Archimedes 69 New Studies in the History and Philosophy of Science and Technology

Agathe Keller
Karine Chemla *Editors*

Shaping the Sciences of the Ancient and Medieval World

Textual Criticism, Critical Editions and Translations of Scholarly Texts in History

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Editors

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Pour Pierre Chaigneau (1987–2022)

et

Pour Pauline Schmitt-Vandenbroeck

Ces pages qui cherchent à comprendre
comment le présent reste tissé des mots du passé

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Chapter 1
Shaping the Sciences of the Ancient and Medieval World: An Introduction

Karine Chemla and Agathe Keller

Abstract This introductory chapter gives an overview of the research questions raised in the book as much for historians of science as for anyone working with, or producing editions of, ancient scholarly texts. It highlights the benefits that flow from a worldwide history of textual criticism and editions as well as from a focus on texts dealing with science—two key options that are taken in this book. Following the book's scheme, the introduction first concentrates on ancient editorial practices, in particular examining their potential impact on modern editions. We then highlight how, through time, perceptions changed concerning what a text is, and how this influenced in turn how scholarly texts were made accessible. We offer an analysis of the ways historical, political and social contexts shaped editions and translations of ancient scientific works and documents, using the case studies offered in this book, before turning to an analysis of the specifics of editions and translations that bear on scholarly documents rather than on literary or religious sources. Finally, this introduction looks at how some elements specific to texts dealing with science—such as diagrams and numbers—have been edited and the specific work that has been done editing mathematical and astronomical texts of the past. All these threads help us reflect on how editorial practices have heavily mediated the way we have access to ancient sources dealing with science. The scholarship displayed here lays the foundation for further studies on the history of critical editions. It also raises questions for those who make scholarly translations and critical editions today.

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1.1 Outlining the Project of the Book

1.1.1 Historical Remarks About Textual Criticism

In 1996, shortly before his untimely death, the historian of mathematics in ancient Greece Wilbur Knorr (1945–1997) published an article that bore a striking title: 'The Wrong Text of Euclid: On Heiberg's Text and its Alternatives'. The title was referring to the critical edition of one of the major works of Greek antiquity—Euclid's *Elements*—by Johan Ludvig Heiberg (1854–1928), the philologist who brought out editions of virtually all the ancient Greek mathematical texts.[1] To this day, Heiberg's critical edition of the *Elements* (as well as most of his other editions) remains the authoritative reference. It has served as the basis for all the modern translations of the *Elements*, from the classic English translation published by Thomas Heath (1861–1940) in the first decades of the twentieth century (Heath 1908, second edition: 1926, reprinted as Heath 1956) to the most recent Italian translation (Acerbi 2007), including the French translation published at the end of the twentieth century (Vitrac 1990–2001). In other words, virtually all the historical works on Euclid's *Elements* that have appeared since the publication of this critical edition have built upon it. Yet, Knorr (1996) expresses doubts about the capacity of this critical edition to represent the oldest state of Euclid's *Elements* that could be reached with philological work. One could not explain more clearly how important it is for modern scholarship to reflect critically upon the critical editions of ancient writings that lie at the basis of today's historical and philosophical work. This is precisely the goal of this book.

The thrust of Knorr's argument is disturbing: In his view, because of the way Heiberg worked on his critical edition, he could concretely restore only a state of the text posterior to—and incorporating elements of—Theon of Alexandria's fourth-century recension of the *Elements*. However, Knorr continues, in theory, the available documents allow us to shed light on states of Euclid's *Elements* prior to Theon's work, and hence closer to Euclid's original text. The details of Knorr's analysis are important: For Knorr, Heiberg had *a priori* ideas about the way Euclid had written the *Elements*. In particular, in Heiberg's view, Euclid avoided logical gaps in proofs. This a-priori assumption led Heiberg to discard medieval Arabic and Latin manuscripts of the *Elements*, on the sole ground that they did not fit with his expectations concerning this Greek work. Indeed, they had logical gaps that the earliest extant Greek witnesses (some of which were more recent than these medieval editions) did not have. Accordingly, Heiberg based his editorial work on these Greek witnesses, thereby carving his own assumptions into the corpus at the basis of his philological work, and, accordingly, into the critical edition that we now all use in our research

[1] Heiberg's edition of the *Elements* (1883–1888) was published as part of that of Euclid's complete works by Heiberg and Heinrich Menge (1838–1904) (Heiberg and Menge 1883–1916). (Knorr 2001), published posthumously, returns to the same issue.

on the *Elements*. How can research on Euclid's proofs rely on Heiberg's edition? This is the key issue that Knorr's critical remarks raise.

By contrast, Knorr puts forward the thesis that these Latin and Arabic manuscripts themselves might be considered more faithful witnesses to a state of Euclid's *Elements* prior to Theon's edition and commentary than the Greek editions used by Heiberg, which represented a state of the text dependent on this later editorial work. Knorr further points out that this was precisely the hypothesis defended by the specialist of Arabic studies and history of mathematics Martin Klamroth (1855–1890), who during the same decades suggested basing a critical edition of Euclid's *Elements* on the Arabic witnesses from the Middle Ages. The key point is that, as we will see, this case illustrates the general rule with respect to critical editions of ancient works rather than a marginal phenomenon.

In fact, in the wake of Knorr's seminal article, doubts have also been raised about Heiberg's critical edition of the works of another major scholar of Greek antiquity, Archimedes. Heiberg's assumptions about Archimedes as a mathematician contrasted sharply with his hypotheses about the Euclid of the *Elements.* At variance with the idea that in the *Elements* the original text avoided logical gaps, in Archimedes' case Heiberg advanced the thesis that the mathematician did not bother with obvious arguments. This assumption led Heiberg to suspect a significant number of passages in the received text as 'interpolations', which he accordingly placed between square brackets in both the Greek text and the Latin translation (Chemla 1999). This holds true for Heiberg's first edition of *Archimedis Opera Omnia* (Heiberg 1880–1881) as well as for the second edition (Heiberg 1910–1915), which he published after new Archimedean writings had resurfaced (Netz 2004: 2).[2] As has been the case with Euclid's *Elements*, subsequent translations have drawn on Heiberg's critical editions. However, these translations dealt with Heiberg's suspicions of interpolations in quite different ways, as can be shown from taking a quick look at an example. We have chosen for this the second proposition of Archimedes' *On the Sphere and the Cylinder*. In his first edition, for this proposition, Heiberg (1880 (vol. 1): 14, Greek text) puts between square brackets two expressions, as he does in the translation into Latin (Heiberg 1880 (vol. 1): 14, Latin text). Consequently, in the translation, the bracketed expressions feature as having a status similar to the additions that Heiberg introduces into the text for the sake of explanation. In the second edition, the number of passages suspect of being interpolations increased (Heiberg 1910 (vol. 1): 12, Greek text). If we keep the example of the proposition 2, Heiberg added square brackets around another suspected term. Heath (1897), which offers a free English translation in which Archimedes' text is heavily modernized, relies on Heiberg's first edition: in the aforementioned second proposition, the passages suspect of being interpolations do not feature. In the twentieth century, two French translations of Archimedes' works appeared (Ver Eecke 1921; Mugler

[2] Decorps's chapter in this book outlines a history of editions of Greek mathematical texts of antiquity. She points out that Friedrich Hultsch's critical edition of Pappus' *Collection* (1876–1878) likewise considered several passages as spurious 'on the grounds of an ideal representation of what a Greek mathematical treatise should be' (see note 91).

1970–1972). For the same proposition 2, Paul Ver Eecke (1921: 8) silently translates the larger passage bracketed by Heiberg, but not the other two, without making his choices explicit, let alone what motivated them. However, in a footnote inserted in proposition 10, Ver Eecke makes clear that he does not translate a long passage suspected by Heiberg to be spurious (Ver Eecke 1921: 20). Mugler (1970 (vol. 1): 13–14) does for proposition 2 what he does everywhere: he reproduces Heiberg's brackets in the Greek text but translates the whole text into French without any indication—including the passages suspected of being interpolations. Finally, in the most recent English translation, Netz (2004: 43–45) translates the Greek text of proposition 2 according to Heiberg's second edition, including its square brackets, and he discusses their appropriateness as well as other editorial issues in the 'Textual Comments'. There, for proposition 2 of *On the Sphere and the Cylinder*, Netz expresses doubts about the validity of one of Heiberg's bracketing choices. Moreover, he argues in favor of another one, and introduces a new suspicion of interpolation that Heiberg had not pointed out. Netz's comment about the last and most important of Heiberg's bracketed passages (step 16 in the 2004 segmentation of the text) is worth reading for our purpose:

> Step 16 belongs to an important class: pieces of text which may be authentic (and then must shape accordingly our understanding of Archimedes' practices) or may be interpolated. How to tell? Only by our general understanding of Archimedes' practice—an understanding which is itself dependent upon such textual decisions! Heiberg imagined a purist, minimalist Archimedes. In this, he may have been right: my sense, too, is that Step 16 is by a later scholiast. But we should keep our minds open.

One could hardly better formulate how critical editions and translations shape texts of the past according to the image editors and translators had of them, and therefore surreptitiously communicate these actors' assumptions to the readers. With respect to Greek mathematical texts of antiquity, we still need to assess fully the consequences of Heiberg's editorial practices and assumptions for subsequent historiography.[3] More basically and more broadly, the above observations raise complex questions about the critical editions of ancient texts available today. We will not solve these specific questions here. Rather, this book aims to address general issues that these case studies point out and that can be summarized as follows: As we have already underlined, our work on the history of ancient science depends in an essential way on critical editions that were prepared in modern times in contexts sometimes far removed from our own. The problem is that, on the one hand, we cannot redo these critical editions for each new investigation into the texts that we undertake. On the other hand, the extant editions cannot be used lightly and indiscriminately. This dilemma raises a simple question: How then can we equip ourselves with the appropriate critical tools to use these editions today? The examples of Heiberg's editions of Euclid's *Elements* and Archimedes' works highlight how the authors of editions draw on documents that were in turn produced in contexts different from their own. These authors put into play criteria to select the source

[3] For the case of Archimedes, Netz (2012) offers a reflection on this issue.

material to be used to prepare their editions. They carry out textual criticism according to methods and values that depend not only on their personal choices, but also on the context in which they operate and the goals they assign to their editorial work. Highlighting these criteria, methods and values and analyzing them might enable us to use the results of these philological endeavors with the necessary critical distance. Our project for this book derives from these remarks. It appeared to us that an essential manner for the historian of science in the ancient world to acquire a critical distance of this kind was to develop a historical approach to the modern critical editions that we use daily in our research. This is one of the main aims pursued in this book.

1.1.2 Critical Editions and the Erasure of Clues About Practices

The full deployment of our project requires that analysis such as Knorr's be first expanded. Indeed, Knorr focused primarily on Heiberg's editorial work on the *discursive part* of the *Elements*. His remarks thus have a crucial impact in estimating, for example, the extent to which we can rely on Heiberg's edition to conduct a historical investigation about Euclid's mathematical ideas or about his proofs. More recent work by Saito (2006) has further suggested that Heiberg's edition could also be an obstacle for us to work on Euclid's mathematical *practices*, more specifically in this case, his practices with diagrams. For Saito (2006) has shown that the geometrical diagrams of Heiberg's edition diverged quite dramatically from those of the ancient editions of Euclid's *Elements* on which Heiberg's philological work rested (see Fig. 1.1). These diagrams thus also call for critical analysis. Saito and Sidoli (2012) have actually established that in this case Heiberg seems to have ignored the evidence about diagrams found in the manuscripts and that he simply included into his edition the diagrams from an early nineteenth century edition of the *Elements* by Ernst Ferdinand August (1795–1870) (August 1826–1829).

It is true that some facets of Euclid's practice with diagrams, like those studied by Reviel Netz (1999), can be approached using clues that are found in the discursive part of the text of the *Elements*. Arguably, these facets might, at least partly, be captured using Heiberg's edition. However, Saito highlights other facets of that practice whose study depends in an essential way on material features of the diagrams themselves. The 'overspecification' of the diagrams is a case in point (Saito 2006: 82). By this term, Saito refers to the fact that ancient editions feature diagrams that are more specific than the proposition requires. Let us illustrate this phenomenon with the example of Proposition I.4 of the *Elements*, which is precisely the topic of Fig. 1.1. This proposition concerns two equal triangles and Fig. 1.1 brings together the diagrams for it included in the main ancient editions as well as in Heiberg's critical edition (Saito 2006: 100). Heiberg's diagram depicts these triangles as generic, whereas in Codex P the two triangles are equilateral and in Codex

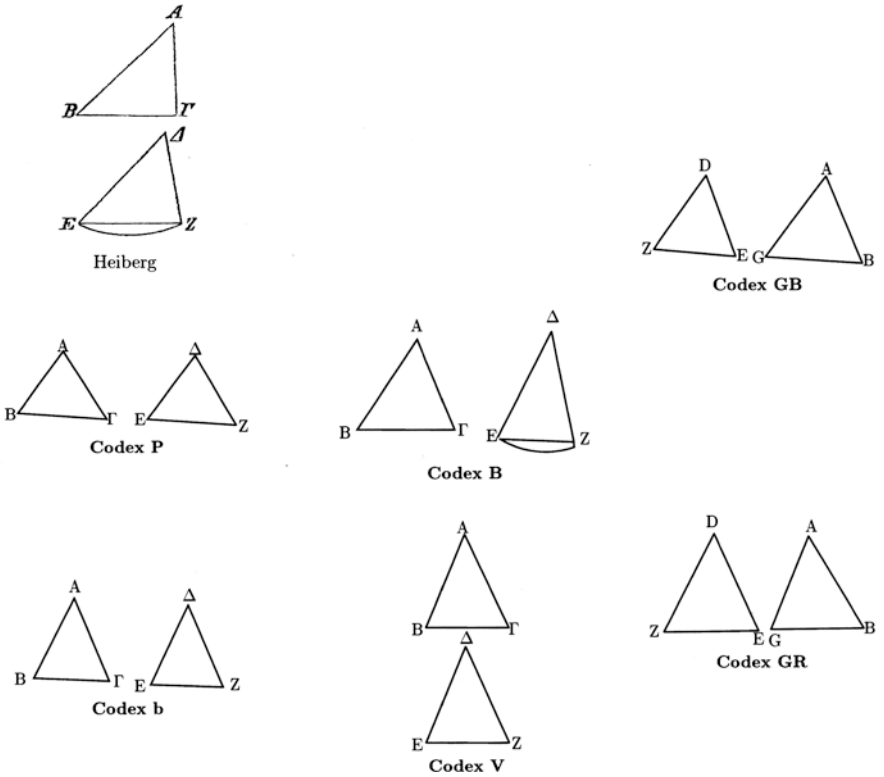

Fig. 1.1 This figure is taken from (Saito 2006: 100). For Proposition 4 of Book I of the *Elements*, it shows the diagram found in Heiberg's edition (top left) as well as a set of diagrams contained in ancient editions. Under Heiberg's diagram, to the left, the reader can see the diagrams of the various Greek editions on which Heiberg relies. **Codex P, Vaticanus graecus 190,** was copied between 830 and 850; **Codex B, Bodleianus Dorvillianus 301**, was copied in 888; **Codex b, Codex Bononiensis, Bologna,** biblioteca comunale, 18-19, dates from the eleventh century, and **Codex V,** Vindobonensis phil.gr. 31, from the twelfth century. To the right, we reproduce the diagrams of two ancient Latin editions that Saito also provided: **GB: Bruges 521** and **GR, Vat. Rossiano 579,** which are two fourteenth-century copies of the Latin translation by Gerard of Cremona (1114–1187) (© Saito)

b and V they are isosceles. Are these witnesses outliers whose testimony should be disregarded, or do they reflect diagrams of a type Euclid used in his mathematical practice? The key point is that the oldest extant papyri also show diagrams that are overspecified, thus inviting us not to discard right away the hypothesis that the singular diagrams found in ancient editions might reflect those used by Euclid.

Figure 1.2a reproduces one of these papyri, Oxyrhynchus I 29, edited by Bernard P. Grenfell, and Arthur S. Hunt (1898). The editors identified this papyrus as containing the enunciation and diagram of Proposition 5 of Book II of the *Elements*. Clearly, the diagram borne by the papyrus shows, on the left hand side, the square dealt with in Proposition II.5 cut into four identical squares. However, the text of the proposition

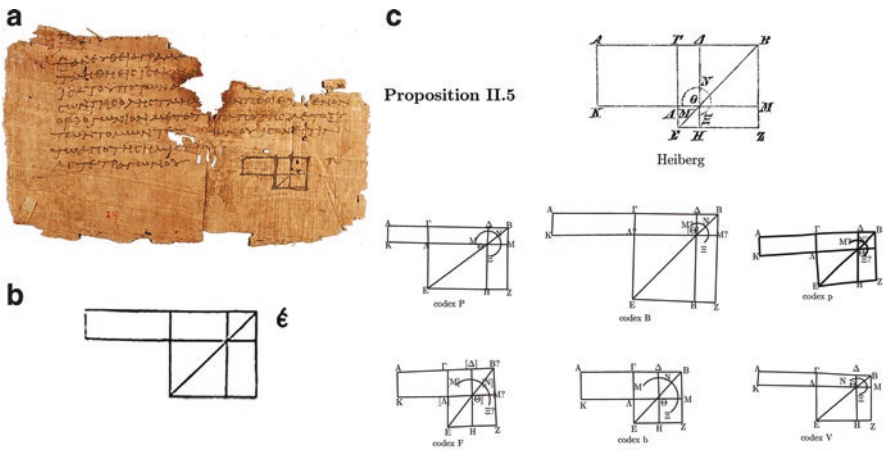

Fig. 1.2 (**a**) Papyrus Oxyrhynchus I 29, University of Pennsylvania. Downloaded from https://en.wikipedia.org/wiki/Papyrus_Oxyrhynchus_29#/media/File:P._Oxy._I_29.jpg (accessed February 16, 2021, ©Wikimedia commons). According to Grenfell and Hunt (1898: 58), who provided the first edition of this papyrus, it shows 'the enunciation, with diagrams' of Proposition 5 from Book II of the *Elements,* and it was copied between the end of the third century and the beginning of the fourth century. Fowler (1987: 210–212) considers the copy was made between 75 and 125. (**b**) The edition of the diagram provided by Grenfell and Hunt (1898: 58). (**c**) Saito (2011: 47) reproduces Heiberg's diagram (on top) and (below) those of the manuscripts Heiberg used in his critical edition (© Saito)

and its proof more generally put into play a division of this square into two different squares and two rectangles. The diagram of the papyrus is thus overspecified, since it transforms shapes that in the general case are different from each other into four identical squares. Grenfell and Hunt's 1898 edition draws the diagram as shown in Fig. 1.2b. Like Heiberg's philological practice for diagrams, their edition thus erases the overspecification of the papyrus' diagram and substitutes it for a diagram that is closer to modern standards regarding the way the figure relates to the text of the proposition. The same remark holds true for Heiberg's treatment of the diagram for the related proposition in the *Elements*, which Fig. 1.2c reproduces along with the diagrams of the main ancient editions (Saito 2011: 47). Heiberg's diagram is lettered like those in the ancient editions of the *Elements*. However, as far as the shapes are concerned, he discarded the evidence of the overspecified diagrams to redraw a diagram similar to the witnesses that were closer to a modern practice of diagrams. In other words, Heiberg drew the diagrams according to his own modern representation.

Recently, the study of Euclid's diagrammatic practices has become a hot topic in the history and philosophy of mathematics. These remarks imply that Heiberg's edition cannot without any further reflection serve as a basis for an approach to Euclid's practice of diagrams. Knorr's analysis thus needs to be extended beyond the discursive part of the *Elements*. In fact, as Netz (2012) further showed, the same conclusions hold true for Heiberg's edition of Archimedes' writings. We have seen that they also apply to Grenfell and Hunt's edition of the Oxyrhynchus papyrus.

Two remarks are important here. To begin with, the editorial practices for diagrams that we have described have an impact on the historiography. Indeed, in redrawing the diagrams of ancient Greek mathematical texts in this way, Grenfell and Hunt as well as Heiberg do not merely 'modernize' them. They further increase their distance from the diagrams found in other ancient mathematical sources, e.g., in ancient Chinese mathematical texts that have come down to us. Let us illustrate this point with *The Gnomon of the Zhou [Dynasty]* (*Zhoubi* 周髀, completed in the first century BCE or CE)—this is the oldest extant Chinese mathematical classic handed down with ancient commentaries through the written tradition—and, more precisely, with diagrams used by the third century commentator Zhao Shuang 趙爽. Figure 1.3a, b, c shows these diagrams as they are found in the earliest extant edition of this work, published by Bao Huanzhi 鮑澣之 in 1213. The other ancient editions share the same diagrammatic features as those illustrated by Fig. 1.3. Zhao Shuang refers to these diagrams to discuss the correctness of algorithms that are associated with right triangles. The use of square units in the diagrams indicates clearly that the figures are drawn for the right triangle whose three sides are, respectively, 3, 4 and 5. Zhao Shuang's text also mentions these particular dimensions. Using Saito's

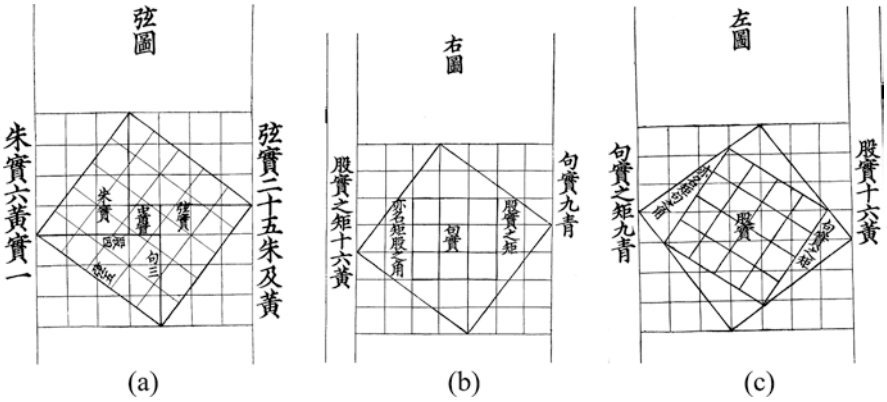

Fig. 1.3 Bao Huanzhi's 鮑澣之1213 edition of *The Gnomon of the Zhou [Dynasty]* (*Zhoubi* 周髀, first century BCE or CE) (Volume *Zhoubi*, in (Shanghai Tushuguan and Beijing Daxue Tushuguan 1980: 3b–4b)). The three diagrams open a section of Zhao Shuang's 趙爽 commentary (third century) titled: 'Figures of the base (*gou*) and of the height (*gu*), of the square and of the circle.' Translation of the textual indications on the diagram: (**a**) The two characters at the top: 'Figure of the hypotenuse'. Then, from top to bottom, from right to left: 'The square (*shi*) of the hypotenuse, twenty-five, is vermillion and yellow.// The square of the hypotenuse//The base is three.//Central yellow area (*shi*).//(in horizontal characters) The height is four.//Vermillion area (*shi*)//(slantwise) The hypotenuse is five.//The vermillion areas are six. The yellow area is one.//' (**b**) The two characters at the top: 'Right Figure'. Then, from top to bottom, from right to left: 'The square of the base, nine, is blue-green.//The gnomon of the square of the height//The square of the base//Is also called the angle of the height as gnomon//The gnomon of the square of the height, sixteen, is yellow.' (**c**) The two characters at the top: 'Left Figure' Then, from top to bottom, from right to left: 'The square of the height, sixteen, is yellow.//The gnomon of the square of the base//The square of the height //Is also called the angle of the base as gnomon//The gnomon of the square of the base, nine, is blue-green'

words, these diagrams are overspecified, in the same way as those found in ancient Greek mathematical documents.[4] This remark underlines a similarity between practices with diagrams to which ancient Greek and ancient Chinese sources attest. However—and this is the key point—the similarity can be seen only if we rely on ancient editions. It is hidden if we compare Chinese sources with Grenfell and Hunt's as well as Heiberg's critical editions.

This is where the second remark comes into play. Indeed, the editorial practices concerning diagrams that we have highlighted in Grenfell and Hunt's edition as well as in Heiberg's are by no means an exception. Modern editions of ancient scientific texts exhibit phenomena of this kind much more broadly. We can illustrate this remark using precisely the way modern critical editions have dealt with the diagrams contained in Zhao Shuang's commentary on *The Gnomon of the Zhou [Dynasty]* that we have mentioned above. Let us take, as an example, the first modern critical edition of *The Gnomon of the Zhou [Dynasty]*, which Qian Baocong 錢寶琮 published in 1963. As we have seen, Fig. 1.3a, b, c reproduces the diagrams as they occur in the earliest extant edition from 1213, whereas, as has already been mentioned, the diagrams found in the other extant ancient editions all share the features that this 1213 edition exhibits. In addition to showing that the shapes displayed bear unit squares, these ancient editions all contain diagrams with the same textual indications. These indications refer to colors (yellow, vermillion, blue-green), to shapes (e.g., gnomon), to places (e.g., center) and to specific dimensions, which echo those shown using the unit squares. Finally, the three figures seem to constitute a set of fundamental figures, from which the correction of all the algorithms Zhao Shuang gives about the right triangle can be established (Chemla 2005). Figure 1.4 reproduces the diagrams that Qian (1963: 15–16) drew for his critical edition in order to feature Zhao Shuang's diagrams. Clearly, the diagrams in the 1963 edition delete salient features of the witnesses. For instance, Qian's diagrams do not make use of unit squares and, in correlation with this point, the textual indications in the modern diagrams do not refer to any particular value. Moreover, Qian replaces the set of three diagrams, as shown in all the ancient editions, by five diagrams, thereby modifying the nature of the relationship between the diagrams and the text. We argue that these changes delete key clues about ancient actors' practice with diagrams, in exactly the same way as Grenfell and Hunt as well as Heiberg did for Greek mathematical texts of Antiquity. Moreover, Qian's substitution of diagrams has had a clear impact on the later transmission of the text of *The Gnomon of the Zhou [Dynasty]*. Indeed, in the same way as Heiberg's diagrams were reproduced in all the translations based on his edition, subsequent critical editions of *The Gnomon of the Zhou [Dynasty]* also used the diagrams that Qian (1963) inserted into the text and that differed radically from those of the ancient editions on which he drew.[5]

[4] Chemla (2005) argues that Zhao uses these diagrams as paradigms.

[5] See, e.g., for the *Elements*, (Vitrac 1990, volume I: 200–202) and, for *The Gnomon of the Zhou [Dynasty]*, the critical edition by Guo Shuchun 郭書春 and Liu Dun 劉鈍 (1998: 2). Note that, in

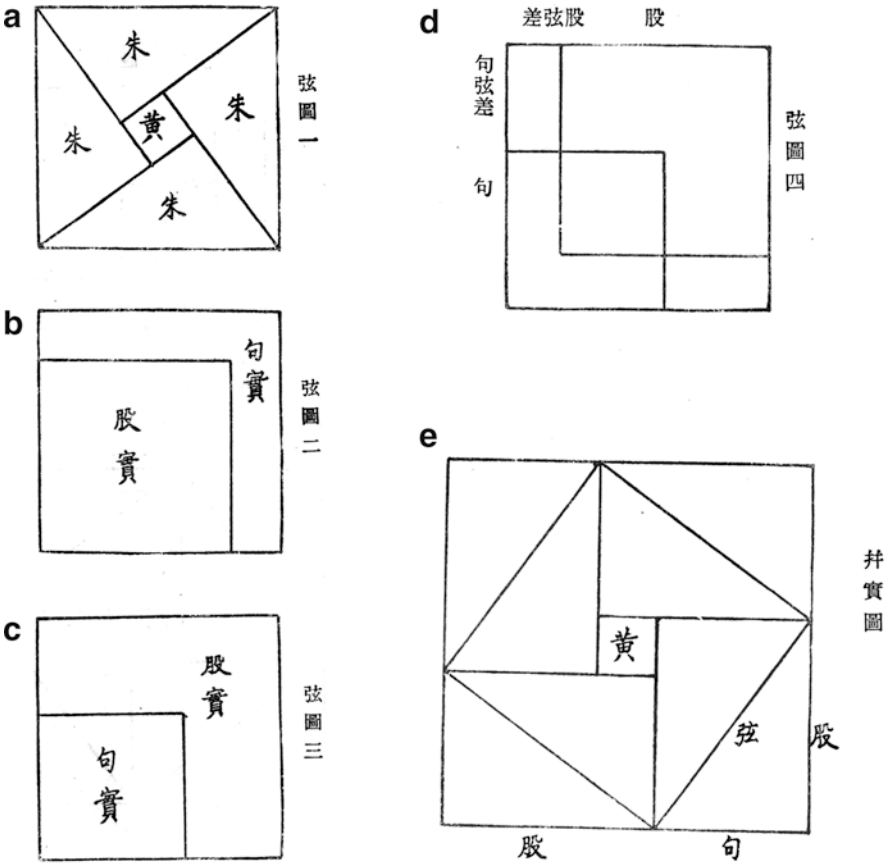

Fig. 1.4 Critical edition by Qian Baocong 錢寶琮 (1963: 15–16) of Zhao Shuang's diagrams. Translation of the textual indications on the diagrams: (**a**) From top to bottom, from right to left: 'Figure of the hypotenuse 1: Vermillion/Vermillion/Yellow/Vermillion/Vermillion' (**b**) From top to bottom, from right to left: 'Figure of the hypotenuse 2: Square of the base/Square of the height.' (**c**) From top to bottom, from right to left: 'Figure of the hypotenuse 3: Square of the height/Square of the base.' (**d**) From top to bottom, from right to left: 'Figure of the hypotenuse 4: Height/Difference between the hypotenuse and the height/Difference between the base and the hypotenuse/Base.' (**e**) From top to bottom, from right to left: 'Figure of the square of the sum (of the base and the height): Height/Hypotenuse/Base/Yellow/Height'

One might argue that Fig. 1.3b, c as displayed in the ancient editions were erroneous and hence that in his critical edition, Qian tried to restore correct figures, as they might have been drawn before mistakes were introduced in the course of the written transmission. Li Jimin (1990: 371) clearly thought along these lines, since he too suggested replacing the diagrams in the ancient editions with correct ones. However, his way of restoring the same diagrams, which is reproduced in Fig. 1.5,

the latter edition, the vertical presentation of the sequence of diagrams given by Qian was transformed into a horizontal one.

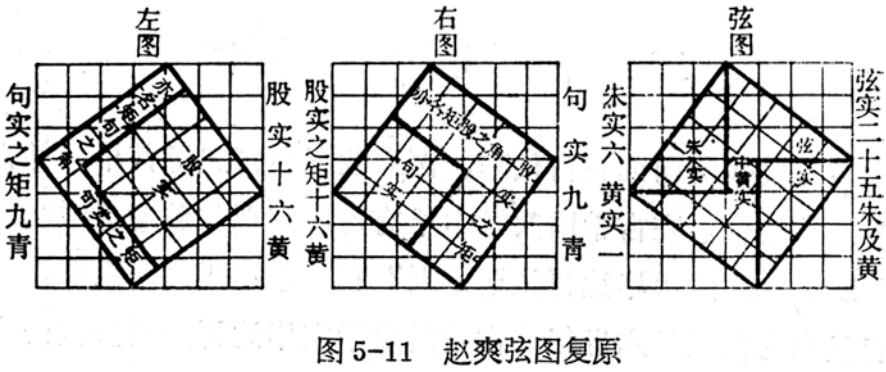

Fig. 1.5 Li Jimin's 李繼閔 (1990: 371) reconstruction of Zhao Shuang's left and right diagrams. Translation of the textual indications on the diagram: To the left, on top: 'Left Figure' Then, from top to bottom, from right to left: 'The square of the height, sixteen, is yellow.//The gnomon of the square of the base//The square of the height //Is also called the angle of the base as gnomon//The gnomon of the square of the base, nine, is blue-green.' To the right, on top: 'Right Figure' Then, from top to bottom, from right to left: 'The square of the base, nine, is blue-green.//The gnomon of the square of the height//The square of the base//Is also called the angle of the height as gnomon// The gnomon of the square of the height, sixteen, is yellow'

clearly follows principles different from Qian's. Li Jimin's diagrams might seem to us closer to those in the ancient editions than Qian's, and we might be tempted to conclude that they are thus more faithful to those that once occurred in the original text. However, we should not jump to conclusions too quickly here: Chemla (2004) argues that the *way* in which the diagrams in the ancient editions are erroneous gives clues on the nature of the original diagrams that are essential for a historical inquiry into the practices with diagrams—clues that are precisely erased in Li Jimin's edition.

This remark illustrates clearly the dilemma that an editor faces: each solution for the diagrams has its merits and its drawbacks. More importantly, exactly as noted above concerning the discursive part of a text, we see here the latitude that editors have in their negotiation between the different criteria by which they could abide in their shaping of diagrams. Here too, the solutions they adopt depend, among other things, on the context in which they operate and the goals they assign to the edition, as much as on their personal assumptions regarding the edited text. The examples concerning diagrams given above highlight what is at issue in the variety of editorial practices that have been put into play in the making of critical editions. These practices have led to quite different ways of presenting editions of the same text to the reader. Depending on the editorial choices, historical work about diagrammatic practices can rely more or less on the editions and thus unfold more or less fully.

This book is predicated upon the conviction that a historical approach to modern editorial work can enhance our understanding of the features of ancient texts to which critical editions have applied (often tacitly) changes. Such a historical approach can further help assess the impact of these changes on the historical work based on these editions. Indeed, as previous historians have sometimes noted, other

elements and features of ancient texts underwent reshaping in the course of editorial endeavors. We need to identify them. This book intends to shed light on changes of this kind that have received less attention and on their bearing upon the historiography. However, before we set out to tackle these issues, let us explain why we need, once again, to broaden our perspective.

1.1.3 Historicizing the Modernization of Ancient Texts in Editions and Translations

Modernizing diagrams, albeit in different ways, suppresses clues with which we could have addressed the issue of ancient actors' mathematical practices with their figures. However, discourse and diagrams are not the only parts of ancient scientific texts that have undergone modernization—or, more generally, changes—in the successive editions, thereby making it more difficult and even sometimes impossible to use these editions to describe ancient actors' knowledge and practices. The same conclusion has been drawn about another facet of ancient scientific texts whose importance for the history of science can hardly be denied, that is, the numbers and quantities that they contain. Another historian of Greek mathematics who also passed away all too early, David Fowler (1937–2004), drew our attention to this issue, offering remarks that will prove useful in defining more precisely the project of this book. Writing about the notation and uses of fractions in early Greek mathematical texts, Fowler (1992: 134) observed:

> Almost all of our written evidence about Greek culture has passed via Egypt, and almost all of it has been later rewritten, from the ninth century AD onwards, in a modernised Byzantine script. Numerical material in these Byzantine manuscripts is liable to have been modernised and uniformised in what might then have been considered to be unimportant ways—this applies, in particular, to the treatment of numbers and fractions (One needs only to look at modern editions and translations, even by the most scrupulous of scholars, to see similar processes at work today.)

Two remarks are essential for us in Fowler's observations. To begin with, Fowler notes that the Greek manuscripts on which modern philologists have relied to produce their critical editions are for the most part posterior to the transliteration of texts from antiquity into the minuscule script, which took place in the Byzantine world starting between the end of the eighth and the ninth centuries. Fowler thus raises the question of the transformations that the notation of numbers and quantities might have undergone in the latter context as well as that of the impact of these changes on subsequent editions and more broadly on the work of historians of science.

This first remark highlights a general and essential issue: a historical and critical approach to modern editions of scientific texts, for the development of which this book pleads, must also take into consideration the contexts and circumstances in which the source material on which the philological work is based was produced as

well as the possible changes to the original features that these old materials may have already incorporated. Research of this kind would not only provide crucial tools to exercise our critical acumen, but it would also allow us to examine how the modern philologists whom we study have dealt with the same question. This constitutes an important facet in the description and the contextualization of their philological practice. Several chapters in this book offer reflections on these issues, notably the two specific case studies presented in Part I.

Fowler points out a concrete example. He emphasizes that changes in the notation of divisions in a few papyri and in later Byzantine manuscripts have led historians to conclude that the concept of fraction that we commonly use today already existed in ancient Greece (Fowler 1992: 137). However, for him, such was not the case, and this gives a distorted view of numbers and arithmetic in ancient Greece. In particular, this creates a gap between hieratic and Greek mathematical documents, where in fact ancient documents point to a great continuity with respect to the nature and the concept of fraction used.[6] Exactly as we had seen above for the diagrams displayed in the critical editions, which create the illusion of a greater distance between Greek and Chinese ancient mathematical texts and a smaller distance between Greek ancient texts and modern mathematics texts, we see here the shaping of a divide between ancient Greek and hieratic texts and that of a similarity between fractions in Greek texts and modern fractions.

In fact, Fowler continues, the same type of modernization recurs in modern translations of ancient source material. This is the second remark which Fowler's quotation above highlights and which is equally important to widen adequately the perspective adopted in this book. Indeed, Fowler notes that, just as ancient editions do, modern editions as well as translations—both crucial tools for historians of science—tacitly modernize in ways that look innocuous but in effect have significant consequences. Fowler's argument relies on two documents (Fowler 1992: 138–140 and 140–141, respectively). Figure 1.6 reproduces the plate with which Fowler illustrates the first document. To the left (Fig. 1.6a), the plate displays part of the papyrus Hibeh I 27 written in *ca.* 300 BCE. The first line shows the notation of a fraction as a sequence—the juxtaposition means a sum—of what we would call 'unit fractions'. Each of these 'unit fractions' is not written as a pair of a numerator and a denominator, but as a number topped by a stroke.[7] These two features indicate that the notation of said quantity in the Greek papyrus is essentially the same as the way of writing fractions attested by hieratic mathematical texts. The edition of the papyrus published by Bernard P. Grenfell, and Arthur S. Hunt (1906: 146) is faithful to the notation as it appears in the original document (Fig. 1.6b). However, beneath the photo of the papyrus and the 1906 edition, Fowler reproduces the English translation given by Grenfell and Hunt (1906: 152)

[6] Fowler (1992) upholds this thesis. In an earlier publication, Knorr (1982) had also highlighted this point.

[7] Fowler and Turner (1983) provide a systematic description of the notation of integers and fractions in the papyrus Hibeh I 27.

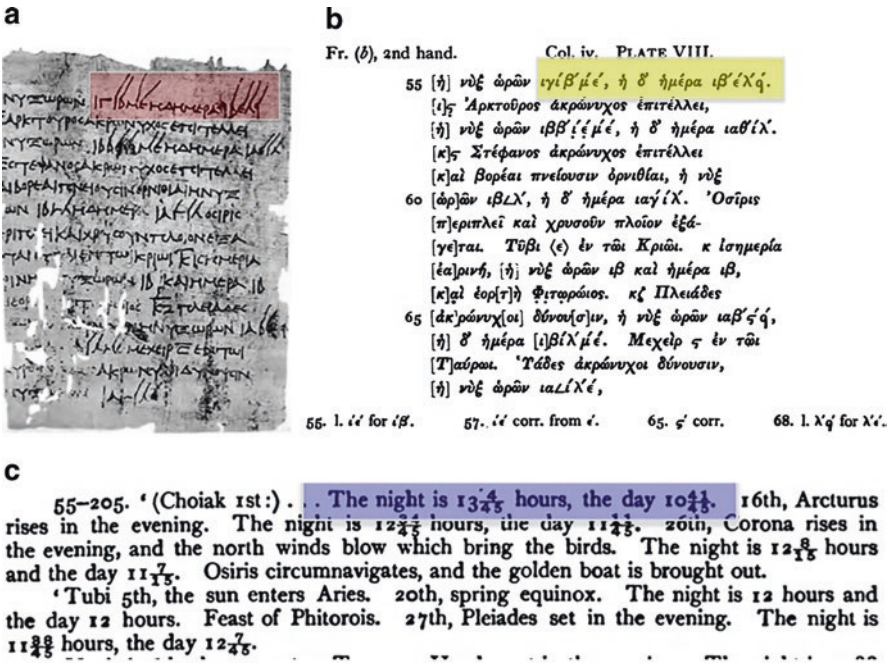

Fig. 1.6 Fowler's first document: Papyrus Hibeh I 27, edited with translations and notes by Bernard P. Grenfell, and Arthur S. Hunt in 1906. These three pieces ((**a**): Facsimile; (**b**): Transcription; (**c**): Translation) are reproduced from Grenfell and Hunt (1906: Plate VIII, 146, and 152, resp.). They were brought together in (Fowler 1992: 139)

(Fig. 1.6c). Just as noted above about the edition of the diagram occurring on a papyrus, the translation by Grenfell and Hunt transforms the fractions of the original document into a completely different concept: a single fraction with a numerator and a denominator. Interestingly, this transformation also precisely echoes the troubling problem in the historiography of fractions that Fowler exposes: an ancient notation, which indicated the use of a specific concept of fraction, is replaced with another—more modern—notation that might induce the reader to assume that the papyrus makes use of a modern notion of fraction. Note that in this case, modernization takes place in the translation. As several examples analyzed in this book suggest, modern editorial work on ancient source material has sometimes been inseparable from the production of translations into modern languages, to the point that sometimes the editorial work takes the form of a translation. This remark will appear to be all the more significant for our book as we adopt a world-wide view on the problems presented above, and at this global level, translations into languages foreign to that of the base text often incorporate editorial work. As a result, the historical inquiry presented in this book has taken both modern editions and translations of ancient scholarly texts into its focus.

1.1.4 Our project

Clearly, ancient and modern editions, translations and, more generally, publications of texts from the past are crucial moments in the multiple processes by which ancient and medieval works as well as other types of documents are made available to us. As we have recalled above, since the 1980s, an awareness has gradually emerged that historians of science ought to scrutinize the changes undergone by ancient scholarly texts, when said texts are presented or represented in editions and translations that are used in historical work. However, these reflections have remained scattered and punctual. We now need to adopt a more systematic approach to this issue. This book aims to take a step in this direction. More importantly, we cannot just expose the problematic character of what until recently was often taken unquestioningly as a direct access to source-texts. It is true that, if pressed, nobody would claim that Heiberg's edition allows us to read Euclid's text of the *Elements*, in an immediate and transparent way, even though, in practice, scholars have behaved as if they believed this. In fact, we also need to analyze *how* editions and translations have tacitly transformed the sources on which they relied, and how these changes left their imprint on the historiography of science, when it was based on these editions and translations.

In a sense, this book belongs to a recently renewed approach to histories of text criticism, philology, and translations, including new perspectives on histories of the book and of critical editions.[8] In this context, it is nevertheless characterized by two key features.

To begin with, we adopt a worldwide perspective on the issues addressed. In contrast, whether we think of Knorr, Fowler or Saito, the first forays into the topic under consideration typically focused on Greek geometrical texts of antiquity. The fact of taking a wider perspective brings to the fore general questions that might otherwise have been overlooked.[9]

For instance, from a world-wide viewpoint, it becomes crystal-clear that scholarly texts of the past were edited and translated in ways that, in particular, made them understandable in new environments and comparable with texts produced in other contexts. This phenomenon is all the more conspicuous if we think that from the eighteenth century onwards, editions and translations of Chinese and Sanskrit scholarly texts were produced in Europe, while since the seventeenth century, Persian and Arabic texts had been translated into Sanskrit, and Latin editions of Greek texts of antiquity translated into Chinese. To the issue of anachronism, which appears to characterize the aforementioned treatments of diagrams and numbers, we thus need to add what Kim Plofker (2021) has referred to as 'anachorism,' that is, in our terms, the problem of overlooking that the texts dealt with were produced not

[8] See notably (Judet de La Combe 1990), (Cerquiglini 1999), (Chartier 2021).

[9] Here again, we are not alone in striving to broaden the discipline in this way. See, notably, (Suarez and Woudhuysen 2013), (Pollock et al. 2015), (Grafton and Most 2016) as well as the contributions to the journal *Philological Encounters*, for instance (Dayeh et al. 2018) and (Pecchia et al. 2021).

only in different times, but also in places and scholarly cultures far removed from those of the editors and the translators. When the evidence has been reshaped, which features of this reshaping can be associated with the fact that texts circulated in places and times in which their original languages, their textual genres, and also the practice of mathematics to which they adhered were unfamiliar? How did editions and translations tacitly make ancient "exotic" texts either more "exotic" or, conversely, comparable in bits and pieces to texts that would have been familiar to the readers? It is precisely on such issues that a world-wide perspective sheds interesting light.

From another angle, poring over sources from different parts of the world raises another key question, that of the methods by which the texts attested by these sources were edited and translated. As a first approximation, the world-wide perspective we adopt suggests distinguishing between two types of situation—which are the two poles of a spectrum of possibilities.

Sometimes, ancient works were edited by scholars whose working language was intimately related to the language of the original works in question, and who were using methods that had been fashioned to deal with sources in cognate textual traditions. We can think of the example of the Chinese mathematical work *The Gnomon of the Zhou [Dynasty]*—which we mentioned above—as it was edited by Dai Zhen 戴震 (1724–1777) in the context of the preparation of the great encyclopedic compilation the *Complete Library of the Four Branches* (四庫全書*Siku quanshu*) at the end of the eighteenth century. Dai Zhen had access to several ancient editions of the work—which he compared to establish the text—as well as editorial tools and methods that had been developed in the context of the movement of 'evidential research' (*Kaozheng* 考證).[10]

In contrast, Edouard Biot's French translation of *The Gnomon of the Zhou [Dynasty]*, which was the first ever translation of the work into a European language, could only rely on the single edition, which he found in the collection of the Royal Library.[11] Moreover, for his approach to the text, which Biot endeavored to render literally, he could rely only on the ancient commentaries with which the work has been handed down as well as on the first Chinese dictionaries in foreign languages published, and, to begin with, that published by Chrétien-Louis-Joseph De Guignes (1759–1845) in 1813.[12] This example illustrates the second type of situation for a translation.

As shown in, e.g., Chap. 10, in which Cooper studies how Sumerian texts were edited in the past, this book also exemplifies situations of this kind not only for

[10] See this book, Chap. 4, to which we return below. (Chu 2010: 147–151) outlines more generally Dai Zhen's restoring of the Chinese mathematical 'canon' in the context of his work for the *Complete Library of the Four Branches*.

[11] Biot had access to *The Gnomon of the Zhou [Dynasty]* by means of the Ming edition included in the *Jindai mishu* 津逮祕書 (Biot 1841: 596–597). On this edition, see (Chemla 2020: 286). (Biot 1841) gives a translation of the text, and is complemented by (Biot 1842), which relies on astronomical data and computation to analyze *The Gnomon of the Zhou [Dynasty]* further.

[12] On Biot's literal approach, see (Chemla 2021: 49–57). (Martija-Ochoa 2001–2002) has analyzed Biot's translation more broadly.

translations but also for editions. Indeed, sometimes, editorial work was carried out adopting assumptions that had been shaped for sources produced by different scriptural acts and attesting to texts that derived from different conceptions of authorship. The backdrop for the example is this: In nineteenth century Europe, philological techniques had been devised, in particular in the context of editing ancient Greek and Latin sources, or biblical Hebrew. For sources of this kind, a philological method imposed itself, which consisted of organizing written evidence using a stemma and then of focusing on only part of the sources in relation to the structure of the stemma. Note that, just as we have seen above for Heiberg's edition of Euclid's *Elements*, the method led to carving an assumption about the history of the sources in the corpus on the basis of which editorial work was performed. In this context, in the first decades of Assyriology, some European scholars applied this philological method directly when dealing with cuneiform sources, despite the fact that these sources were the outcome of wholly different stories and processes. Was it appropriate to believe that this method was suited for all types of ancient documents worldwide? Chapter 10 explains why there are reasons to doubt the validity of the operation for contexts in which the sources available derive from scriptural acts other than copying.[13] Which assumptions about the sources and which related editorial practices were more generally transferred from one context to another, and what consequences did this have on the editions and translations produced? These are thus other key questions that a world-wide perspective highlights as promising.

For us, this global approach to the issues addressed is all the more needed that, from the outset, the history of ancient and medieval science has adopted an international perspective, comparing writings produced in different parts of the world through the editions and translations available. It is thus essential to examine in a critical way the material foundations on the basis of which these comparisons were carried out. What is at issue here is the historical study of the fashioning of an estrangement or, conversely, of a homogeneity of texts of science.

The latter remarks bring us to the second key feature that characterizes our book in the wider context of an interest for the histories of philological endeavors: we focus on scholarly texts, with a special emphasis on documents that attest to activities in mathematics, astral sciences, and medicine. One might doubt that this fact has any bearing on the questions on which we focus. However, it clearly does. One example will suffice to illustrate this point. For the German philologist Georg Friedrich Wilhelm Thibaut (1848–1914), who prepared, with the Indian scholar Sudhākara Dvivedin (1855-*ca.* 1910), a critical edition of Varāhamihira's *Pañcasiddhāntikā* (a sixth century work on astronomy),

> texts of purely mathematical or astronomical contents may, without great disadvantages, be submitted to a much rougher and bolder treatment than texts of other kinds. What interests

[13] On the genesis of the philological method associated with the name of Karl Lachmann (1793–1851), see (Timpanaro 2005). Interestingly, the history of the production of sources that Timpanaro assumes in his reflections shows a clear bias due to the type of works to which philological endeavor was first applied in Europe. Indeed, sources are assumed to have been produced by copying, and copyists are assumed either to have made mistakes or to have produced copies following specific types of scenario.

> us in these works, is almost exclusively their matter, not either their general style or the particular words employed, and the peculiar nature of the subject often enables us to restore with nearly absolute certainty the general meaning of passages the single words of which are past trustworthy emendation.[14]

Thibaut's declaration illustrates one way in which the editing of mathematical or astronomical texts was done in a specific fashion, compared to other types of texts. In this book, we will be interested in understanding how, in the nineteenth century, and sometimes well into the twentieth century, different editors and translators perceived scientific documents as specific and separate in their study from other scholarly and literary texts. We also question how that perception may have affected their editing practices.

Clearly, scientific documents raise specific editorial issues. Scientific practices sometimes put into play textual practices that are not purely discursive, like interacting with diagrams and images, and carrying out computations. Some of these practices leave specific traces in the texts in the form of non-discursive components, like drawings and tables, while others—no less specific, like computations carried out materially—leave only clues. The fact of attending to the edition of scientific texts thus commonly requires that editors deal with several kinds of specific non-discursive elements, and all the more so that, as we have pointed out, all these textual facets have historically been subject to many editorial manipulations. How they have attended to this task, and also how they have dealt with traces and clues are questions that are central for us, in particular because of the potential impact of the result on the historiography of science. Indeed, as has already been emphasized, in the past decades, non-discursive elements of scientific practices and texts have become a key issue in the history and philosophy of science. This has led to question how these elements have been passed down, edited, and translated in what until then was often taken unquestioningly as a direct access to source-texts. Addressing this issue in a systematic way can certainly benefit these discussions.

However, the example from Thibaut quoted above shows that these issues are also worth addressing with respect to the discursive parts of these texts, which might have been perceived as less specific. Indeed, for Thibaut, because of the nature of the subjects treated in texts of this kind, the discursive part of a scholarly work allows for a specific type of editing. This is in line with the argument that what counts for scientific texts is their content not their form, thus inducing specific text criticism, modes of translation and editing for them. In fact, the two examples of Heiberg's editions of Euclid's *Elements* and Archimedes's works that we have sketched above show two strikingly different illustrations of how in the editions of scientific texts, the discursive parts were molded in relation to the philologist's assumptions about these two practitioners' mathematical activities. Here too, thus, Heiberg's philological practice for these discursive parts was intimately correlated with his perception of these texts as scientific writings. However, the assumptions

[14] The assertions, taken from Thibaut's preface (p. v) to (Thibaut and Dvivedin 1889), were quoted in (Keller 2012: 265).

he adopted and how they were brought to bear on his editorial practice differed for both cases, and in both cases, they differed from those in Thibaut's edition. Both philologists valued authenticity and faithfulness. However, they understood these values differently and they also translated them into different editorial practices. The general issues of the values prized by editors and translators and also of how they shaped their practices in response to their respective values appear as meaningful for our project.

Much is thus at issue for historians and philosophers of mathematics in deconstructing the appearance of immediacy and transparency that readers focusing essentially on the contents sometimes attach to editions and scholarly translations.

The specificity of scientific works and documents in these respects should nevertheless not obscure the fact that, to a certain extent, practitioners of editorial work and translation have applied to such texts operations that they would have applied to any other text. Seen from this angle, we may still benefit from considering the ancient and modern production of editions and translations from the broader perspective of a more general history of texts, translations and books. Conversely, precisely because of the singularity of their subject matter, editions and translations of scholarly works and documents could allow us to better perceive transformations undergone in the course of philological and translation work that would be difficult to apprehend for other types of writing. This is a conclusion that can be drawn from Part I of this book, which is devoted to ancient editorial practices.

1.2 Ancient and Modern Actors and Institutions at Work in the Manufacturing of Sources for Ancient and Medieval Texts

As we have argued in Sect. 1.1.3, inquiring into editions and translations of ancient and medieval scholarly texts implies that we begin with a reflection on editorial practices before early modern and modern times. Indeed, we have seen that the documents upon which early modern and modern actors relied for their philological endeavors already incorporated the results of operations carried out by ancient actors in the context of their editorial activities and that these operations had significant consequences on the historiography of science. We have encountered above the impact, on modern scholarship, of the edition of the *Elements* made by Theon of Alexandria, who operated in a context upon which historical work has already been devoted. We have also encountered the potential impact, on the inscription of numbers contained in our sources, of the transliteration of ancient Greek sources from majuscule to minuscule script, which began in the Byzantine world at the end of the eighth century. To deal with this issue more broadly, in this book, we have concentrated on ancient editors from other parts of the world.

1.2.1 Ancient Editorial and Cross-Linguistic Practices

Interestingly, these other ancient actors broaden our views on the types of editorial intervention that were carried out, whether texts were worked upon, copied or translated. These actors also give us clues as to how we can detect such interventions in the documents that came down to us. This is what Piotr Michalowski argues in Chap. 2 of the book. In fact, he holds a radical view. Indeed, for him, the oldest written documents we know—that is, the first accounting texts from the fourth millennium BCE, which attest to the birth of writing—are already edited texts. The crucial remark is that these texts are quite uniform and thus seem to reflect the intention to shape an organized accounting system, using standardized writings.

In Michalowski's view, the same holds true for another basic type of text that was crucial in elementary scribal education: lexical lists. These texts were inventories of nouns in Sumerian, probably composed at the same time as the accounting documents mentioned above. However, the first material testimonies of these texts are the standardized lists that are associated with the expansion of the Ur III state (ca. 2112–2004 BCE), its languages and institutions—schools in particular—throughout much of the Middle East. Piotr Michalowski's chapter argues that the lists borne by these earliest surviving tablets should also be considered as already shaped by editorial practices. To highlight operations ancient actors carried out as they were editing these lists, Piotr Michalowski concentrates on a widespread professions list, which travelled all over Mesopotamia, from South to North and beyond, notably to Ebla in today's Syria. For the unique palace archive of Ebla reveals the manner in which the lists were copied. Some of the professions lists were copied from tablets coming directly from southern Babylonia, while others were produced from copies. At times, features of these copies testify to the scribes' intention to preserve formal textual properties of the original. Indeed, the first copies respected the norm of nineteen lines per column, while the copies of copies did not. The former copies added a double line after each nineteenth line, showing again that the scribes—although adopting a new format—wanted to keep traces of the old ones as well. Michalowski interprets these often imperceptible acts as clues of philological activity. Indeed, they reveal that ancient actors not only reflected on how to preserve the original but also created textual acts with this aim in mind. On the other hand, Ebla's palace archive provides evidence that scribes also adapted these lists. This is another facet of their editorial work. Here language is important. In southern Babylonia we know that texts were read in Sumerian while in the north they were probably read in semitic languages. Michalowski shows that the migration of lists involved all sorts of 'interlanguage procedures': lists were sometimes translated or gave birth to new lexical lists in regional languages. These operations were also editorial in nature: they aimed to re-actualize the list to make it readable for new audiences. In some cases, the antiquated professions list was adapted by listing regional professions. In others, the professions list was made into a bilingual list, serving then as a translating tool or an indicator on how to pronounce some Sumerian words.

In short, Piotr Michalowski argues that these ancient tablets testify to processes of standardization and acculturation, while at the same time providing evidence of ancient actors' reflection on how to preserve features of the original. All these acts have left clues that only indirectly tell us how texts were shaped and reshaped so that new audiences could read them. The argument highlights how challenging it is, for ancient contexts of this kind, to characterize what past editorial work consisted of. This is true because this work bears on textual aspects that we do not always consider important, such as the diagrammatic features of texts seen above. And yet features of this kind might yield crucial pieces of evidence for the historiography of science (Chemla 2020). This is also true because we only have traces of this work. What are the operations observable today that testify to the fact that in the past actors reflected on how to preserve and transmit a given text? This is a key question for our endeavor. To this question, Sheldon Pollock can give another kind of answer, because of the nature of the writings on which he relies. Indeed, he focuses on different types of commentaries on ancient Sanskrit works, which enable him to deploy a contextual approach to modes of edition in a wide range of sources in this corpus.

In comparison with the pieces of evidence discussed by Michalowski, Sanskrit commentaries attest to other types of additions to a base text, which meant to offer their readers a new form of approach to the text. Each of them reflects modalities that actors shaped in order to transmit the base text. Moreover, commentaries quote the root text, and hence they are compositions in which editions are carried out and conceptions of original texts are discussed. In this context, Pollock sheds light on another phenomenon worth contemplating. For his contextual approach allows him to establish that, depending on the genre, ancient commentators wanted to preserve and transmit different aspects of a Sanskrit text. Indeed, Pollock first underlines how little information we obtain directly. Nevertheless, he highlights that commentators put into play, in their discussions, key editorial notions such as that of 'interpolation' (*prakṣipta*, *kṣepaka*). This is the case of Haradatta Miśra, a ninth century commentator of the work of the grammarian Pāṇini, who uses precisely a term to qualify the 'original' text—the term *sāṃpradāyika* ('traditional' or 'original') being employed in opposition with that of 'interpolated'. The use of such notions allows historians to approach actors' varying representations of the genuine base text.

Moreover, Pollock sets forth clues indicating the principles by which actors determined what was interpolated, and which variant represented the original composition. The essential point for us is that the criteria used by classical, medieval and early modern editor-commentators of Sanskrit works, as they opposed original and interpolated texts, reveal two main types of editorial approaches. Indeed, Pollock suggests distinguishing between commentaries that gave pride of place to content and those that mainly relied on stylistic features, to decide over issues of interpolation. Pollock further suggests that commentators adopted one or the other approach in relation to the types of works commented upon.

For him, commentaries to knowledge forms (*vidyasthāna*s) belong to the first category, as do scriptures—an intermediate textual form between scholarly texts and poetry. Pollock illustrates the case of the edition of scriptures using the example of Buddhist texts and analyzing how the editors aim to establish what for them is