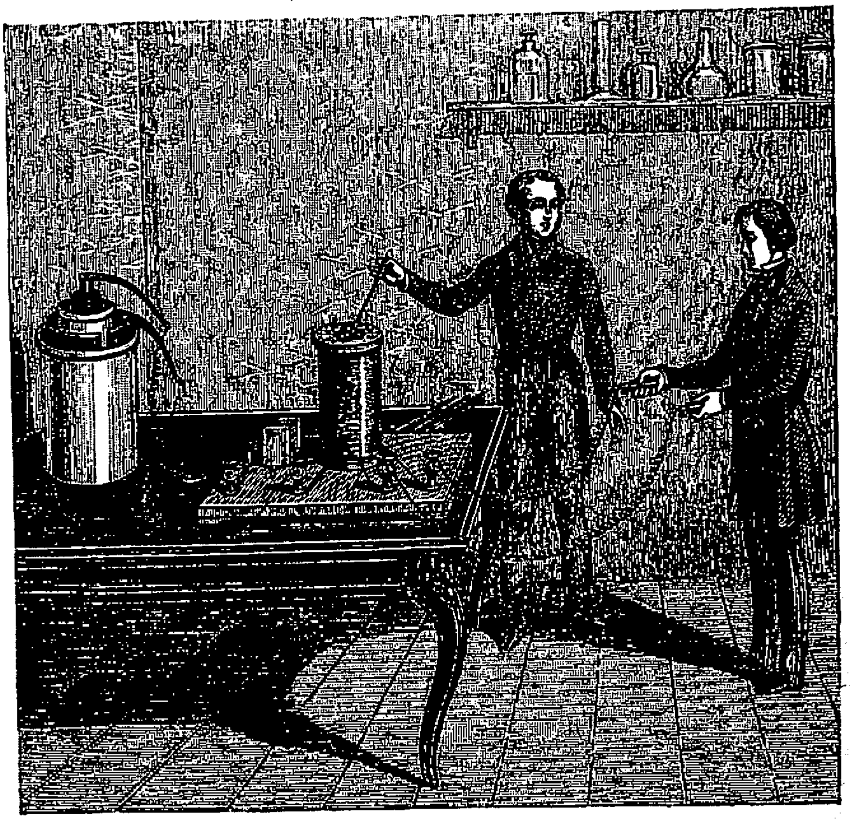

Fig. 372. — Effets physiologiques des courants d'induction.

à les isoler entre eux. Deux bornes de cuivre placées à gauche, sur la planchette qui porte la bobine, sont en communication avec les pôles d'un seul élément de Bunsen. De la borne la plus à gauche part une lame de cuivre qui se rend à une petite roue dentée, mue par un mouvement d'horlogerie, et communiquant avec l'un des bouts du gros fil de la bobine. L'autre bout du même fil se prolonge sur la planchette jusqu'à la seconde borne. Enfin, sur la droite, sont deux autres bornes auxquelles aboutissent les deux extrémités du fil fin qui recouvre le premier; et des mêmes bornes partent deux autres fils qui représentent les prolongements du fil induit. Pour avoir des commotions, on termine ces deux derniers fils par des cylindres de cuivre qu'on prend dans les mains, comme

Figure 5.1 Normal type size. The performance of the demonstration of induction by a magnet in the *Cours*: 'Men, the Body and the Senses'. Ganot, *Cours* (1859), p. 524.

Cette expérience montre que l'électricité des machines électriques peut, aussi bien que celle de la pile, donner naissance à des courants d'induction.

L'appareil de M. Matteucci sert aussi à démontrer la production des courants induits par l'influence des courants voltaïques. Pour cela, on fait passer le courant d'une pile dans le fil inducteur C, et, en même temps, on fait communiquer les deux fils *h* et *i* avec un galvanomètre. Or, on observe, au moment où le courant inducteur commence ou finit, les mêmes phénomènes qu'avec la bobine décrite ci-dessus (fig. 520), et l'aiguille du multiplicateur est d'autant plus déviée que les deux plateaux A et B sont plus voisins.

698. **Induction par les aimants.** — On a vu que l'influence

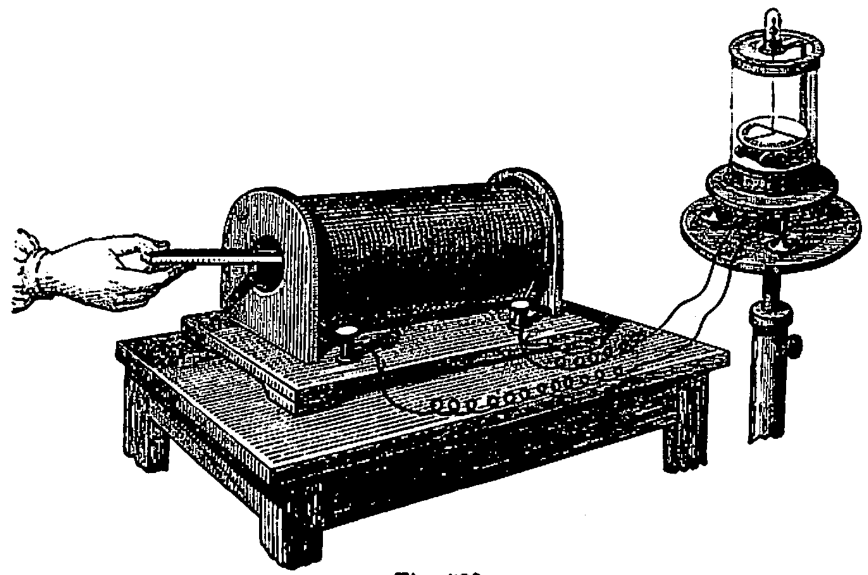

Fig. 522.

d'un courant aimante un barreau d'acier (685) ; réciproquement, un aimant peut faire naître, dans les circuits métalliques, des courants d'induction. M. Faraday l'a démontré au moyen d'une bobine à un seul fil de 200 à 300 mètres de longueur. Les deux extrémités du fil étant mises en communication avec un galvanomètre, comme le montre la figure 522, on introduit brusquement dans la bobine, qui est creuse, un fort barreau aimanté, et on observe alors les phénomènes suivants :

1° Au moment où on introduit le barreau, le galvanomètre indique, dans le fil, un courant induit instantané, inverse de celui qui existe autour du barreau, en assimilant celui-ci à un solénoïde, comme on l'a fait dans la théorie d'Ampère (684).

Figure 5.2 Normal type size. The performance of the demonstration of induction by a magnet in the *Traité*: 'The Lonely Hand, the Galvanometer and the Sight'. Ganot, *Traité* (1859), p. 691.

However, the *Cours* had fewer illustrations than the *Traité*, both absolutely and proportionally. Concerning the composition, the *Cours* used more exemplification, exclamation marks, historical anecdotes and analogies with 'ordinary language'. Instrument and experiment descriptions, the enunciation of laws and definitions, and historical introductions were shortened by limiting the number of elements introduced. Algebraic and numerical applications and the section of problems present in the *Traité* disappeared in the *Cours*. Some of the books, chapters and articles composing the former were eliminated or amalgamated in the latter.

In spite of this, both had the same basic structure and contents. In general, their illustrations described the same experiments, and one could move from the *Traité* to the *Cours* simply by adding a body to the hands of the anonymous manipulator appearing in the former, and a location background. The use of a special typographic system and its pedagogical aims were also coincident in the two books.

By 1859, Ganot had acquired experience as author and publisher in the production, marketing and use of eight editions of the *Traité*. The *Cours* was thus designed to target a different market, whose public grew due to educative reforms expanding the teaching of science in schools. These reforms were propounded by the French scientific and political elite. However, their configuration was the result of the communicative interaction between 'esoteric' and 'exoteric' circles. Ganot's redesign of his first textbook was a result of this interaction, and of his own appropriation of a work which had already played a major role in the configuration of a 'thought style', in the context of French physics education. As a result, a new book was produced, contributing in turn to reshaping this configuration.

Ganot's textbooks were translated into most European languages. Their study thus offers the opportunity to assess the processes of the international communication and appropriation of science in nineteenth-century Europe. The agents in these processes shaped and translated the books into new contexts and meanings, contributing to the configuration of a 'thought style' of an international character. The next section analyses these processes in a case study of their development in Britain, one of the countries in which the communication and appropriation of Ganot's textbooks had a longer and wider extension.

The Communication and Appropriation of Ganot's Physics in Nineteenth-Century Britain

The communication and appropriation of Ganot's physics in Britain was first developed through the agency of international booksellers and international students. The *Traité* was published in English by Hippolyte Baillière, whose family arguably built the most important nineteenth-century international network in the scientific and medical book trade. Their work contributed to defining the communication and appropriation of French science into Britain and vice versa, thus playing an important role in the configuration of a Franco-British 'thought style'.[41] Their role was shared by international students. Educative trips to France and Germany were then a common route for British medical and chemistry students.[42] Back in Britain, many of them engaged in the translation of continental books and articles for scientific journals.[43] The appropriation of foreign works involved the design of new publics, constrained by different cultural and social settings, including different disciplines and school cultures.

Edmund Atkinson (1831–1900), the English translator of Ganot's textbooks, fits into this pattern. Trained as a chemist in England, he subsequently studied in Germany and France.[44] Back in England, he contributed reviews of foreign works to the *Philosophical Magazine*, published by William Francis (who had also studied in Germany). In this context, Baillière commissioned the *Traité*'s translation from Atkinson, through recommendation of his peer, Francis.[45] His translation of Ganot's *Traité* coincided with the start of a long career as a physics teacher, translator and scientific editorial adviser.[46] At the time, only a few physics textbooks designed for high and secondary level education were available in Britain,[47] and the articulation of secondary school education on a national scale, through the organization of science examination systems, was incipient.[48] Atkinson was not a member of the English scientific elite, so he did not have direct input in the design and administration of scientific research and education in England. Initially, he conducted and published research papers as a chemist, but, subsequently, he did not publish research into physics in any specialized journal.

As indicated by James Secord, a book is not only a compilation of pages, but the sum of a wide array of representations including printing and publishing practices, reviews, advertisements, excerpts, prefaces, translations and readers' perceptions and responses.[49] This section will assess some of these representations through the study of the appropriation and communication of Ganot's books in England, and its agents.

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[41] Simon, 'The Baillières'.

[42] Adrian Desmond, *The Politics of Evolution. Morphology, and Reform in Radical London* (Chicago, 1989); Jean-Claude Caron, *Générations romantiques: les étudiants de Paris et le Quartier latin, 1814–1851* (Paris, 1991).

[43] William H. Brock and Arthur J. Meadows, *The Lamp of Learning: Two Centuries of Publishing at Taylor & Francis* (Bristol, 1998).

[44] [George Carey Foster and Hugo Müller], 'Obituary Notices', *Journal of the Chemical Society, Transactions*, 79 (1901): 888–9.

[45] Brock and Meadows, *The Lamp of Learning*, p. 197.

[46] Archive of the House of Longman, *Atkinson File*.

[47] Newton, 'A French influence'.

[48] Roy MacLeod (ed.), *Days of Judgement: Science Examinations and the Organization of Knowledge in Late Victorian England* (Driffield, 1982) and Graham Birley, *Barbarians at Play: A Case Study of Examinations in the Physical Sciences in Nineteenth Century Britain* (Wolverhampton, 1996).

[49] Secord, *Victorian Sensation*, p. 111.

The Publisher

The appropriation of the *Traité* by Baillière had important consequences for the size, format, text layout and intended audiences of the book. Hippolyte Baillière knew that Ganot's *Traité* was a successful book among medical and science students in Paris, and in 1858 he was already selling it in England.[50] Through his education and training in Paris, and his professional experience in London, he had a good knowledge of different 'thought styles' defining practices and knowledge in the book trade, science, medicine, education and reading in two different countries. For this reason, his communicative and appropriative actions played an important role in the configuration of a Franco-British 'thought style' in relation to these fields.

The first edition of the English translation was published between 1861 and 1863 as the *Elementary Treatise on Physics, Experimental and Applied*.[51] In keeping with Baillière's standard commercial practices, the *Treatise* was issued in England in monthly parts.[52] In France, the book had originally been published in only two parts, probably related to Ganot's course's length and financial strategy. Moreover, the size of the book was increased.

The *Traité* contained a typographic system using a small type size and asterisks to address different kinds of readers, and to introduce recent work that did not have the necessary consensus to be included in the main text yet (see Figure 5.3 in contrast with Figure 5.2). This system was completely eliminated in the English edition – apparently English readers did not like it[53] – having important consequences on the configuration of the book as a new product. Sections in small size type were in most cases introduced to the main text, thus acquiring an authoritative stamp that was lacking in the original.

Baillière addressed his edition to 'Colleges and Schools', a subtitle preserved in all subsequent editions. Thus, it was not deemed necessary to target a particular public preparing for specific examinations. Ganot's identification as a 'professeur' – a term used in France for any teacher in secondary and higher education (comprehended by the idea of 'université') – was transformed by Baillière into 'professor' – strictly used in Britain only to designate university positions, thus enhancing the author's authority in England. The book was used in Britain at many schools and colleges during this period, and was the standard in the preparation of a wide range of science examinations.[54]

[50] Hippolyte Baillière, *H. Baillière's Catalogue of Recent Foreign Books on Chemistry, Electricity, Physics, Meteorology, &c., &c.* (New York, 1858).

[51] The fourth edition (1870) of the book had a print run of 5,500 copies, increased in 1879 to around 7,000 in its ninth edition, which sold 4,000 copies in the first ten months. Archive of the House of Longman, *Atkinson File*.

[52] A practice usually identified as characteristic of novels and cheap literature.

[53] Anon., 'Fernet's Elementary Physics', *Nature*, 3 (November 1870): 23–4.

[54] Newton, 'A French influence'; Fox, 'The Context and Practices of Oxford Physics, 1839–77'.

14 degrés à 32, pesant 208 kilogrammes, toujours abstraction faite de la dilatation, ils absorbent une quantité de chaleur égale à 208 (32 — 14) ou 3744 unités; on a donc

$$540\,p + 68\,p = 3744;\ \text{d'où}\ p = 6^{k}{,}158.$$

VI. Dans un premier vase, on a de l'eau à 11 degrés; dans un second, de l'eau à 91; combien doit-on prendre de kilogrammes dans chacun d'eux pour former un bain de 250 kilogrammes à 31 degrés?

Soient x et y les nombres de kilo. à prendre respectivement dans chaque vase, on a d'abord $x + y = 250$ [1]. On obtient une deuxième équation en x et en y, en observant que x kilo. à 11 degrés contiennent $11\,x$ unités de chaleur, et que y kilo. à 91 degrés en contiennent un nombre représenté par $91\,y$. D'ailleurs, les 250 kilo. de mélange, à 31 degrés, renferment 250×31, ou 7750 unités; on a donc l'équation $11\,x + 91\,y = 7750$ [2].

Les équations [1] et [2] étant résolues, on trouve $x = 187$ kil.,5, et $y = 62$ kil.,5.

* THÉORIE DYNAMIQUE DE LA CHALEUR.

344. **Equivalent mécanique de la chaleur.** — Partant de l'idée que le développement de la chaleur est dû à un mouvement vibratoire des molécules, soumis aux lois ordinaires de la mécanique, plusieurs géomètres et physiciens travaillent depuis quelques années au développement d'une théorie nouvelle qu'ils désignent sous le nom de *Théorie dynamique de la chaleur*, et dans laquelle ils se proposent non-seulement de faire voir qu'une quantité de chaleur donnée peut se transformer en travail mécanique (381), et réciproquement; mais de calculer le travail mécanique que peut produire une quantité de chaleur déterminée, ou quelle quantité de chaleur peut développer un certain travail mécanique. On sait, en effet, que la chaleur peut produire un travail mécanique, comme il arrive dans l'expansion des vapeurs et dans la dilatation des gaz; et que réciproquement on peut développer de la chaleur par une action mécanique, telle que la percussion, la pression ou le frottement (383 et 384). La théorie dynamique de la chaleur est pleine d'actualité, et mérite de fixer l'attention des physiciens et des mécaniciens, car elle peut apporter des améliorations de la plus haute importance aux machines à vapeur et aux machines à air chaud.

Montgolfier paraît être le premier physicien qui ait avancé qu'il y a identité de nature entre le calorique et le mouvement, en ce sens non-seulement que la chaleur est une cause de mouvement, et le mouvement une cause de chaleur; mais en ce sens encore que la chaleur et le mouvement sont deux formes différentes, deux effets d'une seule et même cause; en un mot, que la chaleur peut se convertir en mouvement et le mouvement en chaleur.

Se basant sur ces considérations théoriques, Montgolfier inventa, en 1800, une machine qu'il appela *pyro-bélier*, au moyen de laquelle, pensait-il, le travail journalier d'un cheval-vapeur (381) ne devait plus demander qu'une dépense de quelques centimes. Le principe du pyro-bélier consistait à dilater par la chaleur une certaine quantité d'air, toujours la même, enfermée en vase clos; à faire servir cette augmentation de volume et d'élasticité à soulever une colonne d'eau; puis à restituer à cette même masse d'air, la chaleur dépensée par la dilatation et *convertie en effet mécanique*, pour lui restituer la force élastique perdue, et ainsi de suite.

M. Séguin aîné, neveu de Mongolfier, a présenté à l'Institut (le 3 janvier 1855) un mémoire dans lequel il décrit une nouvelle machine à vapeur fondée sur les idées théoriques ci-dessus.

Figure 5.3 The mechanical equivalent of heat. Small type size and asterisk marking knowledge outside of formal education curricula and – according to Ganot – lacking consensus. Atkinson's translation eliminated the asterisk, used normal type size and reshaped this section by a more detailed account, privileging German and English results against French. Ganot, *Traité* (1859), p. 322.

The Translator

Edmund Atkinson appropriated Ganot's books in several ways. First, together with the publisher, he contributed to the design of their intended audience. Second, he reshaped the contents and form of the text in significant ways, according to his pedagogical practice as a teacher, and to the evolving context of scientific education in England. Atkinson's translations were performed while he was teaching at Cheltenham College, and subsequently at the Royal Military College, Sandhurst. This process was constrained by the internal mechanics of the books, vademecums in the sense coined by Fleck. Third, he appropriated Ganot's section of problems as an author. Finally, he appropriated the *Treatise* (and thus the *Traité*) for his translation of the *Cours*.

In the preface to the *Treatise*, Atkinson claimed that he had previously used the *Traité* as a teacher. He valued the book highly for its large number of editions and translations, its 'clearness and conciseness' and 'methodical arrangement', and the quality of its illustrations. However, because of its close link to the 'French systems of instruction', he thought it necessary to make 'alterations and additions' to meet the needs of the English student. In its first edition, the translation was often literal and, in general, did not significantly supplement the *Traité*'s contents. However, it is characterized by more synthetic sentences, more reduced historical introductions, different examples, more algebraic formulae (still simple ones), a more quantitative and mathematical approach, the recalculation for London of observational data given for Paris, and a stronger anti-realist approach in relation to the physical agents and theories of electricity. In subsequent editions, Atkinson introduced new contents and significantly changed some sections.

The first parts to be completely reshaped were the introductory chapters on mechanics, which Ganot had limited to a minimum due to the greater independence in relation to physics of this subject in France, in contrast with Britain.[55] In addition, Atkinson introduced new contents related to recent research conducted in Britain, and results published in English or German. Sometimes additional illustrations were added, often referring to local instrument makers. New articles were typically introduced at the end of chapters, keeping the general structure of the book intact. The *Traité* displayed results produced in France, but also in England, Germany and other countries. However, Ganot's knowledge of foreign research was based on its appropriation by French journal writers and translators.[56] Following Fleck's distinction of 'journal' and 'vademecum' science, Ganot's book was not a mere aggregation of journal articles, but a closed organized system – a vademecum. The

[55] Maurice Crosland and Crosbie Smith, 'The Transmission of Physics from France to Britain: 1800–1840', *Historical Studies in the Physical Sciences*, 9 (1978): 1–61.

[56] Ganot cited Moigno's *Cosmos*, Germer Baillière's *Revue des cours scientifiques* and the more 'elitist' *Annales de chimie et de physique* and *Journal de physique*, John Tyndall's *La Chaleur*, Rudolf Clausius' *Théorie mécanique de la chaleur* and Angelo Secchi's *L'unité des forces physiques*.

tight internal mechanics of the structure of the *Traité*, and perhaps the possibility of saving labour on the basis of Ganot's regular new editions,[57] are factors configuring Atkinson's appropriation. Hence, he respected the general structure and most of the contents of the *Traité*'s successive editions, and, in general, only introduced additions at the end of chapters. Thus, for instance, Atkinson never completely reconfigured the *Treatise* in terms of the driving concept of energy conservation, promoted in Britain from the 1860s. But he introduced an article on this subject at the end of the first book of the *Treatise* as early as in 1868.

The close links between translation and authorship are especially noticeable for the case of Atkinson's appropriation of the *Traité*'s problems. The book's appendix of examination questions and problems was a characteristic feature of his origin in the context of French private preparatory schools, subsequently generalized in French state schools and, concomitantly, in most French physics textbooks. Although there were some previous books on physics problems, Ganot arguably pioneered the configuration of physics textbooks as closed systems organizing knowledge in ways mapping all the sides of pedagogical practice at schools including student interrogation and examination. Atkinson included this section from the *Treatise*'s seventh edition (1875), arguing that teachers and other users of the book had told him of the need for this. He found many of Ganot's problems devoid of interest in having only algebraic or geometrical solutions. Hence, he added new problems focusing on the use of physical principles, based on his teaching experience and that of his colleagues.[58] In addition, the appendix was published separately in 1876 with Atkinson identified as the author.

After Baillière's death, Atkinson successfully negotiated the handing over of the *Treatise* to Longman, the most important publisher of this period in London.[59] In 1868, he proposed the translation of Ganot's *Cours*.[60] Its first edition was published in 1872 as the *Natural Philosophy for General Readers and Young Persons*.[61] Atkinson intended to address it to students at a more elementary level of instruction. It was therefore a priority to eliminate the *Treatise*'s mathematical formulae. Considering it difficult to produce a coherent work by expurgating the

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[57] Ganot sent – at least on certain occasions – a copy of his book to its English publisher, in order to help the work of the translator, and apparently he regularly sent engraving stereotypes for each new edition. Archive of the House of Longman, *Atkinson File*.

[58] 'Preface' in Adolphe Ganot, *Elementary Treatise on Physics Experimental and Applied* (London, 1875).

[59] Topham, 'Scientific Publishing', p. 584.

[60] Archive of the House of Longman, *Atkinson File*.

[61] Its second edition (1875) had a print run of 5,000 copies and sold around 2,600 copies in the first seven months. The print run of the third edition (1878) was increased to 7,000 copies and the fourth (1881) and fifth (1884) attained 9,000 and 10,000 copies respectively (Archive of the House of Longman, *Atkinson File*).

Treatise,[62] he thought it better to translate Ganot's *Cours*, which already had an extensive circulation in France. His translation introduced modifications aimed at targeting students in the upper classes of boys' and girls' schools, and candidates for the University of London's entrance examination. It was also considered suitable for the general reader who wished to acquire knowledge of the main physical phenomena and laws in 'familiar language'.[63] In his opinion, there were many English books that targeted this audience but most of them were not sufficiently suitable for teaching purposes, or were too expensive.[64]

Atkinson's translation of the *Cours* shared the textual and conceptual characteristics of his translation of the *Traité*. Again, the asterisks system (see Figure 5.3) was eliminated. Furthermore, some articles were eliminated, and articles and illustrations from the *Traité* and the *Treatise*, not included in Ganot's *Cours*, were introduced. In addition, from the third edition (1878) Atkinson provided an appendix of questions, which was never included in the *Cours*. Thus, he not only appropriated the *Cours* for his *Natural Philosophy*, but also the *Traité* (through his previous appropriation of the *Treatise*) in the making of his second physics textbook.

The Reviewer

The subsequent editions of the *Treatise* and *Natural Philosophy* were reviewed in a wide range of English periodicals that addressed different readerships in Victorian England. The reviewers addressed a wide range of audiences (from working-class to middle- and upper-class readers) and considered the books suitable for such diverse readerships.[65] The reviewer of Ganot's books was a special kind of reader

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62 As previously pointed out, Fleck's concept of 'vademecum' helps to understand the fact that the *Traité* was a closed organized system.

63 Note here the analogy with the qualification of *Vestiges of Natural Creation* as a book displaying 'familiar knowledge'. Secord, *Victorian Sensation*, p. 100.

64 'Preface' in Adolphe Ganot, *Natural Philosophy for General Readers and Young Persons* (London, 1872).

65 Periodicals such as the *Athenaeum* (weekly, of liberal orientation, one of the most influential and independent Victorian literary journals) and the *Academy* (linked to the Oxford reform movement and appealing to an educated middle- to upper-class readership); journals addressed at middle- to upper-class readers with a general interest in science, such as the quarterly *Popular Science Review* (one of the best-known periodicals of its time in this spectrum), the widely circulated *Nature* (a weekly incorporating science 'popularization' among its aims)- and the *Quarterly Journal of Science* (addressing middle- to upper-class science amateur readers); popular weekly illustrated journals such as the agricultural *Land and Water*, and cheap mass-circulating science weeklies addressed at working-class readers such as the *English Mechanic*; scientific and medical specialized journals such as the weekly *Telegraphic Journal*, the institutional weekly *British Medical Journal* and the leading independent weekly *Lancet*. See *Waterloo Directory of English Newspapers and Periodicals, 1800–1900, Series 1 and 2.*

– a paid reader – and thus his appropriation of the books, when not anonymous, involved an exercise of social and professional legitimization.[66]

The books were commonly praised for their print layout and the large number and quality of illustrations – considered a distinctly French feature[67] – for the large number of subsequent French and English editions; for their structure and contents;[68] and for the usefulness of their questions section, particularly for self-taught students.[69] In the 1870s, the *Treatise* was already considered a standard physics textbook.[70] Despite the publisher's and translator's intended differentiation between the two books and their readerships, different reviewers and readers accorded to them common aspects.

Natural Philosophy was explicitly addressed at candidates for the London Matriculation examination.[71] Nonetheless, both textbooks had a questions section, and in fact the *Treatise* was also used for this purpose by some students.[72] Following Atkinson, it was often stressed that *Natural Philosophy* was not an abridgement

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66 Gowan Dawson, Richard Noakes and Jonathan Topham, 'Introduction', in Geoffrey Cantor et al. (eds) *Science in the Nineteenth-Century Periodical: Reading the Magazine of Nature* (Cambridge, 2004), pp. 1–34.

67 Anon., 'Elementary Treatise on Natural Philosophy', *Nature*, 3 (31 August 1871): 343–4; Anon., 'Natural Philosophy for General Readers and Young Persons', *Quarterly Journal of Science*, 9 (July 1872): 379 and Anon., 'Ganot's Physics', *Popular Science Review*, 13 (1874): 415.

68 Anon., 'Ganot's Elementary Treatise on Physics', *The Lancet*, 81/2068 (1863): 444; Anon., 'Elementary Treatise on Physics Experimental and Applied, for the Use of Colleges and Schools', *The Lancet*, 114/2925 (1879): 429 and George F. Rodwell, 'Ganot's Physics', *Nature*, 5/8 (February 1872): 285–7.

69 Anon., 'Elementary Treatise of Physics', *Quarterly Journal of Science*, (1876): 110.

70 Anon., 'Ganot's Elementary Treatise on Physics Experimental and Applied', *British Medical Journal*, 6 (April 1872): 370; Anon., 'Ganot's Popular Natural Philosophy', *Popular Science Review*, 11 (1872): 297–8; Anon., 'Natural Philosophy for General Readers and Young Persons', *Quarterly Journal of Science*, 9 (July 1872): 379; Anon., 'An Elementary Treatise on Physics, experimental and applied', *The Lancet*, 110/2828 (1877): 691–2 and Anon., 'Natural Philosophy for General Readers and Young Persons', *The Lancet*, 111/2848 (1878): 466.

71 Anon., 'Natural Philosophy for General Readers and Young Persons', *Quarterly Journal of Science* (1872): 379 and Anon., 'Natural Philosophy for General Readers and Young Persons', *The Lancet*, 111/2848 (1878): 466.

72 This is the case of Oliver Lodge, who subsequently became a well-known physicist. It might be, however, that Lodge referred to *Natural Philosophy* when talking of 'Ganot's Physics'. As discussed later there was a certain confusion in the familiar designation applied to the two books. Oliver J. Lodge, *Past Years: An Autobiography* (London, 1931), pp. 79–80.

of the *Treatise*.[73] The former was often qualified by reviewers, publisher and translator as 'more popular' than the latter, but sometimes the same designation was used to refer to both.[74] The relative status of the two books in relation to what was 'popular' was not clearly defined. Instead, they served both functions linked to formal education, self-instruction and popularization, and different readers assigned different functions to them according to their own expectations and perceptions.

For Ganot, the *Cours* was 'popular' because it was 'accessible to everyone'. For different English reviewers, the 'popular' aspect of the *Treatise* was linked to the subject matter, the type of descriptions, the easy reading and the 'sensation'.[75] In parallel, they considered it significant to stress that the books were accurate and covered a wide subject matter. Thus, both the form and the contents of the books are aspects linking them with the social and the cultural, and their qualities seemed to appeal to a wide range of audiences both in 'esoteric' and in 'exoteric' circles. Furthermore, as reflected by reviewers, the continued editions and the test of time provided them with authority. All these factors made Ganot's textbooks 'standard' works.[76] In fact, as indicated by Fleck, the 'standard' is one of the qualities of the 'popular'.[77] Their enduring role in the processes of communication and appropriation between 'exoteric' and 'esoteric' circles, within and between two different countries, are congruent with their important contribution to the definition of a Franco-British 'thought style' constraining physics, education organization, pedagogy, printing and the book trade in different ways.

The reviews of Ganot's books were usually positive. Nevertheless, some included criticisms, in general related to the relative presence of English actors in them[78] and to the different conceptual structure of French and British physics, in particular on the use of the concept of energy conservation, promoted by William

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[73] J. Stuart, 'Ganot's Natural Philosophy', *Nature*, 5 (29 February 1872): 339; although some reviewers did not hesitate to state exactly the opposite. Anon., 'Natural Philosophy for General Readers and Young People', *Quarterly Journal of Science*, Oct., 12 (1875): 528.

[74] Anon., 'Ganot's Physics', *Popular Science Review* (1874): 415.

[75] Anon., 'Ganot's Physics', *Popular Science Review*, new series, 3 (1879): 406 and Anon., 'Ganot's Elementary Treatise on Physics, Experimental and Applied', *British Medical Journal* 6 April (1872): 370. For the meanings of 'sensation' in nineteenth-century England see Secord, *Victorian Sensation*, pp. 11–17.

[76] Fyfe has discussed on categories 'classic' or 'standard works'. Olesko uses the concept of 'canon', but restricts her discussion to the context of physics laboratory instruction. Aileen Fyfe, 'Publishing and the classics: Paley's *Natural theology* and the nineteenth-century scientific canon', *Studies in History and Philosophy of Science*, 33 (2002): 729–51 and Kathryn Olesko, 'The Foundations of a Canon: Kohlrausch's *Practical Physics*', in D. Kaiser (ed.), *Pedagogy and the Practice of Science: Historical and Contemporary Perspectives* (Cambridge, MA, 2005), pp. 323–55.

[77] Fleck, *Genesis and Development*, p. 112.

[78] R. Hunt, 'Elementary Treatise on Physics Experimental and Applied', *The Athenaeum*, February 21 (1843): 260; Anon., 'Electricity for Students', *Popular Science*

Thomson and Peter G. Tait's *Treatise on Natural Philosophy*.[79] These concerns are discussed in the next section, in relation to the appropriation of Ganot's textbooks by a particular kind of reviewer: the science teacher.

The Science Teacher

Science teachers, like Edmund Atkinson, were major readers of Ganot's textbooks. Scientific education in England developed rapidly from the 1860s through the consolidation of national systems of examinations contributing to the strengthening and configuration of the science school and university college curriculum. School science examinations were held by the old universities (Oxford and Cambridge), the new liberal university (London), the Department of Science and Art, and the Society of Arts. Private schools played an important role in the science movement, and from the 1840s foundations such as Cheltenham and Marlborough College were important agents in the constitution of a science curriculum.[80]

George F. Rodwell was a science master at Marlborough[81] in 1872 when he wrote a long review in *Nature* on the *Treatise*.[82] Like Atkinson, he had conducted research as a chemist before focusing on physics teaching. In 1873, he published a small textbook on natural philosophy based on his lectures at Guy's Hospital.[83]

Rodwell regretted the scarce presence of the key concepts of 'Thomsonian Physics'. Thomson and Tait had established in Britain a new set of canonical concepts in mechanics involving the reconfiguration of kinematics, statics and dynamics, and the substitution of 'force' by 'energy' as the fundamental entity in nature. The conservation of the energy principle was an essential part of this conceptual structure.[84]

In spite of this, Rodwell considered that Ganot's book included many new relevant articles on instruments and experiments. Four instrument illustrations – extracted from the *Treatise* – were appropriated for reviewing purposes, and Rodwell intended to show the reader how familiar he was with their main characteristics and manipulation.

Review, 6 (1867): 69–70; Anon., 'Natural Philosophy', *Popular Science Review*, 10 (1871): 72 and Rodwell, 'Ganot's Physics', 285–7.

[79] Crosbie Smith and M. Norton Wise, *Energy and Empire: A Biographical Study of Lord Kelvin* (Cambridge, 1989), pp. 348–9.

[80] Trevor Hearl, 'Military Examinations and the Teaching of Science, 1857–1870', in MacLeod (ed.), *Days of Judgement*, pp. 109–49.

[81] John Foster Kirk, *A Supplement to Allibone's Critical Dictionary of English Literature and English and American Authors* (Philadelphia, 1891).

[82] Rodwell, 'Ganot's Physics'.

[83] George F. Rodwell, *Notes of a Course of Nineteen Lectures on Natural Philosophy: delivered at Guy's Hospital during the session 1872–3* (London, 1873).

[84] Smith and Wise, *Energy and Empire*, p. 349.

Rodwell's book followed a similar plan to that of Ganot's *Treatise*, but was shorter. However, it assigned an important role to the concept of energy where the *Treatise* gave more relevance to 'force' and 'work'. In addition, it encouraged students to make their own instruments by dispensing with unnecessarily expensive instrument collections [like those displayed by Ganot].

In 1884, Silvanus P. Thompson (1851–1916) – a university lecturer in physics – cited Ganot's book in a general review of elementary physics textbooks, assigning – like Rodwell – a major role to the principle of energy conservation. While considering both the *Treatise* and *Natural Philosophy* to be among the best English elementary physics books, he thought that, despite Atkinson's efforts, they were still affected by 'Ganot's academically conservative way of treating physical problems'. Instead, he considered that Balfour Stewart's *Elementary Lessons in Physics* – the major promoter of the 'doctrine of energy' in the range of elementary textbooks – was far superior.[85] A decade earlier, Thompson had probably used Ganot's textbooks to prepare the University of London BSc examinations, and, subsequently, he purchased one of his books just before becoming a physics lecturer at Bristol.[86]

The conservation of energy was also an important factor on the agenda of another kind of science reader, one who considered that science and theology were congruent systems explaining the mechanisms of the world. This reader's appropriation and communication of Ganot's textbooks is discussed in the next section.

The Theological Reader

Ganot's books played a standard role in the cultural and social strategies of theologians of different kinds, vindicating – through their communicative interaction with the 'esoteric' circle of nineteenth-century British science – their role in the configuration of the 'thought style' of science. This interaction is analysed in this section through the analysis of the use of Ganot's work by Henry Drummond and Helena Blavatsky.

Henry Drummond (1851–97) studied science and theology in Edinburgh, where he was a lecturer in natural science and theology professor at the Free Church College. He travelled extensively, giving lectures to students and the working classes which were subsequently compiled in successful books. Drummond was considered a heterodox theologian and a 'cultivated amateur man of science', and renowned as a skilful orator. His work was driven by the idea that nature and the spiritual world were operated by the same principles.[87]

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[85] Silvanus Phillips Thompson, 'Daniell's Physics', *Nature*, 30 (15 May 1884): 49–51.

[86] Jane Smeal Thompson and Helen G. Thompson, *Silvanus Phillips Thompson, D.Sc., LL.D., F.R.S. His Life and Letters* (London, 1920), p. 3.

[87] D.W. Bebbington, 'Drummond, Henry (1851–1897)', *Oxford Dictionary of National Biography* (Oxford, 2004) <http://www.oxforddnb.com/> (accessed December 2007). All

Drummond relied on the status of Ganot's 'Physics' in 'The Third Kingdom', one of his lecture papers,[88] in which he analysed the relations between the 'Spiritual', the 'Inorganic' and the 'Organic' by drawing on analogies with scientific concepts and theories such as 'energy', 'force' and 'evolution'. The 'Spirit' was represented as a type of 'Energy' operating through physical phenomena analogous to those in nature. The difficulty of observing 'Spiritual forces' was compared to that of observing physical forces.[89] In this context, Drummond introduced a colourful parable: an extraterrestrial reader of Ganot's 'Physics' and Grove's 'The Correlation of Physical Forces', landing in Labrador, would be puzzled to learn that even if many physical forces were available there, they were ignored and had never been used. Therefore, thinking that spiritual energies were not real was as inconclusive as thinking that physical forces were not real where they were not used.

Ganot's 'Physics' was considered by Drummond to be both an authoritative and familiar physics work for the audiences and readers he addressed – students, but also workers – that he could use to argue for the correlation of all forces, including the spiritual. Like Atkinson, and in contrast to Rodwell and Thompson, Drummond did not have any problem with combining Ganot's physical explanations through forces with Thomson and Tait's focus on energy and its conservation.

Like Drummond, Helena Petrovna Blavatsky (1831–91) used science to support her theological work, and considered that theology and science shared a common ground: scientific laws were insufficient to understand the universe, and needed to be completed with other laws of nature that were only accessible to occult wisdom. However, she was explicitly confrontational against elite scientific writers such as T.H. Huxley and John Tyndall on this matter

Like Drummond, Blavatsky travelled extensively, publicizing Theosophy – her theological system – in public lectures and private meetings. In 1888, she published *The Secret Doctrine*, a complex work covering a large number of topics, including cosmic evolution, the origins of the universe, the history of humankind and reincarnation.[90] There, she provided a frame to defend Theosophy against the criticism of scientists, citing a wide range of works, including 'standard books on Science' such as Ganot's 'Physics'. Blavatsky argued that basic concepts in science such as 'ether', 'energy' and 'force' were as 'mysterious' as those of Theosophy, and their agents even less well defined than those of her system. After discussing 'ether' and 'energy', she cited Ganot's 'Physics' definition of 'molecular energy or

references to the *DNB* in this chapter were accessed electronically on the aforementioned date.

[88] Contained in a posthumous compilation of his papers. Henry Drummond, *The New Evangelism and Other Papers* (London, 1899).

[89] Drummond used the example of gravity, that he considered to be a force for a long time unnoticed in the history of mankind. Ibid., pp. 150–5 (I have used the American edition simultaneously published in New York by Dodd, Mead and Company).

[90] R. Davenport-Hines, 'Blavatsky, Helena Petrovna (1831–1891)', *Oxford Dictionary of National Biography*.

forces' to argue that, paradoxically, the same scientists that criticized Theosophy completely ignored the nature and agent of these forces.[91]

Thus, for Blavatsky, like for Drummond, Rodwell's and Thompson's discussion on the need to adopt 'Thomsonian physics' privileging 'energy' and its conservation over 'force' was not relevant. Instead, Ganot's *Treatise* represented a standard work in physics, well known by the lecture audiences, which could be used to argue for the congruence of science and theology. Furthermore, it could be used to attack the authority of the scientific elite on science.[92] Thus, communication between individuals such as Drummond and Blavatsky, belonging to the 'exoteric circle' of science, and the British scientific elite was not only intellectual, but also of a strongly social character.

The social character of the 'thought community' constrained by Ganot's textbooks was also defined by the practices of scientific instrument design and its actors. In the next section, I analyse the appropriation of Ganot's books by British instrument makers and scientists involved in instrument design.

The Researcher and the Instrument Maker

The communicative power and close relation to modern developments in science of Ganot's textbooks' illustrations – highlighted by all their reviewers – played a major role in the appropriation of his work by different actors engaged in instrument design. In this context Ganot's *Treatise* was a science vademecum, that is, a reference work representing the 'thought style' constraining a 'thought community'. This view was not only shared by members of the British scientific elite such as William Thomson, but also by individuals cohabitating with Thomson in the social context of engineering and instrument design, such as Sebastian Ferranti and the heads of the firms Horne & Thornthwaite and Elliott Brothers.

William Thomson used Ganot's *Treatise* as a 'vademecum' in the context of his daily research practice. In 1863, he wrote to Thomas Andrews in reply to his demand for technical details about Holmes's electric light apparatus for lighthouses. Andrews was then a professor of chemistry at Queen's College, Belfast, and maintained a close professional and personal relationship with Thomson and Tait.[93] Thomson stated that he could not send him exact details, but could alternatively provide descriptions of Nollet's French apparatus for which he had previously

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91 Helena Petrovna Blavatsky, *The Secret Doctrine: The Synthesis of Science, Religion, and Philosophy* (London, 1888).

92 In fact, the British scientific élite opinions on the relations between science and theology were not at all homogeneous. Scientific materialism was not only rejected by Drummond and Blavatsky, but also by scientists of the status of Peter G. Tait and Balfour Stewart. P.J. Hartog, 'Stewart, Balfour (1828–1887)', rev. Graeme Gooday, *Oxford Dictionary of National Biography*.

93 Arthur Harden, 'Andrews, Thomas (1813–1885)', rev. Anita McConnell, *Oxford Dictionary of National Biography* and Smith and Wise, *Energy and Empire*, pp. 352–5.

taken notes. Furthermore, he remarked that Ganot gave an illustration of one of these apparatus, although of different proportions.

Indeed, Ganot's *Traité* and the first edition of the *Treatise* included four illustrations and a detailed description of this apparatus, built in Paris. Thomson used Ganot's book as a vademecum which made it possible to fish for data, in particular on French instrumentation. Furthermore, he specifically cited Ganot's illustration, rather than its written description, showing that Ganot's illustrations were important for physicists designing their own instruments in the laboratory or the workshop.

This was also the case for several London instrument makers who inserted at the end of Ganot's *Treatise* lists of instruments displayed in the book and available in their shops.[94] Hence, instrument makers such as Horne & Thornthwaite and Elliott Brothers appropriated the *Treatise* for their commercial purposes. The selection of instruments portrayed in the *Treatise* contributed to defining their trade catalogues and thus, to a certain degree, their production strategies. This production was diversified by targeting different cultural and social communities, including the scientific elite, schools and amateur scientists. This diversity is also represented in Ganot's *Treatise* that, in turn, contributed to defining it.

The illustrations and text of Ganot's *Treatise* were also important for the research by the engineer Sebastian Ferranti.[95] He first encountered the book in his school days, as an introductory 'standard work' to physics,[96] then probably in his (unconcluded) engineering studies at University College, London, and finally, both as a 'standard work' and a 'vademecum' in the course of research leading to his successful design of easy-reading electrical meters.

According to Ferranti, he started his research by reading the articles on the action of a current upon another in Ganot's *Treatise*.[97] The latter included an illustrated discussion of Ampère's laws applied to this phenomenon in several cases,[98] and some of Ferranti's diagrams and explanations are simplified versions of Ganot's illustrations.[99] Thus, he used Ganot's work as a 'vademecum' in which the standard knowledge defining the 'thought style' of his 'thought collective' could be checked. But, in addition, having confronted the book on his own since his childhood, his use of it to fish for core ideas that could be developed into

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[94] Ganot, *Treatise* (1866) and (1868); copies available at the Bodleian Library, Oxford.

[95] I thank Graeme Gooday for guiding me towards Ferranti's work.

[96] John F. Wilson, 'Ferranti, Sebastian Ziani de (1864–1930)', *Oxford Dictionary of National Biography*.

[97] Gertrude Ziani de Ferranti and Richard Ince, *The Life and Letters of Sebastian Ziani de Ferranti* (London, 1934), p. 239 and Sebastian Ziani de Ferranti, 'On the Ferranti Electricity Meter and its Evolution', *Transactions of the Royal Scottish Society of Arts*, 14 (1896): 52–3.

[98] Ganot, *Treatise* (London, 1863), pp. 648–57.

[99] Especially figures 499, 500, 507 and 508. Ibid., pp. 652 and 654.

successful engineering designs conforms to Fleck's analysis of popular knowledge as 'the major portion of every person's knowledge' that often 'set the standard for the content of expert knowledge'.[100]

Conclusion

Ganot's books were originally intended principally for an audience enrolled in formal education in a particular economy of teaching. However, both books had complex and varied real readerships. One of the intended aims of one of Ganot's books was to 'popularize'. However, both books were considered to be 'popular' by different readers. The *Traité* and the *Cours*, and their English translations, were linked by a complex relation of appropriations performed by their author, their translator and in general their readers.

Readers appropriated the books in different and contradictory ways. For different readers they represented school manuals, aids for the preparation of examinations, introductions to science, sources of self-instruction, popular science books, 'sensational' readings, symbols of French physics, sources supporting the fight against scientific materialism, science vademecums, and instrument trade catalogues, respectively. It is their ways of reading and using, of appropriating and communicating the books that defines their status.

The perception of the books varied among readers but also changed over time. The multiplicity of readers and responses to the books contributed to their long survival and rise to the status of 'standard'. The books were an essential tool in the multilateral communication between different 'esoteric' and 'exoteric' circles in France and Britain, and the diversity of their readers tells us how diverse their appropriations and communications were. Such diverse, international and enduring processes determined the contribution of Ganot's textbooks to an international 'thought style' or a cultural centre within a 'central value system' by becoming science vademecums, constraining a large 'thought collective' comprehending all their readers located both in 'esoteric' and 'exoteric' circles.

In this process, the distinctive French features of Ganot's books were appropriated into the British context by adapting them to the distinctive features of British physics, printing and publishing, pedagogy, reading practices and instrument making. In turn, the original characteristics of Ganot's books helped shape the British context in all these fields and secured for them a central position in British culture and society.

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[100] Fleck, *Genesis and Development*, p. 112. In addition, Ferranti's historical narrative of the development of his meter might have also had a pedagogical and academic intention in starting by introducing a standard work known to any reader.