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Towards a Negative History of Science: The Unknown, Errors, Ignorance, and the "Pseudosciences"

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Abstract: This article outlines elements of a negative history of science. For historians wishing to get a fuller picture of scientific practice both internally and externally, there is a lot to be gained by considering the dialectical constitution of scientific knowledge. To fully comprehend this relationality, historians should, therefore, trace the *negative* relations science maintains. Through oppositions, such as known/unknown; success/error; consideration/ignorance; and inclusion/exclusion, scientific knowledge emerges and disappears, and the social position of scientific practice is both established and contested. To exemplify our argument, we present four areas: the unknown, errors, ignorance, and the "pseudosciences". Taken together, this approach allows us to understand how science constitutes itself epistemically and socially across different locations and historical periods.

Keywords: history of science; unknown; errors; ignorance; pseudoscience; non-knowledge; agnotology; epistemology; dialectics

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Citation: Rathjen, Lukas, and Jonas Stähelin. 2022. Towards a Negative History of Science: The Unknown, Errors, Ignorance, and the "Pseudosciences". *Histories* 2: 146–156. https://doi.org/10.3390/histories2020011

Academic Editors: Volker Remmert, Dania Achermann, Cécile Stephanie Stehrenberger and Fabian Link

Received: 25 February 2022
Accepted: 16 May 2022
Published: 20 May 2022

1. Introduction

Do the boundaries of the history of science mirror the boundaries of science itself? Or does the former always transcend the latter?[1] Questions such as these have been a part of the history of science since its inception as an independent discipline (Daston 2017). In what follows, we want to contribute to this ongoing discussion with the following hypothesis: to get a better picture of both the internal as well as the external workings of scientific practice, the history of science may gain a lot by considering the dialectical constitution of scientific knowledge. In calling this approach a "negative history of science", we are not arguing that historians of science should position themselves negatively against their own discipline. Rather, we are offering a new perspective that looks at the *negative* relations scientists maintain and how they constitute their practice through them.

Drawing on different lines of research in the history of science, we will map out this "other" side of science. Four areas will be presented below: the unknown, errors, ignorance, and the "pseudosciences". On the one hand, we shall direct our attention to social practices that interrupt or are perceived by scientists as dangers and setbacks to scientific knowledge production. On the other hand, we aim to show how science only functions in and through its relation to the unknown or errors.

In what follows, we argue that all these four areas refer to phenomena from which scientists or the scientific community at once seek to distinguish themselves while remaining closely bound up with them. The analysis of the unknown and errors draw our attention to localized laboratory or visual practices, such as map making, while looking at the production of ignorance and "pseudoscience" debates takes us to the interface between the scientific community and sources of power, such as institutional funding and public authority. Although scientists usually relate to these areas in negative terms, as something that has to be eliminated or excluded, this relation also carries important social and epistemic functions. Taken together, this approach reveals a dialectic movement that is central to the establishment of scientific practice across different locations and historical periods.[2]

2. Tackling the Unknown

At first glance, it seems obvious to identify the unknown with the opposite of knowledge.[3] This may lead us to assume that what we do not know is necessarily located outside of the established scientific order. From an epistemological perspective, however, such an assumption is problematic because it obscures the ways in which the unknown has been and continues to be part of scientific knowledge production—rhetorically as well as practically.

For example, in Francis Bacon's *Novum Organum,* the unknown figured as the frontier that knowledge was to conquer—famously visualized in the original frontispiece where a ship sets out to the great sea (Shapin 1996, p. 20). The colonial underpinnings of such a view of scientific advance are quite striking, and Bacon's imbrications with colonialism have been the subject of some research (Zeitlin 2021). The historian of science Carolyn Merchant developed this point into a feminist and ecological critique of Bacon's "new science" (Merchant 1980, 2008). As she argues, Bacon's new experimental method that aimed to extract the "secrets of nature" was closely tied to the desire of extracting the "secrets of women" (Merchant 2008, p. 151).

Such a territorial understanding of the unknown as a *terra incognita* yet to be explored and conquered leads back to the history of early modern cartography and the problem of empty spaces (Relaño 2002; Laboulais-Lesage 2004; Hiatt 2008). However, according to Cornel Zwierlein, the unknown was not only limited to the empty spaces on maps that cartographers had to designate and visualize, but the period in general was characterized by a new and evolving drive to "define the unknown across the four fields of politics and economics, religion, general knowledge and history, and science" (Zwierlein 2016b, p. 2). Zwierlein's approach thus shows how orders of knowledge, such as enlightened empires, were built on the processing of the unknown in different epistemic fields (Zwierlein 2016a).

While the frontier suggested a potentially limitless expansion of scientific knowledge, 19th century scientists increasingly underscored the epistemological limits of their practice. In 1872, the German physiologist Emil du Bois-Reymond famously proclaimed that certain "riddles" of the universe—the nature of matter and the relation of the brain to consciousness—would never be solved (du Bois-Reymond 1874). To ensure science's continued progress, he further argued scientific practice had to be restricted to controlled measurement and calculation. This in turn entailed recognizing an absolute limit of knowledge, which science would never be able to surpass (Finkelstein 2013; Anacker and Moro 2016).[4]

With respect to 20th century scientific practice, the historian of science Hans-Jörg Rheinberger argues that the unknown is not just an external point of reference, but lies at the very heart of what he calls "experimental systems" (Knorr-Cetina 1991; Rheinberger 2005, 2010a, 2010b, 2021). Studying the historical emergence of the concept of the gene as an "epistemic object", Rheinberger has shown that the productivity of this concept resulted from the fact that it organized experimental access to the organism and thus allowed acting in and through the unknown. Experimenting with the gene presupposed not knowing what it was. Once it became known, it was no longer an epistemic object but a technical one (Rheinberger 2000). To drive the main point home, experimental practice precedes knowledge. Rather than starting from the basis of the known to then build up ever more knowledge, experimental systems instead integrate the unknown "in such a way that it becomes the source of knowledge" (Rheinberger 2005, p. 81). For Rheinberger, therefore, the whole material practice of experimenting is centered around generating and increasing the possibility of unforeseen events rather than eliminating the unknown (Rheinberger 2010a, p. 149; Rheinberger 2021, p. 200).

By underlining the epistemic functions of the unknown, however, we should not fail to recognize that scientists may also engage in covering up its existence. Such an observation can be made concerning a well-known topic in the history of science, namely gene mapping. Genetic researchers—not least in order to gain financial resources—had to present genetic maps by arguing for their completeness, while, in truth, their mapping method always left gaps open. Consequently, the unknown was rejected or transformed into an empty formula that suggested knowledge where knowledge was actually missing. As the historian of technology David Gugerli noted, "[m]aps ask to be completed" (Gugerli 2004, p. 215).

Whether understood as a frontier, an absolute limit, or as an experimental tool for the production of scientific knowledge, scientists continuously relate to the unknown in different ways. In the examples we portrayed, the unknown did not figure as a threat or an obstacle to knowledge but rather served as the condition for science's continued existence and historical development. By forming an epistemic horizon, the unknown gives science its direction. This mobilization of the unknown can have rhetorical dimensions, as in the case of Francis Bacon, as well as practical ones, as in the case of Rheinberger's conceptualization of experimental systems. There is much to be gained, therefore, by taking a closer look at the ways in which the unknown forms the substructure of epistemic orders.

3. Dealing with Errors

The history of science is littered with past errors. As science evolves, sometimes through revolutionary means, what was once considered scientifically valid can turn out to be based on a cascade of errors; an observation that is equally true with respect to our current knowledge. Historians of science have directed their attention to errors in varying degrees. In the history of astronomy and mathematics, for example, errors have been a somewhat recurring topic of research for historians interested in observational errors and the mathematical solutions proposed in response to them (Sheynin 1977; Proverbio 1988).

However, errors are not only hindrances to knowledge and looking at them should not lead to the adoption of a whiggish perspective. As some examples drawn from the history of physics show, they are also integral to the process of scientific knowledge production. This is particularly visible within the research tradition of "New Experimentalism". In 1983, the philosopher of science Ian Hacking described one of the great scientific breakthroughs of the 20th century, the discovery of cosmic microwave radiation, as resulting from the analysis of possible sources of instrumental error. Against this backdrop, Hacking then famously argued that experiment "may for long have a life of its own" (Hacking 1983, p. 160). In 1987, Peter Galison urged historians and philosophers of science to get rid of their theoretical aloofness and follow the historical actors into the material depths of their experimental labs (Galison 1987, p. 19).[5] To understand the particular moment when experimenters considered the reality of an investigated phenomenon to have been convincingly established, historians needed to take account of the role dealing with errors or background noise played in this process: "In the laboratory the scientist wants to find local methods to eliminate or at least quantify backgrounds, to understand where the signal is being lost, and to correct systematic errors" (Galison 1987, p. 245).

The sociologist of science Karin Knorr-Cetina sees errors as part of the larger category of "liminal phenomena". Instead of treating liminal phenomena, which also include uncertainties and imperfections, as marginal, Knorr-Cetina argues, the high energy physicists she studied at the CERN put them at the center of their attention, thus cultivating a form of "negative knowledge" which is "not nonknowledge, but knowledge of the limits of knowing, of the mistakes we make in trying to know, of the things that interfere with our knowing" (Knorr-Cetina 1999, p. 64). Because high energy physicists never directly see the objects they are studying—a fact Knorr-Cetina calls the "loss of the empirical"—they spend a lot of time figuring out if what their apparatuses are showing them refers to something really existing or if it is not simply the result of an instrumental artifact with no basis in reality (Knorr-Cetina 1999, p. 46).

Instead of reducing the experiment to an abstract practice of theory confirmation or refutation, looking at how scientists deal with errors reveals something about experimental procedures as a concrete historical practice. The history of experimental practice in particular can be written as a history of practices concerned with identifying and solving errors, an area which has been of particular interest to scholars working at the intersection of historical and philosophical approaches to the study of science (Mayo 1996; Elliott 2004; Schickore 2005; Buchwald and Franklin 2005; Boumans et al. 2016). More recently, a systematic approach to this topic was taken up in an edited volume that mapped out the epistemological functions of errors within the broader category of science "going amiss" (Hon et al. 2008).[6]

However, the study of errors need not be restricted to the study of experimental practice. According to the historian of science Lorraine Daston, the emergence of modern science can be explained by a shared "fear of errors" and the search for possibilities of counteracting them (Daston 2005, p. 4).[7] To this day, the scientific community continues devising mechanisms that supposedly shield it from erroneous knowledge. The peer-review process is the most well-known example in this regard. Yet, while many consider this to be science's self-correcting mechanism par excellence, it often fails to stop research from being published that later turns out to be faulty or difficult to reproduce.[8] An awareness of this problem exposes that science's error-correcting processes do not work correctly, and it has forced the scientific community to rethink its standards of publication and quality assurance.

4. Producing Ignorance

The role of ignorance in science can be approached from different angles (Wehling 2021). Ludwick Fleck and Thomas Kuhn pointed out that ignoring, selecting, and even rejecting certain facts were important to establishing the coherency and productivity of a given group of scientists (Fleck 1979; Kuhn 1962).[9] In "Against Method", Paul Feyerabend even argued that "ignorance [. . .], far from impeding the forward march of knowledge may actually aid it" (Feyerabend 1993, p. 197). Studying how these types of ignorance, integral to scientific practice, are socially constructed was further developed in the 1980s by sociologists of science Michael Smithson and Jerome Ravetz (Smithson 1985, 1993; Ravetz 1986).[10] While the just mentioned examples stressed the non-intentionality of ignorance as a necessary byproduct of scientific practice, we should also focus on intentional scientific ignorance. For example, scientists may block certain data for career reasons, choose to ignore scientific knowledge that may cause public harm or ignore data that contradicts one's own argument.

In the past three decades, intentional forms of ignorance production were mainly investigated in connection with practices that strategically aim to hamper and weaken the status of scientific knowledge in society. The main approach to study such practices has come to be known as "agnotology", a term developed in 1995 by the historians of science Robert N. Proctor and Iain Bol. In its most concise formulation, Proctor defined "agnotology" as "the study of ignorance making, lost and forgotten". (Proctor and Schiebinger 2008, p. I)

Investigating how ignorance is made and sustained strategically was then taken up by a range of historians (Proctor and Schiebinger 2008; Proctor 1996; Schiebinger 2004; Galison 2004; Oreskes and Conway 2008, 2010; Kleinman and Suryanarayanan 2013; Henry 2017; McGoey 2019). In "Merchants of Doubt", the most prominent work to have emerged from this field, Naomi Oreskes and Eric Conway outlined how four distinguished scientists adopted strategies that the tobacco industry had used since the 1960s to make people doubt the dangers of smoking. Backed by major conservative think tanks and the Reagan administration, these scientists also produced doubt regarding global warming, acid rain, and the ozone hole. By fostering such a false culture of doubt, they constructed themselves as defenders of open scientific discourse—they were "using science against science" (Oreskes and Conway 2010, p. 13)—and thus transformed doubt, which is normally considered as an important epistemic virtue, into its opposite, an epistemic vice (Cassam 2021).

Oreskes' and Conway's study reveals the often-hidden mechanisms of power that can shape science's position and influence on public discourse and it also challenged some of the popular misconceptions of science. We are often led to assume that science provides us with absolute certainty. Yet, precisely this assumption allowed these so-called "merchants of doubt" to continuously question the scientific consensus surrounding the hazards of tobacco consumption. According to Oreskes and Conway, we should adopt a more nuanced image of science that acknowledges that science does not produce certainty, while it nonetheless produces consensus driven by standards and norms shared by the scientific community. We would then be in a better position to question which kind of doubt is based on genuine scientific interest and which one is driven by covert political and economic ones (Oreskes and Conway 2010, pp. 266–75).

Janet Kourany and Martin Carrier synthesized forms of scientific ignorance as well as the production of doubt under the more general header of "Agnoepistemology" (Carrier and Kourany 2020b). In their understanding, ignorance encompasses both intentional as well as non-intentional and "passive" constructions of ignorance that scientists perform on a regular basis (Carrier and Kourany 2020a, p. 4). Arguing from a slightly more historical angle, Lukas Verburgt and Peter Burke recently proposed using ignorance as an umbrella term that points to the fact that the "knowledge society" may already be a thing of the past (Verburgt and Burke 2021; Verburgt 2020). Verburgt urged us to consider phenomena such as ignorance of the potentially negative effects of techno-scientific progress and of large-scale interventions into our natural environment as part of a joint history of ignorance and the Anthropocene. He then coined the term "agnotocene" to describe this current predicament. Although this approach may be read as a simple extension of Ulrich Beck's conception of "reflexive modernity", Verburgt departed from Beck's modernist convictions, according to which ignorance and uncertainties can be turned into a "knowable risk" (Verburgt 2021, pp. 6–9; Beck 1986; Bauman 1991).

We agree that ignorance should not be considered simply as the absence of knowledge but using it as an overarching concept would not adequately capture the dialectical dynamic between science and its others that our contribution underscores. We also agree that it is important to devote attention to all practices of ignorance, including the selection and rejection of knowledge.[11] However, it is equally important to maintain some differences. This concerns, for example, the deliberate manufacture of doubt. To be sure, doubt can also cause ignorance. However, what seems to distinguish the production of doubt from the other kinds of ignorance making, such as the rejection or outright censorship of knowledge, is that the former proceeds by producing a surplus of (dis)information that destabilizes the perception of scientific consensus.

Despite such reservations, looking at intentional as well as non-intentional practices of ignorance in science and the wider context of the (non-)knowledge society allows a precise description of the moments in which the production of scientific knowledge and its political, economic, and cultural impact is interrupted. Considering recent political upheavals, such as the Trump presidency; the rise of ultra-right-wing conservatism across Europe; as well as the COVID-19 pandemic, studying the intentional production of ignorance offers an important research perspective. In the age of "fake news" and the growing impact of conspiracy theories—consider the "doubts" raised against the safety of vaccines—the critique of politically and economically motivated doubt is a necessary political task.

5. Debating "Pseudosciences"

Calling an entire domain of research "pseudoscientific" results in a particularly strong form of doubt, for what has been labelled as "pseudoscientific" can be safely excluded from the scientific community. Looking at "pseudoscience" debates, therefore, offers an important extension to the concept of ignorance because it brings the question of the boundaries separating science from non-science into clearer focus. Studies exist on a diverse array of sciences that the majority of today's scientific community considers "pseudoscientific" (Pigliucci and Boudry 2013). These include, among others, astrology (von Stuckrad 2007), phrenology (Cooter 1984; Poskett 2019), eugenics (Adams 1990; Levine 2017), creationism (Numbers 2006), and parapsychology (Mauskopf and McVaugh 1980; Collins and Pinch 1982; Oppenheim 1985; Wolffram 2009; Noakes 2019). However, how were these areas of research distinguished from accepted science? For what reasons were they excluded from the scientific community? What does this distinction do for scientists and historians of science?

Paralleling the emergence of the modern concept of "science", the term "pseudoscience" began to attract wider currency in the 19th century (Thurs and Numbers 2011). In 1822, the French physiologist Francois Magendie used it to discredit the claims of phrenology to scientific status (Poskett 2019, p. 10). Although phrenology enjoyed quite a strong degree of popularity throughout the 19th century, it never achieved a firm place within the ranks of official science. Yet treating this episode merely as a pseudoscientific blunder, risks losing sight of the way in which phrenology captured many 19th century aspirations and sensibilities, such as a desire for a strict empiricism and the search for a material basis of racial, gender, and cultural inequalities—some of which continue to this day.[12] A similar thing can be said about eugenics, a field of research which was imbricated and largely compatible with the scientific and political aspirations prevalent at the time of its emergence (Levine 2017, p. 23; Adams 1990, p. 219).

Should we therefore refrain from using the term "pseudoscience" altogether? If not, who exactly is in charge of labeling a doctrine a pseudoscientific one? One way of answering these questions has been to shift the burden onto the historical actors themselves. The historian, in other words, should not use the term "pseudoscience" as an explanatory category but rather as an object of historical analysis (Adams 1990, p. 220). In his history of creationism, the historian of science Ronald L. Numbers, argued that, instead of exposing the defenders of creationism as "pseudoscientists", the task of the historian should be to trace "how persons and parties *used* 'science' and 'pseudoscience' to further their ends rather than in judging whether they employed these labels appropriately by the standards of the 1990s" (Numbers 2006, p. 14).

The more science consolidated itself into an "orthodoxy", the more it became necessary to distinguish itself from rival practices by denouncing them as pseudoscientific (Thurs and Numbers 2011, p. 284). Against this backdrop, a number of historians have recently taken to understanding "pseudoscience" as a particular instance of "boundary-work", a concept first developed in 1983 by the sociologist of science Thomas Gieryn to account for the ways in which scientists practically engage in demarcating their own work from other professional activities.[13] "Pseudoscience" comes into play in specific historical circumstances when individual or groups of scientists perceive a doctrine as a threat to their own social status. This threat is especially felt when the doctrine and the proponents thereof aspire to achieve access to the same resources, such as state funding or official university recognition (Rupnow et al. 2008; Hagner 2008, p. 25). The historian of science, Michael Gordin, who specializes in the history of the "pseudosciences", pointed out that studying "pseudoscience" debates reveals how "scientists thought about their standards, their position in society and their future". (Gordin 2012, p. 3). Most recently, Gordin has, therefore, contended that the existence of "pseudosciences" is inevitable and the sign of a healthy and dynamic scientific culture. Understanding how the boundaries between science and "pseudosciences" are established and disputed can help us come to grips with those "pseudosciences" that cause actual harm (Gordin 2021, p. 101).

In this light, the history of the "pseudosciences" is inseparable from the history of science. Science continuously relies on the construction of another to sharpen its own boundaries. The study of pseudoscience debates reveals how scientists continuously struggle to retain their place within the economic, political, and cultural structures of power at work in society. Looked at from the opposite side of the fence, these debates allow the study of how scientists deal with social trials in which their authority is questioned.

6. Conclusions

Our contribution has presented the unknown, errors, ignorance, and the "pseudosciences" as possible areas of interest for what we have called a *negative history of science*.[14] Apart from these there are others, such as precarious and threatened knowledge, which reveal similar dialectical dynamics. Nevertheless, we have chosen the above four because they provide us with a cross section through the history of science—from scientists exploring the unknown in the imperial age to scientists defending knowledge from being ignored in the age of disinformation. This cross section is a heuristic that is able to show both the tense relationship of science and its other and the historical dynamics of this field.

To different degrees, and at different moments in history, certain areas may become more important than others. Although we treated them separately for reasons of clarity, interrelations of course do exist. They bleed into each other and thus transcend a clear-cut distinction between an internalist or externalist understanding of science. For instance, errors or the existence of blank spaces of knowledge may just as much be ignored instead of becoming the center of attention. Yet scientists who choose to ignore or reject certain errors, which the majority of the scientific community considers as such, risk sliding off into the realm of “pseudoscience”.

We would like to close our contribution with a systematic consideration drawn from the above analysis. Our article has suggested that these four areas, which previous research has considered separately, can be brought into a closer relationship with each other. All fields refer to phenomena from which scientists at once seek to distinguish themselves while simultaneously maintaining a close connection to them. As long as scientists carry out their work, the unknown will be tackled, errors will be dealt with, ignorance will be produced and the “pseudosciences” debated. Taken together, this has revealed a dialectic movement lying at the core of science’s epistemic and social formation. Through oppositions, such as known/unknown; success/error; consideration/ignorance; and inclusion/exclusion, scientific knowledge emerges and disappears, and the social position of scientific practice is both established and contested. It is precisely this historical dimension of scientific practice that a *negative history of science* aims to capture. In this manner, science itself may provide some answers to the question of what it is—and it does so negatively, by confronting areas where it is not, cannot be, or does not want to be.

Author Contributions: Conceptualization, L.R. and J.S.; methodology, L.R. and J.S.; investigation L.R. and J.S.; data curation L.R. and J.S.; writing—original draft preparation, L.R. and J.S.; writing—review and editing, L.R. and J.S. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Swiss National Science Foundation.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: We would like to thank Kijan Espahangizi, our colleagues from the doctoral program *Geschichte des Wissens* as well as Michael Gordin for their critical comments and reviews. We are grateful to the guest editors of this special issue, in particular Cécile Stephanie Stehrenberger and Fabian Link, who kindly reviewed earlier drafts of this article. We are also thankful to the anonymous reviewers of this article.

Conflicts of Interest: The authors declare no conflict of interest.

Notes

1 Whether such questions necessitate a shift from a “history of science” to a broader conception of the discipline as a “history of knowledge” that includes domains previously considered non-scientific is not the central theme of this contribution (Cunningham and Williams 1993; Schneider 2003; Vogel 2004; Sarasin 2011; Speich Chassé and Gugerli 2012; Lässig 2016; Daston 2017). For recent discussions about the exact contours a “history of knowledge” is supposed to take, see the following references (Marchand 2019; Sarasin 2020; Borck 2020; Hagner 2020).

2 The understanding of the dialectical relations operating in science is not to be confused with the teleological underpinnings the term “dialectical” has in the tradition of Hegelian philosophy or historical materialism. Nor are we referring to Adorno’s “negative dialectics”. To lay out the differences and similarities between our understanding and the just mentioned philosophical schools in more detail, necessitates further theoretical work that would transcend the scope of this introductory article.

3 Historians of science have come up with a similar term to describe this supposedly unmapped terrain: The German term *Nicht-Wissen* has had a particularly wide currency among academics in the German speaking context, which is partially due to

the fact that this concept has enjoyed wide circulation within sociology since the 1990s (Beck 1996; Luhmann 1992; Böschen and Wehling 2004, 2015; Gross 2014). *Nicht-Wissen* was systematically taken up by historians at the end of the 2000s. This was part of a transition from a narrower emphasis on laboratory studies, which had dominated the 1980s and 1990s, to a broader history of knowledge (Geisenhanslüke and Rott 2008; Adler and Godel 2010; Bies and Gamper 2012). More research followed, which expanded the scope of *Nicht-Wissen*/non-knowledge in time and space (Espenhorst 2013; Dilley and Kirsch 2015; Zwierlein 2016a, 2016c; Corbin 2020). Literally translated as non-knowledge, the term has not found its way into much anglophone scholarship.

4 Emil du Bois-Reymond labelled his speech held in front of the Society of German Natural Scientists and Physicians *The Limits of our Knowledge of Nature.* This 19th century debate was not just restricted to scientific discourses, but also found its way into literary forums (Bies and Gamper 2012; Beiser 2014; Karpenko and Claggett 2017).

5 The method of following scientists into their labs to study what they were actually doing on a daily basis was championed a couple of years prior by Bruno Latour and Steven Woolgar in Laboratory Life (Latour and Woolgar 1979).

6 Apart from errors the authors also included “confusion”, “malfunctions”, “anomalies”, “artifacts” as further examples of science gone amiss.

7 According to Daston, we can better understand the emergence of the concept of objectivity in the 19th century by looking at how the intrusion of subjectivity gradually came to be considered the principal source of error (Daston 2005, p. 17). This argument strongly echoes her later work on the history of objectivity (Daston and Galison 2007).

8 The latter issue is known as the “replication crisis” and it especially concerns psychology and biomedicine. A cornerstone in this debate was the paper “Why Most Published Research Findings Are False” published by John P.A. Ioannidis in 2005 (Ioannidis 2005). For a brief overview on the topic see also (Gordin 2021, pp. 86–88).

9 Kuhn stressed that the “paradigm” acted as a relatively conservative force which channeled the establishment of new knowledge into clearly defined and agreed-upon domains. In his view, such a restriction guaranteed the continued operation of a given paradigm (Kuhn 1977).

10 In 1957, Robert K. Merton mentioned “specified ignorance” as “a first step toward supplanting [. . .] ignorance with knowledge”(Merton 1957, p. 417). Merton’s understanding of ignorance matches more closely with our notion of the unknown that directs the production of new knowledge. In this chapter, however, we have taken to understand ignorance more in the sense of a practice, intentional or not, that ignores things.

11 Most recently, historians introduced the concept of “threatened knowledge” that includes loss and forgetting as important aspects of a history of ignorance (Dürr 2022). This term can be seen as an extension of Martin Mulsow’s notion of “precarious knowledge” that underscores the material fragility of the production, circulation, and conservation of knowledge (Mulsow 2012).

12 In 2004, the historian of science, Michael Hagner, raised some critique towards more recent neuroscientific attempts at localizing intelligence in the brain, deeming them forms of “cyber-phrenology” (Hagner 2002).

13 Gieryn developed this concept in response to decades of failed attempts at solving the problem of “demarcation”, a term coined by the philosopher Karl Popper. Popper famously devised his criterion of *falsifiability* as the main marker distinguishing science from non-science (Popper 1963). Instead of trying to come up with universally applicable, philosophical criteria separating science from non-science through logical and semantical analysis, Gieryn argued on the contrary, that we should rather look at the practical ways through which scientists distinguish their work from “‘non-scientific’ intellectual or professional activities”. (Gieryn 1983, p. 791).

14 Although some of our claims could also be extended to a history of knowledge, we have focused on scientific knowledge. As long as *scientists* tackle the unknown, deal with errors, are engaged in practices of ignoring and debate “pseudosciences”, this network of relations falls within the subject range of the history of science.

References

Adams, Mark B., ed. 1990. *The Wellborn Science: Eugenics in Germany, France, Brazil, and Russia*. New York: Oxford Univ. Press.

Adler, Hans, and Rainer Godel, eds. 2010. *Formen des Nichtwissens der Aufklärung*. München: Wilhelm Fink.

Anacker, Michael, and Nadia Moro, eds. 2016. *Limits of Knowledge: The Nineteenth-Century Epistemological Debate and Beyond*. Philosophy 15. Milano: Mimesis.

Bauman, Zygmunt. 1991. *Modernity and Ambivalence*. Cambridge: Polity Press.

Beck, Ulrich. 1986. *Risikogesellschaft: Auf dem Weg in eine andere Moderne*. Frankfurt a.M: Suhrkamp.

Beck, Ulrich. 1996. Wissen oder Nicht-Wissen?: Zwei Perspektiven ‘Reflexiver Modernisierung’. In *Reflexive Modernisierung. Eine Kontroverse*. Edited by Ulrich Beck, Anthony Giddens and S. Lash. Frankfurt a.M: Suhrkamp, pp. 289–315.

Beiser, Frederick C. 2014. *After Hegel: German Philosophy 1840–1900*. Princeton: Princeton University Press.

Bies, Michael, and Michael Gamper, eds. 2012. *Literatur und Nicht-Wissen: Historische Konstellationen 1730–1930*. Zürich: Diaphanes.

Borck, Cornelius. 2020. Wissenschaft—After All. In *Feierabend? (Rück-)Blicke auf “Wissen”*. Edited by Sandra Bärnreuther, Maria Böhmer and Sophie Witt. Nach Feierabend. Zürcher Jahrbuch Für Wissensgeschichte 15. Zürich: Diaphanes, pp. 83–94.

Böschen, Stefan, and Peter Wehling. 2004. *Wissenschaft zwischen Folgenverantwortung und Nichtwissen: Aktuelle Perspektiven der Wissenschaftsforschung*. Wiesbaden: VS, Verl. für Sozialwiss.

Böschen, Stefan, and Peter Wehling. 2015. *Nichtwissenskulturen und Nichtwissensdiskurse: Über den Umgang mit Nichtwissen in Wissenschaft und Öffentlichkeit*. Baden-Baden: Nomos.

Boumans, Marcel, Giora Hon, and Arthur C. Petersen, eds. 2016. *Error and Uncertainty in Scientific Practice*. London: Routledge.

Buchwald, Jed Z., and Allan Franklin, eds. 2005. *Wrong for the Right Reasons*. Berlin: Springer.

Carrier, Martin, and Janet A. Kourany. 2020a. Introducing the Issues. In *Science and the Production of Ignorance. When the Quest for Knowledge Is Thwarted*. Edited by Janet A. Kourany and Martin Carrier. Cambridge: The MIT Press, pp. 3–26.

Carrier, Martin, and Janet A. Kourany. 2020b. *Science and the Production of Ignorance: When the Quest for Knowledge Is Thwarted*. Cambridge, MA: The MIT Press.

Cassam, Quassim. 2021. *Vice Epistemology*. London: Routledge.

Collins, Harry M., and Trevor J. Pinch. 1982. *Frames of Meaning: The Social Construction of Extraordinary Science*. London: Routledge and Kegan Paul.

Cooter, Roger. 1984. *The Cultural Meaning of Popular Science: Phrenology and the Organization of Consent in Nineteenth-Century Britain*. Cambridge History of Medicine. Cambridge: Cambridge University Press.

Corbin, Alain. 2020. *Terra Incognita: Une Histoire de l'ignorance, XVIIIe-XIXe Siècle*. Paris: Albin Michel.

Cunningham, Andrew, and Perry Williams. 1993. De-Centring the 'Big Picture': The Origins of Modern Science and the Modern Origins of Science. *The British Journal for the History of Science* 26: 407–32. [CrossRef]

Daston, Lorraine. 2005. Scientific Error and the Ethos of Belief. *Social Research* 72: 1–28. [CrossRef]

Daston, Lorraine. 2017. The History of Science and the History of Knowledge. *KNOW: A Journal on the Formation of Knowledge* 1: 131–54. [CrossRef]

Daston, Lorraine, and Peter Galison. 2007. *Objectivity*. New York: Zone Books.

Dilley, Roy, and Thomas G. Kirsch. 2015. *Regimes of Ignorance: Anthropological Perspectives on the Production and Reproduction of Non-Knowledge*. New York: Berghahn.

Dürr, Renate, ed. 2022. *Threatened Knowledge: Practices of Knowing and Ignoring from the Middle Ages to the Twentieth Century*. Knowledge Societies in History. London: Routledge Taylor & Francis Group.

du Bois-Reymond, Emil. 1874. The Limits of Our Knowledge of Nature. *The Popular Science Monthly* 5: 17–32.

Elliott, Kevin. 2004. Error as Means to Discovery. *Philosophy of Science* 71: 174–97. [CrossRef]

Espenhorst, Martin, ed. 2013. *Unwissen und Missverständnisse im vormodernen Friedensprozess*. Göttingen: Vandenhoeck & Ruprecht.

Feyerabend, Paul. 1993. *Against Method*. London: Verso.

Finkelstein, Gabriel. 2013. *Emil Du Bois-Reymond: Neuroscience, Self, and Society in Nineteenth-Century Germany*. Cambridge: MIT Press.

Fleck, Ludwik. 1979. *Genesis and Development of a Scientific Fact*. Chicago: University of Chicago Press.

Galison, Peter. 1987. *How Experiments End*. Chicago: University of Chicago Press.

Galison, Peter. 2004. Removing Knowledge. *Critical Inquiry* 31: 229–43. [CrossRef]

Geisenhanslüke, Achim, and Hans Rott, eds. 2008. *Ignoranz: Nichtwissen, Vergessen und Missverstehen in Prozessen kultureller Transformationen*. Bielefeld: Transcript.

Gieryn, Thomas F. 1983. Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists. *American Sociological Review* 48: 781–95. [CrossRef]

Gordin, Michael. 2012. *The Pseudoscience Wars: Immanuel Velikovsky and the Birth of the Modern Fringe*. Chicago: University of Chicago Press.

Gordin, Michael. 2021. *On the Fringe: Where Science Meets Pseudoscience*. New York: Oxford University Press.

Gross, Matthias. 2014. *Experimentelles Nichtwissen: Umweltinnovationen und die Grenzen sozial-ökologischer Resilienz*. Bielefeld: Transcript.

Gugerli, David. 2004. Mapping. A Communicative Strategy. In *From Molecular Genetics to Genomics: The Mapping Cultures of Twentieth-Century Genetics*. Edited by Hans-Jörg Rheinberger and Jean-Paul Gaudillière. London: Routledge, pp. 210–18.

Hacking, Ian. 1983. *Representing and Intervening: Introductory Topics in the Philosophy of Natural Science*. Cambridge: Cambridge University Press.

Hagner, Michael. 2002. Cyber-Phrenologie. Die neue Physiognomik des Geistes und ihre Ursprünge. In *Die Politik der Maschine: Computer Odyssee 2001*. Edited by Hartmut Böhme, Christina Braun and Martin Burckhardt. Hamburg: Verlag Hans-Bredow-Institut, pp. 182–97.

Hagner, Michael. 2008. Bye-Bye Science, Welcome Pseudoscience? Reflexionen über einen beschädigten Status. In *Pseudowissenschaft*. Edited by Dirk Rupnow, Veronika Lipphardt, Jens Thiel and Christina Wessely. Frankfurt a.M: Suhrkamp, pp. 21–50.

Hagner, Michael. 2020. Anstatt einer Einleitung. Rückblick auf die Wissensgeschichte. In *Feierabend? (Rück-)Blicke Auf "Wissen"*. Edited by Sandra Bärnreuther, Maria Böhmer and Sophie Witt. Nach Feierabend. Zürcher Jahrbuch für Wissensgeschichte 15. Zürich: Diaphanes, pp. 35–48.

Henry, Emmanuel. 2017. *Ignorance Scientifique et Inaction Publique: Les Politiques de santé au Travail*. Paris: Presses de Sciences Po.

Hiatt, Alfred. 2008. *Terra Incognita: Mapping the Antipodes before 1600*. Chicago: University of Chicago Press.

Hon, Giora, Jutta Schickore, and Friedrich Steinle, eds. 2008. *Going Amiss in Experimental Research*. Berlin: Springer.

Ioannidis, John P. A. 2005. Why Most Published Research Findings Are False. *PLoS Medicine* 2: e124. [CrossRef]

Karpenko, Lara, and Shalyn Claggett, eds. 2017. *Strange Science: Investigating the Limits of Knowledge in the Victorian Age*. Ann Arbor: University of Michigan Press.

Kleinman, Daniel Lee, and Sainath Suryanarayanan. 2013. Dying Bees and the Social Production of Ignorance. *Science, Technology, & Human Values* 38: 492–517. [CrossRef]

Knorr-Cetina, Karin. 1991. *Die Fabrikation von Erkenntnis: Zur Anthropologie der Naturwissenschaft*. Frankfurt am Main: Suhrkamp.

Knorr-Cetina, Karin. 1999. *Epistemic Cultures: How the Sciences Make Knowledge*. Cambridge: Harvard University Press.

Kuhn, Thomas S. 1962. *The Structure of Scientific Revolutions*. Chicago: University of Chicago Press.

Kuhn, Thomas S. 1977. *The Essential Tension: Selected Studies in Scientific Tradition and Change*. Chicago: University of Chicago Press.

Laboulais-Lesage, Isabelle. 2004. *Combler Les Blancs de La Carte: Modalités et Enjeux de La Construction Des Savoirs Géographiques (XVIe-XXe Siècle)*. Strasbourg: Presses University de Strasbourg.

Lässig, Simone. 2016. The History of Knowledge and the Expansion of the Historical Research Agenda. *Bulletin of the GHI Washington, Issue* 59: 0029–0058.

Latour, Bruno, and Steve Woolgar. 1979. *Laboratory Life: The Social Construction of Scientific Facts*. Thousand Oaks: Sage Publishing.

Levine, Philippa. 2017. *Eugenics: A Very Short Introduction*. Oxford: Oxford University Press.

Luhmann, Niklas. 1992. Ökologie des Nichtwissens. In *Beobachtungen der Moderne*. Edited by Niklas Luhmann. Wiesbaden: VS Verlag für Sozialwissenschaften, pp. 149–220. [CrossRef]

Marchand, Suzanne. 2019. How Much Knowledge Is Worth Knowing? An American Intellectual Historian's Thoughts on the Geschichte Des Wissens. *Berichte zur Wissenschaftsgeschichte* 42: 126–49. [CrossRef] [PubMed]

Mauskopf, Seymour H., and Michael R. McVaugh. 1980. *The Elusive Science: Origins of Experimental Psychical Research*. Baltimore: Johns Hopkins University Press.

Mayo, Deborah G. 1996. *Error and the Growth of Experimental Knowledge*. Chicago: University of Chicago Press.

McGoey, Linsey. 2019. *The Unknowers: How Strategic Ignorance Rules the World*. London: ZED.

Merchant, Carolyn. 1980. *The Death of Nature: Women, Ecology, and the Scientific Revolution*. San Francisco: Harper & Row.

Merchant, Carolyn. 2008. Secrets of Nature: The Bacon Debates Revisited. *Journal of the History of Ideas* 69: 147–62. [CrossRef]

Merton, Robert K. 1957. *Social Theory and Social Structure*. Glencoe: The Free Press.

Mulsow, Martin. 2012. *Prekäres Wissen: Eine andere Ideengeschichte der Frühen Neuzeit*. Berlin: Suhrkamp.

Noakes, Richard. 2019. *Physics and Psychics: The Occult and the Sciences in Modern Britain*. Cambridge: Cambridge University Press.

Numbers, Ronald L. 2006. *The Creationists: From Scientific Creationism to Intelligent Design*. Cambridge: Harvard University Press.

Oppenheim, Janet. 1985. *The Other World: Spiritualism and Psychical Research in England, 1850–1914*. Cambridge: Cambridge University Press.

Oreskes, Naomi, and Erik M. Conway. 2008. Challenging Knowledge: How Climate Science Became a Victim of the Cold War. In *Agnotology: The Making and Unmaking of Ignorance*. Edited by Robert N. Proctor and Londa Schiebinger. Redwood City: Stanford University Press, pp. 55–89.

Oreskes, Naomi, and Erik M. Conway. 2010. *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming*, 1st U.S. ed. New York: Bloomsbury Press.

Pigliucci, Massimo, and Maarten Boudry, eds. 2013. *Philosophy of Pseudoscience: Reconsidering the Demarcation Problem*. Chicago: The University of Chicago Press.

Popper, Karl R. 1963. *Conjectures and Refutations: The Growth of Scientific Knowledge*. London: Routledge and Paul.

Poskett, James. 2019. *Materials of the Mind: Phrenology, Race, and the Global History of Science, 1815–1920*. Chicago: University of Chicago Press.

Proctor, Robert N. 1996. *Cancer Wars: How Politics Shapes What We Know and Don't Know About Cancer*. New York: Basic Books.

Proctor, Robert N., and Londa Schiebinger, eds. 2008. *Agnotology: The Making and Unmaking of Ignorance. Agnotology: The Making and Unmaking of Ignorance*. Redwood City: Stanford University Press.

Proverbio, Edoardo. 1988. R. G. Boscovich's Determination of Instrumental Errors in Observation. *Archive for History of Exact Sciences* 38: 135–52.

Ravetz, Jerome. 1986. Usable Knowledge, Usable Ignorance. In *Sustainable Development of the Biosphere*. Edited by William C. Clark and Richard E. Munn. Cambridge: Cambridge University Press, pp. 415–32.

Relaño, Francesc. 2002. *The Shaping of Africa: Cosmographic Discourse and Cartographic Science in Late Medieval and Early Modern Europe*. Hampshire: Ashgate.

Rheinberger, Hans-Jörg. 2000. Gene Concepts: Fragments from the Perspective of Molecular Biology. In *The Concept of the Gene in Development and Evolution: Historical and Epistemological Perspectives*. Edited by Hans-Jörg Rheinberger, Peter J. Beurton and Raphael Falk. Cambridge: Cambridge University Press, pp. 219–39. [CrossRef]

Rheinberger, Hans-Jörg. 2005. Nichtverstehen und Forschen. In *Kultur Nicht Verstehen: Produktives Nichtverstehen und Verstehen als Gestaltung*. Edited by Juerg Albrecht, Jörg Huber, Kornelia Imesch, Karl Jost and Philipp Stoellger. Vienna: Springer, pp. 75–81. [CrossRef]

Rheinberger, Hans-Jörg. 2010a. *An Epistemology of the Concrete: Twentieth-Century Histories of Life*. Durham: Duke University Press.

Rheinberger, Hans-Jörg. 2010b. The Art of Exploring the Unknown: Views on Contemporary Research in the Life Sciences. In *Science as Cultural Practice, Vol. I: Cultures and Politics of Research from the Early Modern Period to the Age of Extremes*. Edited by Moritz Epple and Claus Zittel. Berlin: Akad.-Verl, pp. 141–52. [CrossRef]

Rheinberger, Hans-Jörg. 2021. *Spalt und Fuge: Eine Phänomenologie des Experiments*. Berlin: Suhrkamp.

Rupnow, Dirk, Veronika Lipphardt, Jens Thiel, and Christina Wessely, eds. 2008. *Pseudowissenschaft: Konzeptionen von Nichtwissenschaftlichkeit in der Wissenschaftsgeschichte*. Frankfurt am Main: Suhrkamp.

Sarasin, Philipp. 2011. Was ist Wissensgeschichte? *Internationales Archiv für Sozialgeschichte der deutschen Literatur* 36: 159–72. [CrossRef]

Sarasin, Philipp. 2020. More Than Just Another Specialty: On the Prospects for the History of Knowledge. *Journal for the History of Knowledge* 1: 2. [CrossRef]

Schickore, Jutta. 2005. 'Through Thousands of Errors We Reach the Truth'—but How? On the Epistemic Roles of Error in Scientific Practice. *Studies in History and Philosophy of Science* 36: 539–56. [CrossRef]

Schiebinger, Londa. 2004. *Plants and Empire: Colonial Bioprospecting in the Atlantic World*. Cambridge: Harvard University Press.

Schneider, Ulrich Johannes. 2003. Wissensgeschichte, nicht Wissenschaftsgeschichte. In *Michel Foucault—Zwischenbilanz einer Rezeption*. Edited by Axel Honneth and Martin Saar. Frankfurt a.M: Suhrkamp, pp. 220–29.

Shapin, Steven. 1996. *The Scientific Revolution*. Chicago: University of Chicago Press.

Sheynin, Oscar B. 1977. Early History of the Theory of Probability. *Archive for History of Exact Sciences* 17: 201–59. [CrossRef]

Smithson, Michael. 1985. Toward a Social Theory of Ignorance. *Journal for the Theory of Social Behaviour* 15: 151–72. [CrossRef]

Smithson, Michael. 1993. Ignorance and Science: Dilemmas, Perspectives, and Prospects. *Knowledge* 15: 133–56. [CrossRef]

Speich Chassé, Daniel, and David Gugerli. 2012. Wissensgeschichte. Eine Standortbestimmung. *Traverse. Zeitschrift für Geschichte* 19: 85–100.

Thurs, Daniel P., and Ronald L. Numbers. 2011. Science, Pseudoscience, and Science Falsely So-Called. In *Wrestling with Nature: From Omens to Science*. Edited by Peter Harrison, Ronald L. Numbers and Michael H. Shank6. Chicago: University of Chicago Press, pp. 281–30.

Verburgt, Lukas M. 2020. The History of Knowledge and the Future History of Ignorance. *KNOW: A Journal on the Formation of Knowledge* 4: 1–24. [CrossRef]

Verburgt, Lukas M. 2021. History, Scientific Ignorance, and the Anthropocene. *Journal for the History of Knowledge* 2: 12. [CrossRef]

Verburgt, Lukas M., and Peter Burke. 2021. Introduction: Histories of Ignorance. *Journal for the History of Knowledge* 2: 5. [CrossRef]

Vogel, Jakob. 2004. Von der Wissenschafts- zur Wissensgeschichte. Für eine Historisierung der 'Wissensgesellschaft'. *Geschichte Und Gesellschaft* 30: 639–60.

von Stuckrad, Kocku. 2007. *Geschichte der Astrologie: Von den Anfängen bis zur Gegenwart*. München: Beck.

Wehling, Peter. 2021. Why Science Does Not Know: A Brief History of (the Notion of) Scientific Ignorance in the Twentieth and Early Twenty-First Centuries. *Journal for the History of Knowledge* 2: 6. [CrossRef]

Wolffram, Heather. 2009. *The Stepchildren of Science: Psychical Research and Parapsychology in Germany, c. 1870–1939*. Amsterdam: Rodopi.

Zeitlin, Samuel Garrett. 2021. Francis Bacon on Imperial and Colonial Warfare. *The Review of Politics* 83: 196–218. [CrossRef]

Zwierlein, Cornel. 2016a. *Imperial Unknowns: The French and British in the Mediterranean, 1650–1750*. Cambridge: Cambridge University Press.

Zwierlein, Cornel. 2016b. Introduction: Towards a History of Ignorance. In *The Dark Side of Knowledge. Histories of Ignorance, 1400 to 1800*. Edited by Cornel Zwierlein. Leiden: Brill, pp. 1–47.

Zwierlein, Cornel, ed. 2016c. *The Dark Side of Knowledge: Histories of Ignorance, 1400 to 1800*. Leiden: Brill.