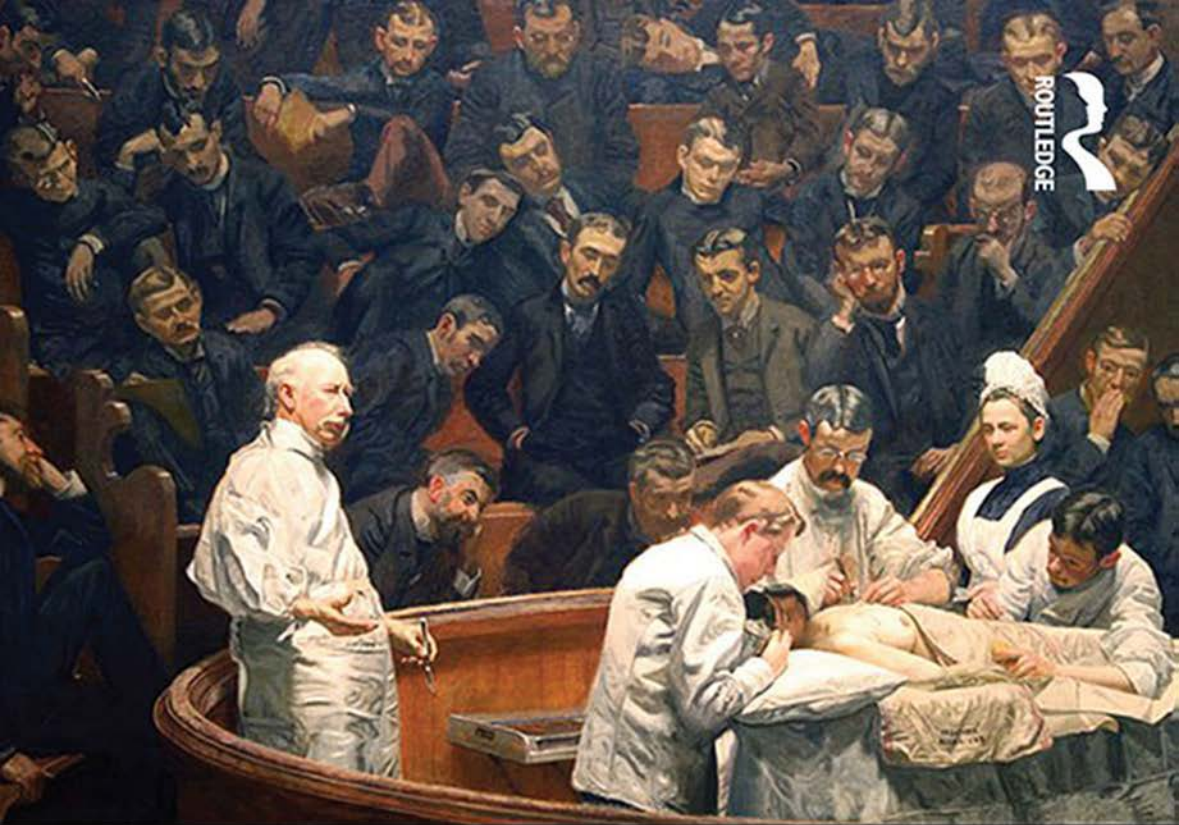




SCIENCE IN THE PUBLIC SPHERE

A history of lay knowledge and expertise

Agustí Nieto-Galan



SCIENCE IN THE PUBLIC SPHERE

Science in the Public Sphere presents a broad yet detailed picture of the history of science popularisation from the Renaissance to the twenty-first century. Global in focus, it provides an original theoretical framework for analysing the political load of science as an instrument of cultural hegemony and giving a voice to expert and lay protagonists throughout history.

Organised into a series of thematic chapters spanning diverse periods and places, this book covers subjects such as the representations of science in print, the media, classrooms and museums, orthodox and heterodox practices, the intersection of the history of science with the history of technology, and the ways in which public opinion and scientific expertise have influenced and shaped one another across the centuries. It concludes by introducing the ‘participatory turn’ of the twenty-first century, a new paradigm of science popularisation and a new way of understanding the construction of knowledge.

Highly illustrated throughout and covering the recent historiographical scholarship on the subject, this book is valuable reading for students, historians, science communicators and all those interested in the history of science and its relationship with the public sphere.

Agustí Nieto-Galan is Associate Professor of History of Science and Director of the Centre d’Història de la Ciència at the Universitat Autònoma de Barcelona. He has written widely on the history of chemistry and natural dyestuffs, and on the history of science popularisation (eighteenth to twentieth centuries). His publications include *Barcelona: An urban history of science and modernity: 1888–1929* (co-editor, 2016) and *Popularizing Science and Technology in the European Periphery, 1800–2000* (co-editor, 2009).

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To the memory of Rosa Ambròs Barbany (1900–89), a wise lay
woman

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PREFACE

This book is the outcome of a long intellectual journey. It came into being in April 1994 in the Modern History Faculty at the University of Oxford, in a History of Science graduate seminar. There, at the heart of British academia, in the land of Isaac Newton, Charles Darwin and Michael Faraday, among other great names in Western science, I heard about ‘popular science’ and ‘scientific culture’ for the first time; I decided to revive and learn about not only the great luminaries from the past but also those who were lay, ignorant, forced aside from the epic struggle to explain the supposed truths of nature. At this informal gathering, someone mentioned an article published that same year by historians Roger Cooter and Stephen Pumfrey.¹ Despite the difficulty of reading it and the dense web of ideas it contained, the paper made a deep impact on me and led me to question the meaning of my work as a historian of science and to wonder about the ultimate reasons to ask certain questions of the past instead of others.

A few weeks later, my current colleague, Dr Xavier Roqué, who at that time held a post-doctoral position at the University of Cambridge, told me about the recent publication of a history of the science displayed at the nineteenth-century world’s fairs, especially London’s famous Great Exhibition held in 1851. It was a work by historian Robert Brain,² which contained amazing engravings of the Crystal Palace and some of the pavilions that housed machinery, inventions and scientific instruments in London, and also in Paris, Vienna, Chicago and Philadelphia.

Never before had I seriously considered the possibility of examining the history of science from the perspective of entertainment, fairs or popular culture, or from the plural perceptions of its multiple actors. Furthermore, back then I was particularly interested in the role of artisans, as crucial actors in the history of technology, but often forgotten in the romantic mythology of the great inventors, along with professional scientists and engineers working under the aegis of their academic institutions.

Some ideas need a long time to ripen, to slow-cook in the deepest recesses of our minds. Focusing on ‘science in the public sphere’ – I will return to this concept later – means to make old research topics useful and to dive into the abyss of a new field yet to be explored. So these first fascinating readings hibernated for ages in the messy drawer of disjointed musings, on the lists of good intentions that we all jot down in our notebooks during lulls in the maelstrom of everyday academic life.

In the summer of 2003, once I had finished my work on the craftsmanship skills of eighteenth- and nineteenth-century European dyers and printers, my seminal fascination for science in the public sphere resurged. It was during my stay at the Université de Paris X, Nanterre, when I spent many glorious days at the Bibliothèque nationale de France reading and rereading papers and books by authors that have become close friends in my teaching and research activities and who play a crucial role in the chapters of this book.

In the first decade of the twenty-first century, our group at the Universitat Autònoma de Barcelona worked intensively on the history of science popularisation in Spain. We took advantage of the numerous masters dissertations and doctoral theses from our History of Science graduate programme, whose results were presented at national and international conferences. After collecting new, unexplored case studies and developing some work at a comparative level, I personally decided to write in Spanish a sort of synthetic historical essay, a big picture of science popularisation, which could interest a great variety of readers particularly targeting the Spanish-speaking Latin American market. As a result, *Los públicos de la ciencia* appeared in 2011 published by Marcial Pons.

I am pleased to see how in the last four years the book has been well received and reviewed. It soon became a useful tool for history of science and science communication graduate teaching and a good starting point for those interested in science popularisation in a broad sense. I am indebted to my first reviewers – José Luis Peset, Jaume Navarro, Ana Simões, Jesús Galech and Oliver Hochadel for their critical, stimulating comments, but also to other friends and colleagues who encouraged me to try to produce an English version of the book, addressed to a global market of potential readers.³ Thanks to Routledge’s interest in the book (I am particularly indebted to Senior Editor (history), Eve Setch, to Editorial Assistant, Amy Welmers, and to the positive comments of five anonymous referees) an updated, revised English version, now titled *Science in the Public Sphere*, has luckily become a tangible reality. My indebtedness goes to Fiona Kelso for the translation and for her unfailing effort to adapt the Spanish syntax into a readable text in English.

In the present English version, some Spanish case studies have been substituted by other examples; the theoretical framework, which deals with difficult concepts such as ‘popular science’, ‘public sphere’, ‘science as cultural hegemony’, ‘public participation in science’, and ‘co-production of knowledge’, has been refined and polished to produce a more robust introduction and conclusion. Nevertheless, this new English version preserves the main spirit of the 2011 edition, which attempted to write a new big picture of the history of science popularisation, a historical essay

which integrated the main works and authors of the secondary literature, but also provided a personal view of science as a genuine part of modern culture. The book uses a great variety of historical evidence to strengthen the analysis of the present-day participatory turn in science, which forms the core of debates on the ways in which scientific knowledge should be communicated and displayed in the early twentieth century. The book also attempts to reinforce the political dimension of science popularisation and refine its theoretical framework.

Many friends and colleagues were crucial in encouraging me to produce the Spanish version in 2011, and I expressed my deepest gratitude to all of them in the preface of the edition published by Marcial Pons. For the present English edition I am particularly grateful to José Ramón Bertomeu-Sánchez and Ana Simoes for their unfailing encouragement (in view of my early scepticism) to publish the book elsewhere in a new updated version for an international readership. My lectures, research seminars and conference papers in Lisbon, Valencia, Barcelona, Madrid, Mexico City, Berlin, Oxford, Paris, Athens, Corfú, St Andrews and Chicago have been extremely useful for the polishing of several aspects of this new edition. The ICREA-Acadèmia research prize, which I was awarded by the Catalan Government (2009–14), has also been of great help for the final success of the whole project. Research projects funded by the Spanish Ministerio de Economía y Competitividad, in particular (HAR2009–12918–C03–02), Science and Expertise in the Public Sphere: Barcelona (1888–1992) and (HAR2012–36204–C02–02), Scientific Authority in the Public Sphere in Twentieth-Century Spain, have also made a significant contribution.

As in the Spanish version, this book mainly uses nineteenth-century engravings from the works of the French science populariser Louis Figuier. It is a way, in my view, to pay tribute to one of the most outstanding figures of science popularisation in the past who still merits further historical investigation. It is also a useful way to reinforce the historical sensitivity, even when discussing present-day problems of science communication. I am therefore indebted to the Biblioteca de Catalunya (Barcelona) for allowing the consultation of Figuier's books and for its permission to reproduce the selected images.

Finally, my deepest indebtedness goes to Montserrat and Martí, who, as usual, have unconditionally supported my never-ending commitments and academic duties, and have given to me the patience and love to help me finish the book. I have no words to express what I feel for them.

★ ★ ★

This updated English version also entails complex ideas and concepts that can only be properly understood from a historical perspective, from specific cultural and geographic contexts. Words like 'popular', 'popularisation', 'public sphere', 'communication', 'instruction', 'curiosity', 'entertainment', 'demonstration' and 'show' have a history of their own, as historical actors used in the past. Even today they

take on different meanings according to the cultural tradition we are examining. For example, in the Latin context the concept of 'vulgus', of vulgarisation or dissemination, has prevailed over 'populus', or the 'popular' or 'popularisation' from the English tradition. Furthermore, the word 'communication' has become the icon of different professional groups throughout the twentieth century (science journalists, science museum curators, science teachers, professional popularisers), but its use in other historical periods and cultural contexts is questionable at best.

When outlining the details of the specific historical cases, the book remains faithful to the nomenclature used by the main actors in each period and place: from the 'curious' science of the Renaissance to the 'domestic' science of the medical treatises from the Enlightenment, the 'recreational' science of nineteenth-century book series and, for example, the 'entertaining' science of twentieth-century interactive museums. The majority of these concepts have been shaped and reshaped over time through complex interactions between the issuers and receivers of discourses, between actors with diverse social statuses and levels of intellectual authority, yet ultimately actors who have been the meaningful protagonists of the fascinating process of constructing scientific knowledge.

In this morass of concepts and ideas, the publics (audiences) emerge as a diffuse and somewhat ambiguous category, often flexible and changing, yet with a unifying capacity throughout the book. Far from the rigid categories which are supposedly separated by a neat boundary between creators and receivers of knowledge, the publics of science refers to the constant feedback among the different actors involved at any given point in history; it refers to that process of constant exposition and debate of ideas for the legitimisation of scientific authority in Western societies, as a hallmark of our modernity.

Once the walls between those who know and those who do not have been shaken, we all at some point become active publics of science, as students, visitors, spectators, users or patients, but also as disseminators, amateurs and experts of a given corpus of knowledge. Even the leading world experts in subatomic particles or molecular biology, to cite just two emblematic examples from the latest frontiers of science, are also ignorant in other spheres of knowledge or other human skills. This dynamic view of the construction of knowledge is thus based on this flexible use of the idea of 'publics'. As the media theoretician Michael Warner recently noted, the concept of 'publics' (or 'audiences') is crucial to understanding our societies, yet at the same time it is very difficult to define. It is a kind of social space created through the reflective circulation of a given discourse, a relationship among different groups of individuals within a given historical context.⁴

Equally, 'science' refers throughout the book to an embracing, generalist concept of 'knowledge' in a broad sense, beyond strict academic, disciplinary boundaries. Despite the widespread processes of professionalisation and specialisation, historical research enables us to identify numerous sources that demonstrate how scientific knowledge has travelled and continues to travel through society today, and how the 'publics of science' have participated and still participate actively in this complex social web.

In spite of the growing interest shown by historians, and historians of science in particular, in popular science and science popularisation in recent decades, the majority of published studies limit themselves to certain national contexts, such as Victorian Britain,⁵ France in the second half of the nineteenth century,⁶ nineteenth-century Germany,⁷ and unified Italy.⁸ Others are the outcome of collective studies which combine examples from different periods and countries,⁹ or alternatively they tend to focus on a given historical period.¹⁰ Many contributions are primarily theoretical in nature.¹¹ Others strive to provide an overview of the issue, yet they still rely on certain examples and case studies within a given context.¹² Therefore, there is no overview that combines a variety of historical examples from different points in time and space in a balanced way within an up-to-date theoretical framework. Thus, this book aims to at least partly fill that lacuna.

This book is a big picture of science popularisation, from the Renaissance to the twentieth century. It attempts to go a step further in terms of the political load of popular science and its cultural role in contemporary societies as an instrument of hegemony and social control. It provides an alternative perspective on science popularisation, and gives a voice to the varied audiences of science in history. It is organised into a series of thematic chapters which become different layers not in an effort to be exhaustive; rather, when superimposed they help us to gradually construct the complete backdrop of the work. Actors, practices, spaces, objects and discourses intermingle throughout the text and provide us with a new, somewhat impressionistic, fresh look at the role of science in society in numerous contemporary cultural debates.

Chapters devoted to 'printed science', 'spectacular science', 'heterodox science', 'classroom science', 'technological science', 'media science' and 'democratic science' all shed light on new actors, all of them active to a greater or lesser degree in the making of scientific authority and the validation of knowledge. These historical actors span diverse periods and sites: printing presses, anatomy theatres and *cabinets de curiosités* from the sixteenth and seventeenth centuries; aristocratic salons, informal gatherings, workshops and public demonstrations from the eighteenth century; bookshops, libraries, exhibitions, factories and museums from the nineteenth century; mass media and its vast popularisation projects from the twentieth century; and the new venues of citizenship and digital participation at the dawn of the twenty-first century. While historical examples from different periods appear in the majority of chapters, albeit with a particular emphasis on the eighteenth and nineteenth centuries, 'media science' and 'democratic science' draw primarily from twentieth-century examples, and even more recent cases from the twenty-first century. Furthermore, they strive to connect the general discussion on the publics of science with issues much more closely linked to our world today.

From the Renaissance until the early twenty-first century (along with occasional allusions to our ancient and mediaeval scientific legacy), shared and yet distinct elements appear. Popularisation in the past usually evolved in constant tension between instruction and entertainment, took place in specific venues and openly affected the relationship between their different audiences and their credibility,

defining the boundaries between orthodox and heterodox knowledge, between professionals and amateurs, in order to capture the interest of the different audiences.¹³ During the Renaissance, in their bid to acquire knowledge, the practices of natural philosophers were not too distant from their displays and public strategies before heterogeneous audiences. At that time, the boundaries between knowledge, entertainment and usefulness, between the professional and the amateur, between expert and lay audiences, were fuzzy.¹⁴ Science in the Enlightenment was an amalgam of multifaceted activities. It flourished in the period between the culture of curiosity – whose forerunners were the *cabinets de curiosités* and the automata of the seventeenth century – and the modern distinction between academic and popular science which gained ground over the course of the nineteenth century. The multiple cultures of science in the eighteenth century – public experiments and demonstrations, theatrical enactments, courses and lectures – created new spaces in the public sphere and stimulated a series of views of nature which competed with religion and traditional political notions.¹⁵

The professionalisation and gradual specialisation of science throughout the nineteenth century devised a widening gap between experts and laypeople. Curricula and popularisation programmes targeted certain audiences of science a priori which were increasingly regulated. In this context, a certain kind of ‘popular’ science could be found on the covers of numerous books as a strategy for attracting potential readers, yet at the same time they served as a kind of opposition to the professionals’ scholarly science. That was also the time of the professional science popularisers being obsessed with finding the right language to convey knowledge to all emerging social sectors, including the lower classes.¹⁶

In the first few decades of the twentieth century, scientism and the growing authority of professional scientists further widened this gap. Scientific progress was based on the victory of expert knowledge (*episteme*) over public opinion (*doxa*), as set forth by French philosopher Gaston Bachelard (1884–1962) in *La formation de l'esprit scientifique* (1938).¹⁷ After World War II, the successive waves of criticism regarding the ulterior motives of the scientific, military and industrial complex which emerged from the conflict, coupled with the rising mistrust of the value of science, led to new attempts to ‘evangelise’ the supposed ignorant, immersed in a purported epistemological abyss of intellectual inferiority. Despite the rising influence of the new media (film, radio, television) and the sweeping expansion of so-called ‘science centres’ or interactive science museums, the barriers did not seem to be blurred in societies that were also afflicted by a sense of mistrust in scientific progress. The last few decades of the twentieth century, however, seemed to reveal a new paradigm of citizen participation, albeit not without controversy of its own, in which scientific knowledge would be ‘co-produced’ in the blurred boundaries of science and society, by different actors actively involved in dynamic negotiation processes.¹⁸

This is a history of science that can inspire readers with widely disparate educational backgrounds. Perhaps by appealing to reflexivity, the book seeks new avenues of dialogue with audiences that until now have been unaccustomed to a critical

discourse on science, often mediated by a positivist legacy that still prevails in our contemporary societies. Although the book is intended for a wide readership, it is particularly useful for professional scientists, science communicators, science museum curators, science teachers and historians and philosophers. Conceived with high academic standards, it is nonetheless written in a way that might arouse the interest of an average reader with historical sensitivity and concern for contemporary cultural problems in Western societies.

In the guise of an essay, the book obviously benefits from the work of expert historians whose ideas I have striven to summarise and reference as faithfully as possible, although it has also been fed from my own research and that of the members of our team at the Centre d'Història de la Ciència (CEHIC) at the Universitat Autònoma de Barcelona. In any event, any error or omission is my own fault. Likewise, the book also draws from numerous intellectual traditions – the history of the book and reading, cultural history, literary studies, 'science, technology and society (STS)' – which unquestionably enrich the work of historians of science, but which also place them on stony ground where one often feels like a temporary visitor, like a member of the lay audience. Here, too, I take full responsibility for my interpretation of these diverse theoretical frameworks and their application to specific historical examples.

The initial hypothesis put forward here is the possibility that the major efforts to popularise science, especially throughout the second half of the twentieth century, have not yielded their desired results, and that we are still trapped in a certain discontent of scientific culture. Through a lengthy journey into the past, this book explores the possible reasons for this discontent and suggests possible solutions. In the turbulent yet enriching crossing of the oceans of history, the reader is gradually transported to a new paradigm of participation in science, which challenges traditional methods of science popularisation today.

I speak from my passion for history and my vocation as a historian of science, yet I am aware that history does not solve today's problems. Perhaps it can only help us to understand some of the hidden causes of our concerns and dissatisfactions, to diagnose our discontent and to think about possible remedies.

I sincerely hope that the reader finds some of these 'remedies' in the forthcoming pages.

Notes

- 1 Cooter, Pumphrey (1994).
- 2 Brain (1993).
- 3 For reviews of the Spanish edition, see *Dynamis*, 32 (2), 2012: 501–21; *Isis*, 103 (4), 2012, 772–3; *Host*, 6 (Fall), 2012; *Actes d'Història de la Ciència i de la Tècnica*, 5 (2012); *Asclepio*, 66, (1), 2014.
- 4 Warner (2002b).
- 5 Secord (2000); Topham (2000); Knight (2006); Fyfe, Lightman (2007).
- 6 Bensaude-Vincent, Rasmussen (1997).
- 7 Daum (1998).
- 8 Govoni (2002).

- 9 Papanelopoulou, Nieto-Galan, Perdiguero (2009).
- 10 Bensaude-Vincent, Blondel (2008).
- 11 Shinn, Whitley (1985); Hilgartner (1990); Bensaude-Vincent (2000).
- 12 Raichvarg, Jacques (1991); Govoni (2002); Topham (2009b).
- 13 My thanks to Oliver Hochadel for his interest in finding unifying elements on the problem of science popularisation in different historical periods.
- 14 Bensaude-Vincent, Blondel (2008).
- 15 Bensaude-Vincent, Blondel (2008: 1–10).
- 16 Raichvarg, Jacques (1991).
- 17 Bensaude-Vincent (2000).
- 18 Jasanoff (2004).

1

INTRODUCTION

The discontent of scientific culture

In 2003, philosopher Joseph Agassi perceived popular science as: ‘vital for culture at large . . . to widen horizons and rationalize life . . . to break the isolation of science from rest of culture’.¹ But his optimism did not hide his concern about the role of science in our contemporary societies and the need to reassess its position. Despite many efforts in favour of its effective dissemination and its growing influence on major political and economic decisions, for many privileged observers, science would have been relegated, especially in the second half of the twentieth century, to a certain marginalisation and isolation in relation to ‘culture’. In his famous book, *Das Unbehagen in der Kultur* (1930) – translated into English as *Civilization and Its Discontents* – Sigmund Freud (1856–1939) believed that modern science had failed to make the Enlightenment dream come true; a dream where the progress of natural philosophy had to yield to the progress of moral philosophy. Most scientific advances have only apparently affected human happiness. Once the euphoria of novelty had worn off, an inevitable hidden face would always appear. In Freud’s own words:

In the last generations, man has made extraordinary strides in knowledge of the natural sciences and technical application of them, and has established his dominion over nature in a way never before imagined . . . But men are beginning to perceive that all this newly-won power over space and time, this conquest of the forces of nature, this fulfilment of age-old longings, has not increased the amount of pleasure they can obtain in life, has not made them feel any happier. The valid conclusion from this is merely that power over nature is not the only condition of human happiness, just as it is not the only goal of civilization’s efforts . . . If there were no railway to make light of distances, my child would never have left home, and I should not need the telephone to hear his voice . . . What is the use of reducing the

2 Introduction

mortality of children, when it is precisely this reduction which imposes the greatest moderation on us in begetting them . . . And what do we gain by a long life when it is full of hardship and starved of joys and so wretched that we can only welcome death as our deliverer?²

This controversial Freudian diagnosis of our supposed unhappiness should be analysed in depth in its own historical context – a task that obviously goes beyond the scope of this book. But Freud's dissatisfaction with the results of scientific progress does not seem to have been completely eradicated in the present, and has become a passionate topic of debate, which certainly requires further analysis.

The positivist optimism that advocated a direct link leading from scientific to moral progress experienced a serious setback with the crisis in capitalism of the stock market crash in 1929, the same year that Freud began to write *Civilization and Its Discontents*. But this regression was only aggravated through the second half of the twentieth century, especially after the appalling consequences of World War II: the tragic end of the German scientific hegemony in 1945, which inspired Theodor Adorno (1903–69) and Max Horkheimer (1895–1973) in their famous *Dialectic of Enlightenment* (1947);³ the start of the nuclear arms race and the Cold War; the persistence of poverty and hunger among much of the world's population; and rising concern over the environmental price of industrial growth.

Perhaps the American historian Leo Marx was right when he said that the second half of the twentieth century was the time of 'post-modern' pessimism, a period that witnessed the death blow to the old Enlightenment dream of progress. The horror of the Nazi military-industrial complex, which was capable of unleashing the Holocaust, the terrible deaths among civilians with the atomic bombs in Hiroshima and Nagasaki, and accidents such as Three Mile Island, Bhopal, the *Exxon Valdez* and Chernobyl were all combined with a worrying process of natural degradation, loss in biodiversity, air and water pollution, acid rain, deforestation and desertification, the greenhouse effect, a hole in the ozone layer and the threat of climate change.⁴ Along similar lines, when analysing the role of science throughout the twentieth century, the prestigious historian Eric Hobsbawm stressed that:

The progress of natural sciences took place against a background glow of suspicion and fear . . . fuelled by four feelings: that science was incomprehensible; that (both) its practical (and moral) consequences were unpredictable and probably catastrophic; and that it underlined the helplessness of the individual and undermined authority.⁵

That pessimism could be even partly quantified. In the 1990s, more than 6,000 scientific articles appearing in the British press between 1946 and 1990 were analysed and classified. Among other striking results of the study, in around 1960 there emerged a kind of natural split between two contrasting views of

science. In the preceding period, despite the horrors of the two world wars, the start of the Cold War and the arms race, the press still mainly disseminated a positive image of science as beneficial for humanity, and one that deserved to be celebrated by reporting on the major events in the lives and deaths of the great scientists and their discoveries. However, articles dating from post-1960 generally showed a much more negative, critical image filled with risks and dangers, albeit without delving too deeply into the underlying causes.⁶

As Harry Collins discussed in his recent book on scientific expertise, we have moved from a heroic image of science to a new scientific culture of everyday life in which things are crowded and complicated, full of uncertainties and risks that weaken the authority of the experts.⁷ The following section is an attempt to analyse the possible causes of this shift.

1.1. The 'deficit model' legacy

In view of this negative image, which questioned the underlying values of Western societies, voices came to the fore that attributed dissatisfaction to the supposed scientific ignorance of the public at large, to a growing distance between contemporary societies and their expert elites.⁸ In the 1980s, the 'deficit model' became popular in the English-speaking world through a movement called the 'Public Understanding of Science' (PUS), which assumed a considerable epistemological inferiority between experts and receivers of a scientific discourse. PUS stressed the chasm separating both camps and reinforced the role of scientists. It legitimised new professionals, science communicators, who were supposed to act as mediators to effectively and faithfully transmit 'official' knowledge to lay audiences, the latter receiving information acritically and supposedly passively via simple accumulation. This was the only way to improve the public image of science, which had been considerably damaged.⁹

The supposed public deficit justified a kind of scientific 'crusade', one that was vertical and one way, top-down, which legitimised an alliance between scientists' professional interests and political and corporate power, which was more concerned with justifying science than with it being effectively understood among large audiences. In theory, PUS was supposed to bring benefits to science itself and to the economy, the nation, the individual and the democratisation of society as a whole, along with moral, aesthetic and intellectual benefits. It would also act as an antidote to 'anti-science' movements which promoted pseudo-scientific practices that had always caused consternation among contemporary science popularisers and professional scientists.¹⁰

PUS was largely justified by the professional scientists' own discomfort with the supposed ignorance of the public, with hopes that better information would ultimately lead to greater social acceptance of science. In 1989, an article entitled 'The Public Understanding of Science', which appeared in the prestigious journal *Nature*, concluded that, based on several surveys conducted in the United Kingdom and the United States, the public had a very low level of scientific

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understanding. Citing the example of Isaac Asimov (1920–92), one of the top science writers of the twentieth century, the authors of the study stressed that in order to eradicate the mistrust caused by disinformation, PUS's popularisation efforts should build a new image of respect and admiration for science. Science popularisation therefore became a prime weapon, the ideal antidote to combat this discontent in scientific culture which had moved large swaths of the population to scepticism, often tinged with parascientific influences regarded as irrational. In its conclusions, however, the article displayed a certain degree of optimism:

Finally, there is the question of the relationship between public understanding and public support for science . . . Preliminary analysis of results on these measures indicates that there are important relationships between public understanding and public attitudes, with a tendency for better-informed respondents to have a more positive general attitude towards science and scientists . . . The results we have provided indicate that although the public is largely uninformed, it is also largely interested in science.¹¹

The problem, however, seems more complex than a certain ingenuous optimism about PUS indicates at first glance, and it dates from decades earlier. Back in the 1960s, numerous intellectuals criticised the populations of Western countries for blithely approving billions of dollars for scientific research through their votes, despite being incapable of understanding the meaning of this research. Unable to organise a political response, the new users of 'black boxes', unaware of their mechanisms and explanations, more or less explicitly mistrusted contemporary science. Its complexity and hyperspecialisation accentuated scepticism and ultimately led to a gradual expert–lay distancing.¹² Despite its qualitative and quantitative exponential growth, along with its intense process of specialisation, professionalisation and institutionalisation over the past two centuries, the social 'conquest' of science had never been fully accomplished. Traditional, popular wisdom had probably prevailed in the most stable communities and among the least adaptable individuals. In spite of the optimism of PUS campaigns, familiar beliefs and practices and a varied set of strategies of resistance would have remained.¹³

In 1965, the American historian Oscar Handlin claimed that the public had learned to tolerate science but not to assimilate it; it had tended to accept science as a useful 'truth' but one that was disconnected from their everyday beliefs or habits. This was top-down science, a science that had not truly changed the ancient beliefs in nature and morality and which had led to the coexistence or juxtaposition of two different kinds of knowledge that were supposedly disconnected from each other. In his unquestioning defence of expert science, Handlin contrasted academic knowledge with a vague, messy set of beliefs that he wished to eradicate. However, their very existence revealed that something had gone awry in the experts' popularisation plans.¹⁴

Along similar lines, in 1976 the prestigious American physicist Gerald Holton, who had a keen intellectual interest in the history and philosophy of science, was concerned about the poor public image of science in contemporary Western societies despite the vast efforts invested in reporting on it.¹⁵ Holton expressed a certain unease regarding the spectacular growth in educational projects, science museums and audiovisual products whose results were questioned then and still are today. His book *Science and Its Public* (1976) was primarily a reaction to the virulent criticisms against science in the nuclear age and the Cold War.¹⁶ Ultimately, Holton sought to use public debate to forge new alliances between science and society; new mechanisms of communication in a context of rejection and criticism.

However, communication problems also emerged within expert circles. As the literary critic Lionel Trilling (1905–75) bemoaned in his 1972 essay ‘Mind in the Modern World’,¹⁷ the core of modern scientific knowledge was not shared by many people in the world of the humanities and social sciences. In other words, Trilling was reviving the old debate from the 1950s unleashed upon the publication of the famous book by British scientist Charles Pierce Snow (1905–72), which criticised the increasing gulf between humanistic culture and scientific culture in Western societies. Snow signalled a gradual impoverishment and isolation of the different expert groups who were unable to engage in fluid, open dialogue, which in the long term would affect their ability to communicate.¹⁸

Some of these problems, which showed symptoms of a Braudelian ‘longue durée’,¹⁹ seemed even to have survived the wave of PUS in the 1980s. In 1994, the exhibition ‘Science in American Life’ opened at the Smithsonian Institution’s Museum of American History in Washington, DC, sponsored by the American Chemical Society, the powerful association of professional chemists in the United States.²⁰ The exhibition comprised five thematic areas: 1. ‘Laboratory science comes to America’, which explained the synthesis of saccharine as a sweetener and the changes this brought about in the diet of everyday citizens; 2. ‘Science for progress’, which described the technological advances from 1930 to 1940 as they were presented at the 1939 New York World’s Fair; 3. ‘Mobilising science for war’, which discussed the atom bomb and the Manhattan project, along with the discovery and application of penicillin; 4. ‘Better than nature’, which presented the benefits of DDT (despite the old controversies from the 1970s which came in the wake of the famous book by Rachel Carson, *Silent Spring* [1962]), plastics and contraceptive pills; and 5. ‘Science in the public eye’, which examined the latest advances in genetics and superconducting.

Despite these clearly positive and constructive titles, not to mention the rhetorical separation between scholarly science and its subsequent applications, the exhibition contained critical notes on the role of science in society – the marginalisation of social minorities from the practice of science, ethical and environmental problems and the close relationship between science and war – which caused significant upheaval in American public opinion and placed the American

Chemical Society in an awkward position as the promoter of the exhibition. The press debate spurred by 'Science in American Life' regarding the worth or shortcomings of the public image of science deserves specific, in-depth examination of its own. However, what is relevant here is the very existence of this controversy, the resistance by many actors in contemporary science to accepting a minimally critical vision of science, its social immersion and its consequences in the everyday lives of citizens. What was the source of this unease? Why is the dialogue between scientific experts and lay citizens still so complex and rough at the edges at the dawn of a new millennium? Why, in short, is scientific progress perceived with mistrust by much of society, while at the same time the leading scientists, entrenched in their shells as the unquestionable authority, often discard lay opinions?

In the recent past, science popularisation has been perceived as a route of legitimisation and social acceptance of science's own status. But there have also been warnings against the dangers of oversimplification and even distortion of supposed 'truths', or even caution about a doorway open to the 'dangerous' pseudo-sciences. The statistics in France largely fuel this concern. In 1995, in the country that was the cradle of the Enlightenment and positivism, 50,000 citizens defined their profession on the income tax declaration form as astrologers, mediums or healers, while only 36,000 defined themselves as Catholic clergy and 6,000 as psychiatrists. Recent surveys confirm a notable rise in the followers of witchcraft and parapsychology. And as a backlash to biomedicine, which deconstructs human nature down to its tiniest particles, France is also the country that consumes and produces the most homeopathic medicine.²¹

To the minds of many scientists, opening the doorways of their palaces of knowledge too wide entails the not negligible risk of comparing science to any other corpus of beliefs and values, in a kind of alarming epistemological symmetry tinged with relativism which has caused a great deal of unease among many professionals in recent decades. Most of them were trained in the epistemological superiority of scientism, so they tend to scorn relativism which upholds a plurality of contingent, local rationalities.²² This was the case, for instance, of the famous 'science wars', which have had many emblematic episodes, including the major scandal caused by physicist Alan Sokal. In 1996, with the specific intention of discrediting this rising relativism, Sokal managed to bypass the peer-review system and publish an article brimming with falsehoods in the journal *Social Text*.²³ With this 'experiment' he sought to demonstrate the depths to which some humanists and social scientists had reached with their interest in the study of science yet imprisoned by their own ignorance.²⁴ The consequences were bitter and rancorous, and once again questioned the problem of scientific authority and the limits of expertise.²⁵ The conflict had probably begun in 1994 with the publication of a controversial book by biologist Paul Gross and mathematician Norman Levitt as a reaction to the criticism proffered against science by the 'academic left' which, in their opinion, was seriously contaminating scientific research.²⁶ The book by Sokal and Jean Bricmont on what they

considered ‘intellectual impostures’ appeared in 1998 at the height of the science experts’ fury towards the supposedly relativist or simply fraudulent new interpretations.²⁷

Indeed, from the 1980s onwards, the supposed excessive influence of the social sciences and humanities in public opinion has become one of the ‘demons’ in the scientific community. Their bid to analyse science as a topic of study has often been regarded as overly radical. From the perspective of the established expertise these positions place too much emphasis on the relationship between science and power and attack this naïve yet effective image of an objective, neutral science as an unquestionable servant to the progress of humanity.²⁸ As noted by the British thinker Jérôme R. Ravetz, the public perception of science had changed considerably.²⁹ In a short time, science went from being considered a neutral, objective method of studying nature or discovering the ‘truth’ to being viewed as a phenomenon that is socially conditioned by factors such as values, beliefs, professional interests, personal ambitions or property rights.³⁰ Thus, the current criticism of science often expresses itself publicly and grounds its opinions on science’s lack of social robustness; that is, on science’s inability to engage itself in sincere dialogue with society.³¹ This nostalgia for pure science can be seen in France, for example, with the frequent protests by professional researchers (around 150,000 in the entire country) against the hierarchisation of the science system and the reduction and control of the public sector. The primacy of academic research with independent cognitive purpose is giving way to a new regime of knowledge in which, within a new techno-scientific paradigm, the distinction between basic and applied research and the supposed idealised independence of the scientist from society is becoming blurred.³²

If modernity is based on values such as the prestige of academic science and its ability to shape technology, the new era has produced, as we shall see in several chapters of this book, the hegemony of technology and the crisis of scientific expertise, the crisis of the traditional disciplines as they gradually converge in a new corpus of knowledge in constant negotiation with social actors.³³ For authors like Helge Nowotny and Dominique Pestre, science can no longer base its authority on claims of its special relationship with truth or its role as a mouth-piece for nature itself. Both claims have lost strength and meaning and have been replaced by other more instrumental values. What truly matters today are relations with industry and the markets to produce complex technical gadgets and tangible benefits for society.³⁴ Along similar lines, in the 1980s the French philosopher François Lyotard (1924–98) heralded a view of knowledge in which traditional academic science gradually lost legitimacy. This was mainly due to a crisis in science’s role as an emancipating agent, the weakness of a big picture for the sake of unbridled specialisation and the accelerated fragmentation and plurality of discourse.³⁵

Still framed within the deficit model, Western science and its experts are increasingly concerned with their public image, and their possible loss of influence and social acceptance. Hence the repeated attempts in expert circles

(professional scientists, public administrators and private managers) to boost the public interest, understanding and even complicity with science – yet another symptom of the discontent of scientific culture which is clearly visible today.³⁶

These are just impressionistic and by no means exhaustive glimpses of our inherited discontent. This is probably due largely to the negative consequences of what could be described as a ‘traditional’ view of science popularisation which must have subtly filtered through our world views and values through the twentieth century. Many authors concur in asserting the legacy of overly biased, vertical, textual, ahistorical scientific knowledge.³⁷ From this angle, scientists and scientific institutions are the indisputable authorities when deciding what is and what is not science, between what should be transmitted to society and what should remain within the restricted expert sphere.³⁸ Expert authority would also be attributable to any historical period with no distinctions or nuances. Moreover, the supposed lay audiences would, in scientific terms, be a desert of ignorance and epistemological passivity; they would have practically no say, nor could they question the experts’ superior and more reliable knowledge. In some cases, they may express their satisfaction or dissatisfaction as the spectators of a given public display of science (lectures, museums, films, etc.), but they could never question the content. Literary or even artistic criticism, which is deeply rooted in the public sphere in the West, could not be extrapolated to science, since knowledge of the latter would always travel one way: from the expert knowledge creators to the ignorant audiences.

In this tradition, scientific knowledge mainly lies in texts. It reinforces experts’ authority as the ‘legislators’ of knowledge, as the authors of the written norms to distinguish a rigorously ‘scientific’ explanation from a more or less superficial account of a given phenomenon. So, in the popularisation process, these texts would be simplified and often distorted or degraded, and knowledge would lose its pristine state of purity once it was modified to be explained to those who are not in the know. Obviously, each scientific speciality would develop its own language (literary, mathematical, symbolic) and choose its own canonical reference texts. However, other ways of expressing scientific knowledge (drawings, photographs, models, scale models, diagrams, laboratory objects, etc.) would have secondary consideration that was more subsidiary or complementary to the essence of written or printed knowledge.

In this traditional view, science popularisation tends to be considered politically neutral. The very formal separation between science and technology in many public discourses would feed into this idea, such that the intellectual creation of pure, rational and objective science would be liberated from the purported miseries of the quotidian, from any ethical responsibility for its applications. This would justify the need to spread science to lay audiences, to prevent them from falling into the boggy terrain of pseudo-science or into the subjectivity of ideology or personal opinions. In fact, all of this stems from the issuers’ self-satisfaction and ethical and epistemological superiority, based on the supposed victory of the expert’s *episteme* over the lay *doxa* or public opinion. In 1990,

historian of science Steven Shapin largely summarised the spirit of the traditional view of science popularisation in the following terms:

Where science . . . was once influenced by or interfered with the public and other institutions, the scientific community controls its own proceedings, stipulates the nature of proper relations between itself and the public, and even extends its influence importantly into the arena of public affairs.³⁹

More or less consciously, the inherited image of modern science is too centred on a very small elite who create fascinating theories, experiments and machines. For decades, the standard accounts of the great figures, the history of the science of luminaries such as Copernicus, Galileo, Newton, Darwin and Einstein and of their outstanding works has distanced us from scientific discourse closely tied to the context in which they were born, grew and developed. They have fostered instead a gulf between the great actors in history and the supposedly ignorant passive masses. This is an apparent paradox, yet one that is extremely important in the construction of Western culture. If at first increasingly large audiences consumed scientific discourses, especially from the nineteenth century, and contributed to the construction of new and more fluid channels of lay–expert communication, precisely the opposite seems to have occurred. The authority of the scientific elites has been legitimised through an almost esoteric gulf between science creators and science consumers. It has constructed a public image of an optimistic, neutral, objective, useful science in which audiences always play second fiddle.⁴⁰ From this perspective, modern science would have been erected based precisely on its distance from public opinion, preventing itself from being influenced or contaminated by it. It would have been forged in the great pro-science crusade of the twentieth century which largely sought to redeem science's poor image after the two world wars, or in its victory over the supposedly depraved opinions of irrationalism and superstition.⁴¹

The now-famous article published by Stephen Hilgartner in 1990 in the journal *Social Studies of Science* accurately describes the stages in the traditional model of science popularisation.⁴² First, from their supposed position of considerable autonomy from the rest of society, professional scientists develop new knowledge in their laboratories and research centres, which are closed to the public. In the second phase, the scientists themselves, who are often science popularisers as well, spread new versions of this knowledge to society at large. However, Hilgartner criticised the way scientists and experts use this popularisation strategy to make their own definition of how science should be interpreted by lay audiences, and to thus maintain their privileged social status. This is a 'dominant view of popularisation', with appropriation and control over the contents of the simplified discourses. This dominant view would give scientists something akin to the epistemic value of the right to mint coins. Even in cases where experts could demonstrate that the popularisers had made mistakes when disseminating

science to the public, this would likewise reinforce their authority as the exclusive repositories of knowledge.⁴³

Other authors have followed Hilgartner's critical thinking towards the traditional view of scientific popularisation and the deficit model. In 2000, David Dickson, the news editor of *Nature* and a brilliant science writer, assessed several aspects of a report by the British House of Lords on the relationships between science and society at the end of the millennium.⁴⁴ Dickson rejected the image of a hierarchical transmission of science (largely legitimised by PUS).⁴⁵ He expressed it with the claim 'The public is not stupid', which perhaps overly succinctly yet powerfully summarises much of the spirit of this book.⁴⁶ In other words, our science audiences in the broad sense do not remain passive. They have a variety of intellectual tools at their disposal to more or less critically examine the addresses from the experts, institutions and media. According to Dickson, years ago publications like MIT's *Technology Review* and *New Scientist* managed to develop a discourse that was sensitive to the complex epistemology of their readers, but this communication style had lost force and influence in recent decades. Dickson advocated stimulating a constructive dialogue between the issuers and receivers; an epistemological strengthening of the public, ultimately through a controversial yet necessary process of gradually democratising contemporary science.

1.2. The power of the publics

A good number of the case studies appearing in this book have been researched and analysed in the last decades under the banner of the social and cultural history of science. The old critique against a history of the great figures and ideas; the relevance of any kind of historical actors for the sake of a more symmetrical approach to the past; the importance of everyday practices, objects, tacit knowledge, as well as the crucial role that the seduction of specific audiences plays for the legitimisation of theories and experiments, all are firm reasons for historiographical renewal.⁴⁷ In 1990 Steven Shapin published 'Science and Its Publics',⁴⁸ a canonical paper on a revisited history of science popularisation, which remains today a reference text to be cited as an introduction. Moreover, in tune with the 'strong programme' of the Edinburgh School of the 1980s, Shapin wrote a critical approach to the Scientific Revolution, a 'social history of truth'.⁴⁹ Together with Simon Schaffer, he described how the distinguished publics shaped the authority of Robert Boyle's experiment with the air pump at the Royal Society, and contributed to a serious revision of the nature of science in the sixteenth and seventeenth centuries.⁵⁰

Nevertheless, as one of the paradoxes of our intellectual adventure, a good part of the critical revision of the deficit model has found its inspiration in thinkers such as Ludwik Fleck (1896–1961) and his 'esoteric-exoteric' circles, Antonio Gramsci (1891–1937) and his concept of 'cultural hegemony', and Jürgen Habermas (1929–) and his description of the 'public sphere'. It is therefore possible to describe a new participatory model through some of their proposals, and link them to later, more