22 How was Greek science imported into other languages?

§1 This chapter widens the view and compares several major traditional languages of science and their ways of expressing Greek scientific thought. The focus will be on Latin, Sanskrit, and Arabic, but some scattered comments about Chinese are added as well. Greek translations into Latin happened in several stages and in at least four key periods, as was shown above (chap. 6 §2 with fig. 7). As the Arabic language has a rather different structure than Greek and Latin (and Indo-European in general), it may come as a surprise how quickly the Arabs were able to assimilate Greek science and learning, subsequently producing significant advances in many fields. The adoption began during the reign of Caliph Hārūn al-Rašīd (r. 786–809) and continued under his son al-Maʾmūn (r. 813–833). It was facilitated by Syriac precursor translations and by translators already used to dealing with scientific Greek. During this relatively short period, Arabic became a more or less standardised language of science and produced adepts who founded schools and traditions that were often to last for half a millennium. Indeed, the ‘revolution’ in Latin science in the twelfth century – which was considered above (chap. 11) – took some of its texts to translate from such Arabic sources. Sanskrit has a rather similar structure to Greek, and could have quite effortlessly been used to translate scientific Greek; it largely relies on compounds to render technical terminology, as will be seen. Greek science does not seem to have been much translated into Sanskrit in Antiquity, yet there was definitely contact that led among other things to a flourishing of mathematics around the fifth century AD (with authors such as Āryabhaṭa) in India, and later on, through Arabic mediation, in many other fields. Already in the time immediately after Alexander the Great, there were quite close relations between the two peoples. King Ašoka (ca. 304–232) had Greek subjects in Kandahar, for he had edicts in-

1 An early stage of this chapter was presented at the congress ‘Translation and Transmission in the Eastern Mediterranean 500 BC–1500 AD’, Finnish Institute in Rome, September 2015.
2 See also Glucker & Burnett (2012), esp. Glucker (2012).
3 See Rashed (1997) as an introduction.
4 Some details about the Arabic language used in these translations can be found in Endress (1982–1992: 3:3–23) and in chap. 2 §6 above.
5 An exception is the astrological treatise Yavanajātaka, even exhibiting its Greek origin in the title (yavana = ‘Greek’). It was edited by David Pingree in 1978. The text is a versification of a translation of a Greek text, apparently made in the third century AD. Pingree in his edition (p. 5) points out a likely process of Indian acculturation in this interesting text.
6 See Karttunen (1997); Stoneman (2019).
scribed in Greek (Schlumberger 1964). The case of Chinese is different again; direct contact between Graeco-Latin science and China seems to start as late as the Jesuit mission in China in the later sixteenth century, and then ran through the Latin medium. The much older indirect access to Graeco-Roman ways of thinking through the Silk Road and through contact with Buddhist India (itself in contact with Greek culture) is hard to gauge. At any rate, it does not seem to have been lasting; for instance, the Chinese only learned that the Earth is spherical from the Jesuits. More general questions of the relation of cultural spheres, language, and science will be taken up below (chap. 24).

§2 In order to argue from concrete data, two influential Greek texts were chosen and their translations into these languages studied: the strongly formalised scientific language of geometry in Euclid’s *Elementa*, and the less mathematical and more descriptive but logically structured kind of Greek in Aristotle’s lectures (namely the *Poetica*, a work that scientifically studies parts of ancient Greek culture) are used as source material. These two works can stand for a ‘hard’ science and a human science text respectively, and will illustrate some differences between them. Both works were translated into all the languages with which we are concerned. In a first part, the translations of these two texts are briefly described in order to provide a background; then some peculiarities of the language of each of them are considered; finally, their way of translating is studied by looking at statistical values on the one hand and at some representative sentences and how they were rendered on the other.

Euclid’s *Elementa* was an immensely successful book; it remained the standard geometry schoolbook for over two millennia. It was studied, commented, and also translated many times. Figure 48 shows some of the translations into the languages studied here. In Antiquity the book quickly replaced all older manuals on geometry, which are now completely lost. The same fate might easily have happened to Euclid’s original text as well, for Theon of Alexandria reworked it slightly around AD 360, correcting inconsistencies. His revised text was the only one known until a single manuscript containing the older text was found in the

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7 Jami & Delahaye (1993) study this cultural contact.
8 See Cullen (2001) on previous cosmological theories in China.
9 For help in mastering of the Arabic material, I am indebted to Benjamin Gleede and Emanuele Rovati. The Chinese was kindly checked by Wolfgang Behr.
10 This was still the case in the nineteenth century; cf. for instance Robert Potts’s school translation of 1845.
11 A recent summary of geometry in Antiquity and the Early Middle Ages by Barbara Ferré can be found in her edition of Martianus Capella, *Les noces*, vol. 6, pp. ix–xxiv.
Fig. 48: Simplified schema of important translations and redactions of Euclid’s *Elementa* into and in the languages considered here. Red: Arabic, green: Latin, blue: Sanskrit, brown: Chinese.

nineteenth century.\(^\text{12}\) It is the basis of Heiberg’s *editio maior*, which, incidentally, also contains a fresh Latin translation. The complicated situation of the early surviving Latin translations – that is, those from the twelfth century – was disentangled in many publications by Busard, who also edited them.\(^\text{13}\) Only one of them was made directly from the Greek, the anonymous ‘Sicilian translation’ (already used above in the text sample in chap. 20); the others went through Arabic. The first known translation, apparently by Boethius, was lost early.\(^\text{14}\) Besides quotations in other works, some fragments of books XI–XIII have survived on a palimpsest.\(^\text{15}\) The few extant pre-twelfth-century Latin writers who wrote about geometry often just used the Greek terminology, as Martianus Capella does in his

\(^{12}\) Città del Vaticano, BAV, Vat. gr. 190, from the early ninth century.  
\(^{13}\) For the disentanglement of the three ‘Adelard’ versions, see Clagett (1953); Burnett (1997b). On Adelard in general, see Burnett (1987).  
\(^{14}\) But at least partial translations of the *Elementa* may have existed before Boethius, as indicated by the accurate knowledge of Martianus Capella (but he may have translated ad hoc from the Greek) of some parts of them (see Stahl 1971: 128–129). See further Stevens (2004).  
\(^{15}\) Verona, Biblioteca Capitolare, XL (38), ed. Geymonat.
book VI (e.g. monas, dyas, lineae cyclicae, lineae helicoides). In order not to have to go too far into this apparently excessively Greek topic, Martianus spends much of the book De geometria on geography (§§567–805; geometry proper only §§706–724).

Fragments of a Syriac version translated from Ḥaḡḡāḡ’s Arabic text are also extant.\(^{16}\) Codex Leidensis 399,1 transmits an altered version of the second, shortened version by Ḥaḡḡāḡ (an epitome for Caliph Maʾmūn).\(^ {17}\) The Sanskrit translation also took a detour through Arabic. ‘The first six books of Euclid’s Elements, published in 1607, was the first substantial translation of a European text into Chinese.’\(^ {18}\) It was translated by the Jesuit missionary Matteo Ricci with the help of a Chinese collaborator. For many of these versions of the Elementa, there is a very useful synoptic online edition by Oslo University,\(^ {19}\) including a comparative article.\(^ {20}\) For an easier overview, the editions used are listed here, not in the bibliographies.

Greek
- Johan Ludvig Heiberg (ed.) (1883–1885): Euclidis elementa. Leipzig: Teubner. Includes a fresh Latin translation.
- Johann Wilhelm von Camerer & Karl Friedrich Hauber (eds) (1824–1825): Euclidis Elementa graece et latine, commentariis instructa. Berlin: Reimer. A print of the Theonine textus receptus.

Latin
- Mario Geymonat (ed.) (1964): Euclidis latine facti fragmenta Veronensia. Milan: Instituto Editoriale Cisalpino.
- Hubert Lambertus Ludovicus Busard (ed.) (1987): The Mediaeval Latin Translation of Euclid’s Elements Made Directly from the Greek. Stuttgart: Steiner.
- Hubert Lambertus Ludovicus Busard (ed.) (1983): The First Latin Translation of Euclid’s Elements Commonly Ascribed to Adelard of Bath: Books I–VIII and Books X.36–XV.2. Toronto: Pontifical Institute of Mediaeval Studies.

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\(^ {16}\) Furlani (1924).

\(^ {17}\) The traditional account of the Arabic translations is presented here. According to it, Ṭābit made a new recension of Ishāq’s revision of Ḥaḡḡāḡ’s text. Brentjes (2018: 51) argues against the existence of this Ṭābit/Ishāq recension. Much remains unclear.

\(^ {18}\) Quoted from the book cover of Engelfriet (1998).

\(^ {19}\) https://www2.hf.uio.no/polyglotta/index.php?page=volume&vid=67.

\(^ {20}\) The article’s authorship is not clear; its author may be Jens Braarvig. Unfortunately, he treats Mediaeval Latin as the product of incomplete knowledge of Classical Latin, and studies features such as dico + quod clauses, which are, of course, completely normal in Mediaeval Latin.
• Hubert Lambertus Ludovicus Busard (ed.) (2001): *Johannes de Tinemue’s Redaction of Euclid’s Elements, the So-Called Adelard III Version*. Stuttgart: Steiner.

• Hubert Lambertus Ludovicus Busard & Menso Folkerts (eds) (1992): *Robert of Chester’s (?) Redaction of Euclid’s Elements, the So-Called Adelard II Version*. Basle: Birkhäuser.

• Hubert Lambertus Ludovicus Busard (ed.) (1984): *The Latin Translation of the Arabic Version of Euclid’s Elements Commonly Ascribed to Gerard of Cremona*. Leiden: Brill.

• Hubert Lambertus Ludovicus Busard (ed.) (1968): *The Translation of the Elements of Euclid from the Arabic into Latin by Hermann of Carinthia (?)*. Leiden: Brill.

• Hubert Lambertus Ludovicus Busard (ed.) (2005): *Campanus of Novara and Euclid’s Elements*. Stuttgart: Steiner.\(^{21}\)

• Christoph Clavius (ed.) (1574): *Euclidis Elementorum libri XV: Accessit XVI de solidorum regularium comparatione omnes perspectionis demonstrationibus, accuratisque scholiis illustrati*, 2 vols. Romae: Vincent. Accoltus; repr., Coloniae: expensis Ioh. Baptistae Ciotti, 1591. Reprint online at http://doi.org/10.3931/e-rara-15504.

Arabic\(^{22}\)

• al-Ḥaǧūǧā b. Yūṣuf b. Maṭar (1897–1932): *Euclidis Elementa ex interpretatione al-Hadschḍschadschii cum commentariis al-Narizii, Arabice et Latine*, ed. Rasmus O. Besthorn & Johan Ludvig Heiberg, 4 vols. Copenhagen: Libraria Gyl dendaliana. From Codex Leidensis 399,1; includes a Latin translation. Online at http://menadoc.bibliothek.uni-halle.de/sg/content/structure/1201488.

• Ps-Naṣīraddin al-Ṭūsī (d. 1274) (1594): *Kitāb taḥrīr usūl li-‘Uqlīdis* (Romae: ex typogr. Medicea; repr., Frankfurt: Institute for the History of Arabic-Islamic Science, 1997.

Sanskrit

• Jagannātha Samrāṭ (1901–1902): *The Rekhāgāṇīta or Geometry in Sanskrit*, ed. Kamalāśaṅkara Prānāśaṅkara Trivedi (Bombay: Gov. Central Book Depot).\(^{23}\)

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\(^{21}\) The complicated relationship between the Latin versions is disentangled by Busard in this edition, pp. 1–40.

\(^{22}\) Many texts are online at http://www.graeco-arabic-studies.org/texts.html. On the Arabic translations, see Brentjes (1994).

\(^{23}\) Online at http://jonathancrabtree.com/euclid/%0Aelements_book_VIIDefinitions_via_Jagannatha_Samrat_The_Rekhaganita.html.
§3 Aristotle’s *Poetica*, on the other hand, was much less successful; indeed, its transmission was rather hazardous and only the first of originally two books is preserved (the lost one treated comedy). Tarán & Gutas have recently published an impressive *editio maior* taking into account the Semitic and Latin translations for the *constitutio textus* of the Greek text. A full stemma is provided (p. 159), which shows that the extant Greek and Moerbeke’s close Latin translation belong to a different primary branch than the Semitic translations. A more detailed genealogical tree of the Semitic translations is also provided (p. 110); from that Semitic branch stems another Latin translation by Hermannus Alemannus (thirteenth century – not used here). The surviving Arabic translation by Abū Bīšr Mattā ibn Yūnus (d. 940) has been edited several times; Tkatsch’s bilingual edition, which includes a fresh Latin translation, is used here. A contemporary Sanskrit translation is used here to study how this language deals with the content. The editions used are as follows.

- Leonardo Tarán & Dimitri Gutas (eds) (2012): *Aristotle: Poetics; Editio Maior of the Greek Text with Historical Introductions and Philological Commentaries*. Leiden: Brill.
- Lorenzo Minio-Paluello (ed.) (1968): *De arte poetica: Translatio Guillelmi de Moerbeke post transcriptionem Ersae Valgimigli ab Aetio Franceschini revisam*, 2nd ed. Bruges: Desclée de Brouwer.
- Jaroslau Tkatsch (ed.) (1928–1932): *Die arabische Übersetzung der Poetik des Aristoteles und die Grundlage der Kritik des griechischen Textes*, 2 vols. Vienna: Hölder-Pichler-Tempsky.
- Bharat Chandra Nath (2010): *Aristotle’s Poetics: Sanskrit Translation and Critical Study*. Kolkata: Kolkata block and print.

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24 On this translation, see Engelfriet (1998); Jami & Delahaye (1993).
25 Close, but ‘Latin is not Greek: it has no article’, as pointed out by Tarán & Gutas (edition, p. 137).
26 Its author does not mention from what text he translates, but as he does not seem to have mastered the Greek language, it is to be expected that he is translating from an unnamed English translation. Still, for our purposes – studying how content tends to be phrased – this is not too problematic (if we take it for granted that the English translation was able to make the original meaning clear).
The first thing even a casual observer notes in the language of the Elementa is its uniform and formal organisation. Except for the definitions and axioms at the beginning of every new subject, the theorems always follow the same form: πρότασις (the formulation), ἔκθεσις (the ‘setting out’, a more detailed exposition introducing the letter nomenclature for the geometric objects in question), διορισμός (the ‘definition’ of how to reach the solution), κατασκευή (the geometric construction), ἄποδειξις (the proof that the construction was correct, often by reductio ad absurdum), and συμπέρασμα (the ‘conclusion’, a restatement of the theorem, ending in the famous ὅπερ ἐδει δείξαι, our ‘Q.E.D.’).27 Besides these six steps, there is a diagram which – contrary to modern maths books (where such diagrams only illustrate the problem and are not essential for the mathematical content) – often contains information that is not explicitly stated in the text, typically the relative position of the points to which letters are assigned. An example sentence, which will be studied in translation below, is Euclid, Elementa I, prop. 47 πρότασις (the Pythagorean Theorem):

Ἐν τοῖς ὀρθογώνιοις τριγώνοις τὸ ἀπὸ τῆς τὴν ὀρθὴν γωνίαν ὑποτεινούσης πλευρᾶς τετράγωνον ἱσοῦ ὡς τοῖς ἀπὸ τῶν τὴν ὀρθὴν γωνίαν περιεχομένων πλευρῶν τετράγωνοι.

‘In any right-angled triangle the square on the side subtending the right angle is equal to the squares on the sides containing the right angle.’

The language itself is also very uniform.28 Acerbi (2021: 1) has described this language in detail, including statistical material and concluding that it is a Kunstsprache ‘exhibiting a limited lexicon and highly regimented syntactic features, which in some cases may well be termed “extreme”’. The technical nominal lexicon is small and is in a one-to-one correspondence with the geometric objects covered (list in Acerbi 2021: 35–36). For other PoS, there is more variation, especially some unexpected synonyms – διπλάσιος, διπλασίων, διπλοῦς (‘double’; 36) – but the number of lemmata and distinct words is very small compared to other Greek texts, as we shall see. Concrete geometric objects are designated by algebraic letter-names such as ‘AB’, each letter standing for one point. Thus, in Euclid we find a very specialised type of language: the vocabulary is small, synonyms are avoided, unambiguity is sought; but, of course, it is a rather specialised vocabulary with many words for things that do not exist outside geometry. Words for such new geometric objects could be coined easily in the Greek language, which

27 For a full example in translation, see Acerbi (2021: 3–4).
28 So much so that there is an online course for learning Greek just to read Euclid: http://mysite.du.edu/~etuttle/clas.
is very fond of compounds – like Sanskrit but in contrast to Latin and Arabic. A few examples show that (i) some terms could be taken from everyday language more or less as is (e.g. σημεῖον, ‘point’; γραμμή, ‘line’; ἐπιφάνεια, ‘surface’; γωνία, ‘corner’; κύκλος, ‘circle’; ἰσος, ‘equal’; ἄνως, ‘unequal’) or in a more technical but still recognisable way (κάθετος, ‘let down (of a plumb line) → perpendicular’; ἀμβλύς, ‘blunt → obtuse (angle)’; ὥξος, ‘pointy → acute (angle)’; μονάς, ‘solitary, by oneself → (mathematical) unit’). Some (ii) are hardly still recognisable, such as ρόμβος (‘rhombus’), normally a sound-producing cult instrument similar to the Australian bull-roarer of rhomboid shape, or ἀντιπάσχω (‘to be reciprocally proportional’, literally ‘to suffer in turn’). Many others (iii) are just compounds of everyday words that are immediately understandable for a Greek-speaker (e.g. εὐθύγραμμος, ‘rectilinear’; ἠμικύκλιον, ‘semicircle’; ἰσόπλευρον, ‘equilateral’; ὀσύμπτωτα, ‘which never meet’; ἰσογώνιον, ‘equiangular’; διάμετρος, ‘diameter’).

(iv) Compounds may, of course, also contain parts that may not be familiar to the non-geometer, such as δώδεκάεδρον (‘dodecahedron’), where ἐδρα means ‘face of a geometric figure’ (usually it means ‘seat’, and a non-geometer would hardly know what a ‘twelve-seater’ is).

The syntax is equally monotonous, as the few numbers in table 25 suggest: among these values, conditional clauses (εἰ, ἐάν, ἐπεί) are very common, as is parataxis using καί (‘and’), γάρ (‘for’), or very frequently ὅτα (‘thus’). Infinitives and participles are much rarer than usual in Greek. Of the linguistic phenomena typical for Greek scientific writing (as will be seen below in Aristotle), absolute and participial constructions are rare, but the article is used a lot more than in other Greek. Indeed, the feminine article without any noun except a formula (e.g. ἡ ΑΒ) signifies a ‘line’ (ἡ γραμμή) through A and B, its neuter τὸ A a ‘point’ (τὸ σημεῖον), and its masculine ὁ ABΓ a ‘circle’ (ὁ κύκλος). There are also more such short designations: τὸ ἄπο AB for the square (τὸ τετράγωνον) ‘on’ AB, ἡ ὑπὸ ABΓ for the angle (ἡ γωνία) ‘under’ the three points.29 But this latter feature is, of course, not essential for geometry; it just shortens the text by saying ἡ AB (‘AB’) instead of ἡ γραμμή, AB (‘a line, called AB’)30 each time.31 Such letter symbols make up a full 16% of all words in the Elementa. Together with the article they make up more than a third of all words in the Elementa. Acerbi (2021: 86) points out:

29 A full list of such abbreviated namings of geometric entities in Acerbi (2021: 42–44).
30 See Acerbi (2021: 81–83) on the precise meaning of these letter symbols as names.
31 But brevity is much appreciated by scientists; compare the famous Indian saying that grammarians rejoice about the saving of a syllable as much as about the birth of a son (in Parībhasena-duśekhara, ed. Kielhorn, p. 115).
The article that precedes the letters has two functions. The first is distinguishing between objects designated by identical strings of letters, because the gender of the article is the same as that of the noun modified by the string of letters: ὁ ΑΒΓ is a circle but τὸ ΑΒΓ is a triangle – for instance inscribed in circle ὁ ΑΒΓ [...]. The second function is to produce a linguistic item suited to be a noun, which must have a declension: the case of the noun can only be deduced from the case of the article.

This latter function is found below to be a crucial feature of Greek scientific language in general (chap. 24 §6). None of the studied translations was able to reproduce this special feature of Greek geometry as none of these languages disposes of an article and three genders.

Table 25: Frequencies in ‰ of some structure words in the texts we consider in comparison to a large general Greek corpus. Striking differences from the Perseus corpus are underlined.

|                  | Euclid, *Elementa* | Aristotle, *Poetica* | Perseus Greek |
|------------------|--------------------|----------------------|----------------|
| καί               | 40.89              | 53.57 (38.16)        | 47.79          |
| ἀρα               | 24.75              | 0.75 (0.64)          | 0.57           |
| εἰ (incl. ἐὰν)    | 5.80               | 3.86 (6.10)          | 3.80           |
| ἔπειρ               | 7.00               | 1.04 (1.34)          | 0.61           |
| γάρ               | 6.31               | 18.17 (16.03)        | 8.71           |
| **Article**       | **220.85**         | **78.49 (68.96)**    | **76.36**      |
| **Relative pronoun** | **18.32**          | **10.55 (8.93)**     | **9.76**       |
| **Infinitives**35  | 1.59               | 22.18 (15.35)        | 23.44          |
| Medio-passive participles | 9.46               | 14.07 (17.15)        | 20.27          |
| **Number of words** | 152,688            | 10,233 (1,077,161)   | 3,791,102      |

Although the genitive absolute is a very concise means of formulating the conditions under which something is to hold true or happen, it is only rarely used by

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32 Data from *TLG* (Heiberg’s edition without the material in the appendix). Acerbi (2020: 32) provides further data about PoS in the *Elementa*.
33 The work is somewhat too short to produce reliable figures, so I have added numbers for the entire Aristotelian corpus on CC in parentheses.
34 The freely downloadable Perseus Greek text corpus (as of July 2015) was used.
35 Searched like this: grep -c ‘εἰν | ἄν | ἐαν | ὅθωσ’ and ‘[^ ]μ[ε[ε]ν[^ |[^ ]|^]ς’ (which also finds a few false positives).
Euclid. Together with conditional ἐπεί clauses, it would seem the natural means for formulating theorems. Figures for Aristotle’s Poetica are also shown in table 25. Its language is much closer to ordinary Greek in the features considered, although there are exceptions. Most notably, the logical γάρ (‘for’) and the if-words are much more common in Aristotle (though not in the Poetica). As was shown in the previous chapter, Aristotle often used existing words in a narrowed-down, more precisely defined way. Indeed, he often resolves apparent problems by finding that a word means several things (the famous πολλαχῶς λέγεται; see chap. 7 §6). As the preserved Aristotelian works are notes from his lectures, his language is somewhat terse and could today be seen as university-lecture-like, sometimes rather compressed. As observed (chap. 21), new coinings, which would in Greek usually be compounds, are relatively rare in Aristotle. Here is an illustrative compressed sentence from the Poetica (1.2–3, 1447a15–18, ed. Tarán & Gutas, p. 165):

πᾶσαι τυγχάνουσιν οὕσαι μιμήσεις τὸ σύνολον. Διαφέρουσι δὲ ἂλλήλων τρισίν· ἢ γὰρ τῷ γένει ἐτέρως μιμέοναι, ἢ τῷ ἕτερον καὶ μὴ τὸν ἕτος τρόπον.

‘All of these may be said on the whole to be representations/imitations. But they differ one from the other in three ways: either representing/imitating by [using] generically different [means], or [representing] different [objects], or [representing them] differently and not in the same manner.’

The two works in translation

§5 In order to study the translatability of these two kinds of scientific Greek, a look is taken first at representative sentences in the translations, then at a list of technical terms and how the translators dealt with them, and finally some figures about the translations are considered. In the case of Euclid, most translations rewrite the text more than translating it: they add comments, make little changes to the proofs, even correcting minor mistakes here and there. Some add long commentaries, such as Clavius, Ḥağğag, and Ps.-Tūsī; on the other hand, the Sicilian

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36 e.g. Elementa I, prop. 16, ed. Heiberg, vol. 1, p. 42: Παντὸς τριγώνου μίας τῶν πλευρῶν προσεκβληθείσης ἢ ἐκτὸς γωνία ἐκατέρας τῶν ἐντὸς καὶ ἀπεναντίων γωνιῶν μεῖζον ἔστιν (‘For any triangle – one of its sides having been produced – the exterior angle is larger than the interior and opposite angles’).

37 Latin’s equivalent, the ablativeus absolutus, is often used thus, for instance in Newton’s Latin. Netz (1999: 259) claims that in Greek mathematical writings the genetivus absolutus and infinitives are most common in the protasis. This is not true for the Elementa, where this feature hardly occurs.

38 For the rendering, compare Fuhrmann’s translation in his edition.
translation from the Greek is slavishly verbatim. Here is the above example (Elementa I, prop. 47, πρότασις) again, with the syntax marked in brackets:

(Ἐν τοῖς ὀρθογωνίοις τριγώνοις) {τὸ [ἀπὸ τῆς (τὴν ὀρθὴν γωνίαν) ὑποτεινούσης πλευρᾶς} τετράγωνον) ἵσον ἐστὶ {τοῖς ἀπὸ [τῶν (τὴν ὀρθὴν γωνίαν) περιεχομένων πλευρῶν] τετραγώνοις}.

‘(In right-angled triangles) {the square [on the side (subtending the right angle)]} is equal {to the squares [on the sides (containing the right angle)]}.

The statement is strongly syntactically nested, a structure which can be imitated with varying degrees of success in the different languages. The Sicilian translation formulates (verbum de verbo, including imitating the article with quod):

(In orthogoniis trigonis) {quod [a (rectum angulum) subtendente latere] tetragonum} equale est {eis que [a (rectum angulum) continentibus lateribus] quadratis}.

Gerard of Cremona translated from Arabic, but the result is much more Latin. Gerard made the best translation from the Arabic according to Busard (edition, p. 25), but was unfortunately little read:

{Quadratum [ex latere (trianguli rectanguli) (recto) subtenso (angulo)] factum} {duobus quadratis factis [ex duobus lateribus (rectum) continentibus (angulum)] est equale}.

Clavius (1594 edition, p. 83) writes normal, yet perfectly understandable Latin, introducing relative clauses. He adds the underlined words for clarity:

(In rectangulis triangulis), quadratum, {quod [a latere (rectum angulum) subtendente] describitur}, aequale est {eis, [quae (a lateribus (rectum angulum) continentibus) describuntur], quadratis}.

Heiberg translates similarly into modern academic Latin. Ḥaḡḡāḡ (p. 172) works with participles (underlined), especially often of kāna (‘to be’) and also relative clauses (italics). A verbum de verbo English translation is given.

[kullu muṭallaṭin (qāʾim l-zawiyati)] faʾanna [l-murabbaʿa l-kāʾina mina l-ḍīlʾi (laḍī yūṭiru l-zawiyata l-gāʾimata) musāwīn [li-mağmūʿi l-murabbaʾaynī (l-kāʾinaynī mina l-ḍīlʾaynī l-bāqiyayn)].

‘[Every triangle (standing according to the angle)], and behold: [the quadrilateral being of the side (which spans the right angle)] is equal [to the sum of the two quadrilaterals (being of the two sides remaining)].’

The Arabic dual is employed. Samrāṭ (vol. 1, p. 62) works with compounds and can formulate very concisely indeed in Sanskrit:
(tatra samakṣaṇāтриbuḥjasya) karṇavargo (bhujadvaṣya vargayogenā) tulyo bhavati.  
‘(Therefore of right-angled-triangle) square of hypotenuse (of the two-sides by square-adding,) equal becomes.’

Everything contained in one word is marked here by lower half-brackets. The Chinese translation puts this (in simplified characters, followed by pīnyīn transliteration):

凡三边直角形、对直角边上所作直角方形与馀两边上所作两直角方形并，等。
fán sānbiān zhíjiǎo xíng: duì zhíjiǎo biān shàng suò zhíjiǎo fāngxíng yǔ yú liǎng biān shàng suò zuò liǎng zhíjiǎo fāngxíng bìng, děng.
‘For any three-sided shape with a right angle [the following applies]: A square shape made above the side facing the right angle and the two square shapes made above the sides of the other two angles combined [are] equal.’

Apparently, Arabic and Sanskrit use opposing strategies: while Sanskrit uses compounds, Arabic resorts to clauses. Chinese uses neither; it states all that is needed paratactically. The Latin syntax can remain much closer to the Greek than the other languages considered here, but like Arabic it tends to use more relative clauses.

The following table (table 26) lists the translations of some of the geometric vocabulary; relatively straightforward examples are given first, then less easily translatable ones. For Sanskrit, the constituent parts of compounds are marked by dashes. Literal translations are added for interesting cases.

### Table 26: Some examples of the translation of technical terminology; loanwords are underlined; non-technical meanings are provided for the non-classical languages. ‘Adel.’ stands for Adelard of Bath, ‘Camp.’ for Campanus of Novara, ‘Ger.’ for Gerard of Cremona, ‘Hei.’ for Heiberg, ‘Robt.’ for Robert of Chester, ‘Tine.’ for Johannes de Tinemue.

| Greek          | Latin (Anonymous  | Latin (others if different) | Arabic | Sanskrit | Chinese |
|----------------|-------------------|------------------------------|--------|----------|--------|
| γραμμή          | linea             |                              | ḫṭṭ    | sūtraḥ    | 线 xiàn |
| εὐθεία (γραμμή) | recta (linea)     | ḫṭṭ mustaqīm                | sarala-rekha | 直线 zhíxiàn |
| ἡ (εὐθεία) AB  | (recta) AB        | (ḫṭṭ mustaqīm) A B           | a-ba-rekha | 甲乙直线 jīyīzhíxiàn |
| γωνία          | angulus           | zāwiya                       | koṇaḥ   | 角 jiào (‘horn’) |
| εὐθύγραμμος     | rectilineus       | mustaqīm                     | sarala-rekha | 直线 zhíxiàn |

39 Literally ‘first-second’.
| Greek            | Latin (Anonymus Siculus) | Latin (others if different) | Arabic         | Sanskrit       | Chinese          |
|------------------|--------------------------|-----------------------------|----------------|----------------|------------------|
| κάθετος          | cathetus                 | alhamud (Camp.), perpendicularis (others) | 'amūd ('pillar') | lamba-rāpe    | 直角 zhíjiǎo    |
| κέντρον          | centrum                  | markaz ('centre')           |                | kendram\[^{40}\] | 圆心 huán xīn ('circle heart') |
| διάμετρος        | diametros                | quṭr v‘to drop’, noun < tractus terrae (Freytag) | kendra-pariga-tam ('gone through') |                  | 圆界线 huán jiè xiàn ('circle boundary line'), 維為圈 jìng wèi huán ('path for circle') |
| τρίγωνον         | trilatera figura         | triangulum (Camp.)          | muṭṭālat ('tripple') | tri-bhujān\[^{41}\] | 三角形 sānbiān xīng ('three edge shape') |
| ισόπλευρον       | isopleurum               | aequilaterum (Robt., Camp.) | muṭṭālat mutasā-wi l-āḍā' ('... same of sides') | sama-tri-bāhu-kaṁ ('same ...') | 三角形有两边线等 sānbiān xīng yōu liāngbiānxīàn děng ('three edge equal') |
| ισοσκελές        | isoskeles                | alia figura (Robt. (!)), triangulus duorum equilium laterum (Adel., Ger.) | muṭṭālat mutasā-wi l-sāqaynī ('... same of two legs') | sama-dvi-bāhu-kaṁ ('same two sides') | 三角形有两边线等 sānbiān xīng ('three edge equal') |
| τραπέζιον        | trapezia                 | elmunharifa (Robt.), irregularares (Adel., Ger.) | munḥarif ('deviant, pervert') | viṣama-koṇa-sam-catur-bhu-jāṛi ('un-same angle ...') | 无法四边形 wūfā sībiānxīng ('no law four edge shape') |
| παράλληλοι       | parallila (also Camp.)   | linea recta equidistans (Ger.) | mutowāzin ('balanced') | samāṁ̊āntarāla-rekhā ('same intermediate-space line') | 平行 jīngxīng ('flat/even go') |

\[^{40}\] The -d- is unexpected and reminds one of the Modern Greek pronunciation. Was the translator in contact with Greeks?

\[^{41}\] Literally ‘three-armed, three-sided’, more usually trikoṇa- ('three-angle, three-corner'); Samrat also uses tribāhu-kaṁ (not in Monier-Williams).
Table 26: (continued)

| Greek                | Latin (Anonymus Siculus) | Latin (others if different) | Arabic | Sanskrit | Chinese          |
|----------------------|--------------------------|-----------------------------|--------|----------|------------------|
| παραλληλόγραμμον      | parallelogram-mum        | superficies ex equidistantibus lateribus (Ger.) | सुतुह अल-मुतावाज़ि (‘of parallel surfaces’) | same-koṇa-ca- tur-bhujā-kṣetraḥ (‘field/figure’) | 平行线方形 pingxing xian fangxing (‘parallel line square shape’) |
| λόγος                | proportio                | ratio (Hei.)                | निश्बा (‘kinship’) | nispatīḥ, f. (‘going forth or out’) | 比例 bì lǐ (‘compare precedent’) |
| ὑποτείνουσα          | subtendens               | subtendo (verbal; Hei.)     | वत्तर (‘stretch’) | karnaḥ (‘furnished with) ear (s)’ (०) | 对 dui (‘facing/opposite’) |
| ἀντιπάσχω            | contraria passe [sic]    | mutekefie (Adel.), mutuus seu mutekefie (Tine.), mutuorum laterum (Robt., Camp.), in contraria ratione (Hei.) | मुटकाफ्या (‘equivalent’) | ekarūpa-nispatīsīve karmin (‘making by uniform proportion’) | 互相视之 háxiàng shì zhī (‘reciprocally regard it’) |
| πρῶτος ἀριθμός       | primus numerus           | ‘ادد’ اوقف (‘first number’) | प्रथमान〈क्र (‘first number’) | not in books I–VI |
| ἀλογος               | aloge                    | irrationalis (Robt.)        | गिर्निश्बि (‘non relative’), गिर मण्टिग (‘non logic’)$^{42}$ | करानह$^{43}$ | not in books I–VI |
| πρίσμα               | prisma (also Hei.)       | corpus serratile (Robt., Camp.) | मनोर (‘spread out’) | chedīta-ghana-kṣetraḥ (‘divided solid’) | not in books I–VI |
| δώδεκάεδρον          | dodecaedron              | corpus duodecim basium pentago- narum equilateral- arum (Robt.), dodecaedrum (Hei.) | इष्टा अश्ले सुतुह (‘of) 12 sides’ | sama-bhuja-dva- daśa-phalaka-kṣetraḥ ( ‘... 12-slab ...’) | not in books I–VI |

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42 The root नट्य means articulatam et significantem protulit vocem (Freytag, s.v.), the noun prolata oratio; logica.

43 This word ‘originally meant a cord of reeds used by the sacrificial priest to measure the side of the square altar’ (Rekhaganita, vol. 2, appendix 2, p. 12). It is totally unrelated to its opposite, mūladarāśih (प्रत्योक, rationalis).
Clearly, many of these terms had to be newly invented by the translators. An example for which all other languages needed lengthy descriptions is παραλληλόγραμμον; others, such as πρῶτος ἀριθμός, were easy to imitate (only English uses Latin ‘prime’, not the expected ‘first number’). The Sicilian translator often just transliterates difficult Greek terms (occasionally including verbs such as παραβάλλειν; I.44), Robert does the same for Arabic (elmunharifa for ‘trapezium’), as does Adelard with mutekefie (‘being reciprocally proportional’) or alkaida for basis. The later Latin translations tend to use much less direct loans. Arabic, Sanskrit, and Chinese do not usually take direct loans at all, Samrat’s kendrain (κέντρον) is an exception. The more complex notions are rendered by compounds in Sanskrit and constructus clauses in Arabic, which clearly feels much less at home with these formulations than Sanskrit, with its compounds, does. For instance, Samrāt writes the descriptive and very clear, although rather long compound viṣama-koṇa-sama-catur-bujaṃ (‘not-same-angle-same-four-sider’) for ‘trapezium’. In Chinese such concepts are formed by combinations of characters, in this case wūfā sībīnxīng (‘no-law-four-edge-form’), which, however, is less precise. Now, some statistical data about the translations.

Table 27: Statistical data for the Euclid translations (book I only). Characters are counted without spaces. The zipped bytes measurement (of a .txt file containing the text) is used as an estimate of the information content.

|                  | Greek | Latin, Anonymous Siculus | Latin, Gerard of Cremona | Latin, Clavius | Arabic, Tūsī | Sanskrit | Chinese |
|------------------|-------|--------------------------|--------------------------|----------------|-------------|----------|---------|
| Words            | 11,340| 9,402                    | 12,600                   | 12,080         | 14,436      | 9,663    | 47      |
| Characters (excluding spaces) | 47,150| 46,510                   | 67,550                   | 54,220         | 55,504      | 82,160   | 5,925   |
| Zipped bytes    | 17,291| 13,133                   | 19,343                   | 18,131         | 25,418      | 26,067   | 6,363   |
| Distinct words48 | 860/619 | 907/690                 | 1255/989                | 1344/1001      | 1738/1716   | 3342     | 321     |
| Lemmata49       | 242   | 240                      | 403                      | 416            | unknown     | unknown  | 321     |

44 Such cases are listed by Busard in his edition (pp. 14–15).
45 Compare the similar behaviour of Arabic and Chinese in the modern examples in the next chapter.
46 On this construction, see Badawi, Carter & Gully (2004: 130–143).
47 Which combinations of characters should count as one semantic unit (‘word’) is often unclear in Chinese; preferably, one just counts characters.
48 The first number includes names for geometric objects, such as AB, as ‘words’.
49 Not counting proper names. The numbers were automatically calculated in Corpus Corporum using word-lists mostly from Perseus. In ambiguous cases, the first lemma was chosen and some
It is to be remembered that Gerard translated from Arabic and that the Sicilian translation is a *verbum de verbo* translation of the Greek: it reaches amazing *brevitas*. Chinese – both the language and its script – functions completely differently. This makes comparison difficult, but the Chinese translation seems to be very short as well, although the number of unique characters is higher than that of the lemmata in the Greek or in the Anonymus Siculus. Further interpretation is provided in the next section and contrasted with Aristotle.

**Aristotle**

§6 For Aristotle’s *Poetica*, the statistical data is provided first (in order to keep the two tables close together), then we consider a representative sentence and the translations of some technical terms.\(^{50}\)

**Table 28:** Statistical data for the *Poetica* translations (for details, see table 27).

|                      | Greek | Latin (Moerbeke) | Arabic (Abū Bišr) | Sanskrit (Nath)\(^{51}\) |
|----------------------|-------|------------------|--------------------|--------------------------|
| **Words**            | 10,262| 9,314            | 11,127             | 8,089                    |
| **Characters (excluding spaces)** | 50,108| 54,915           | 59,903\(^{52}\)    | 73,550                   |
| **Zipped bytes**     | 33,509| 23,618           | 31,917             | 43,007                   |
| **Distinct words**   | 2,662 | 2,560            | 3,339              | 4,933                    |
| **Lemmatas\(^{53}\)** | 1,368 | 1,598            | unknown            | unknown                  |

Here, the Sanskrit translator has to circumscribe many facts of Greek cultural life, and the wording becomes longer, in contrast to the Euclid translation above. Again, the information content speaks for Latin *brevitas*; the near-equal number of distinct words in Greek and Latin is, again, a consequence of the translation technique. The above example sentence (*Poetica* I.1, 1447a16–18) is translated by Moerbeke (p. 3) as:

uncertainty (up to some 5\%\) must be expected. The lemmatising feature only works for Latin and Greek, so we have no numbers for the other languages.

\(^{50}\) I could not find a digitally available Chinese translation of this text.

\(^{51}\) The numbers are based on automated OCR, so an error margin of up to some 5\% must be allowed for. The character count is based on the transliterated forms. As words are often not separated in the Devanagari script, the numbers for words and distinct words will not be very accurate.

\(^{52}\) Counting only the written consonant characters, thus without vowels.

\(^{53}\) Same way of counting as in the previous table.
differunt autem ab invicem tribus: (i) aut enim per genere alteris imitari, (ii) aut per altera, (iii) aut per aliter et non eodem modo.

The Arabic translator Abū Bīšr (p. 220) expands this rather condensed statement considerably:

w-ʾaṣnafu-hā ṭalāṭatun: (i) wa-ḍaliqa ʾima an yakūna yuṣbihu bi-ʾaṣyāʾi ʾaḥari wa-l-hikayatu bi-hā, (ii) wa-ʾima an takūna alā ʾaksi hādā: wa-huwa ʾan takūna ʾaṣyāʾu ʾaḥaru tuṣbihu wa-taḥāki, (iii) wa-ʾima an taḡrā alā ʾahwālin muḥatalifatīn lá alā ʾiḥatin wāḥidatīn bi-ʾayni-hā.

‘And [there are] three classes of it: (i) that is to say either that they are imitating in other things and the imitation [is] in them, (ii) or that they are contrary [to] this, and they are in other things imitating the imitation, (iii) or that it works with different situations, who are not one-and-the-same in respect.’

Sanskrit is again very concise for such sūtra-like statements, basically reducing the three possibilities to one compound (p. 3):

tathāpi tāni anukaraṇasya mādhyaṃ-viṣayaṃ-ṛiti-drṣā tridhā ‘nyonyam vibhaṣijante.

‘Even so, these [kinds] of imitation [by middle-topic-diction-appearance, in three parts from one another are distinguished.’

The translation of scientific descriptions of matters rooted in a particular culture cannot work without a rather deep knowledge of the culture in question – in contrast to geometry, which travels much more seamlessly. The uncommon vocabulary in the Poetica consists mostly of names of genres and poets. Abū Bīšr, an Aristotelian logician, is not interested in the performance of these Greek forms of art at all. Nath provides a list of his transliterations of those terms unfamiliar within Sanskrit, but taken to be familiar to his readers in their international (i.e. English) form, for example dithurambaḥ or platān, for ‘dithyramb’ and ‘Plato’ respectively, which are well formed and can be easily declined in Sanskrit. Rigolino (2013: 146) concludes about the Arabs:

Their awareness of Greek literature was scarce, but nevertheless they were not prevented from reading and studying Aristotle’s Poetics, a treatise dealing with Greek drama. Rather, the distance that separated Greek and Arabic literatures prompted translators and later

54 Tkatsch translates (p. 221): Et species eorum (sunt) tres. Etenim aut adsimulant per res alias et (fit) imitatio per eas aut sunt contraria, quod guidem res aliae adsimulant et imitantur aut fiunt modis diversis, non ratione una ipsa.

55 This is typical for Sanskrit’s sūtra style: texts are very condensed and easy to learn by heart. But they need to be elucidated by commentaries or by a teacher.

56 Unlike what the Sanskrit Wikipedia proposes: plāton.
scholars such as al-Fārābī, Ibn Sīnā and Ibn Rušd to put forward their interpretations of the Aristotelian text.

Again, translations of key vocabulary are compared in table 29.

Table 29: Some examples of the translation of technical terminology; loanwords are underlined. The numbers indicate the chapter in the Poetica where a word is found.

| Greek          | Latin         | Arabic | Sanskrit |
|----------------|---------------|--------|----------|
| (1) τραγῳδία   | tragodia      | madih  | tragādī  |
| κωμῳδία       | komodia       | hīgā'  | kāmādi   |
| ἐποποία        | epopoia       | našid  | mahā-kāvyā |
| (3) δράμα      | drama (idest actitamen) | drāmātā (pl.) | kārya/drāmā |
| δρᾶν          | actitare      | amila  | kṛṣṭa    |
| (4) ἕξαμετρον | exametrum     | al-ʿawzān al-sudāsiyya | ṣaptadī-ḥṛṭta (Hexameter) |
| ιάμβος        | iambus        | yāmbū   | yāmbū     |
| (6) μίρησις    | imitatio      | muḥākāt | anuktiḥi/anukaraqānūḥ |
| μῦθος         | fabula        | ḫurāfa | katha-vastu (‘subject matter’) |
| Ḥθος          | mores         | āda     | caritraḥ |
| λέξις         | locutio       | maqūl   | sabdayoḥanā [sic] |
| διάνοια       | ratiocinatio  | ītiqād  | cintā     |
| δψις          | visus         | naṣra   | prekṣā    |
| μελοποιία      | melodie      | naḡmat al-ṣawt | sorgētaḥ |
| (9) ποιεῖν     | poetizare     | ʿamila (compare ḏrān) | sraṣṭ (‘[be creator’) |
| ποιητῆς       | poetā        | ʿšāʿir (the root means ‘know intuitively’) | kavi (‘seer, poet’) |
| πράξεις       | actio        | ḥrādiyya (‘intention’) | ghaṭānā (‘acting’) |
| ἐπεισοδιώδης   | episodiodea (idest superadventitia) | iqtiṣās⁵⁷ | prasaṅga (‘result, consequence’) |
| (11) ἀναγνώρισις | anagnorisis | istidlāl (‘argumentation’) | āviṣkārama (anagnori-sis) (‘making manifest’) |

57 A technical term in Arabic poetry meaning [q]uod introductio non cohaeret cum ipso carmine scopo (‘that the occurrence of something [in a poem] does not belong in the context of the poem itself’) or similar (Freytag, s.v.); the main meaning of the root qṣ is ‘cut, perforate’.
In this sample, there are a lot more loans in Sanskrit in particular, but there are also some in the Arabic translation. Many of these terms are still used in their Greek form in modern scholarship.

**Conclusions from the two texts**

§7 Despite the fact that none of the translations was made by the same translator, there are some definite patterns in the statistical figures. In comparison to Euclid’s book I (which is of approximately the same size), Aristotle in his *Poetica* uses over five times as many distinct words and lemmata, which says a lot about Euclid’s special type of Greek. Latin is the only target language in which translations tend to be shorter than the original.\(^{58}\) On the whole, the scientific Latin translators tend to translate their Greek originals very closely, sometimes *verbum de verbo*, which generates ‘Greek in Latin letters’.\(^{59}\) Moerbeke uses a Greek term plus *idest* and a tentative Latin equivalent thirty-one times (including cases of quotations that are not translated). This minimises the danger that the translator perpetuates his own misunderstandings, but on the other hand the result is quite unintelligible for someone who has not learned to understand this Greek syntax in Latin and thus to adopt a Greek *Denkstil*. The main problems in translating Greek science into Latin are discussed below (chap. 24 §§5–8): lack of article, compounding, and suffixation.

In the other three languages, such a procedure was clearly impossible, as the languages are unrelated (or at least do not share the *Begriffsgemeinschaft*, as in the case of Sanskrit) and work rather differently syntactically. In Arabic, translators had to reformulate many things; compounds in particular – as seen in the list for Euclid – were often turned into *constructus* clauses. Besides, it was noted that the Arabic translators had a tendency to be rather prolix, for instance to say things twice with slight variation. In Sanskrit things are again very different: this language is so fond of compounding that the number of words tends to become less in translating (though not the number of characters). Samrāṭ even makes compounds of geometric objects and speaks of, for instance, the ‘A–B-line’. Nath makes compounds of lists.\(^{60}\) Sanskrit is famous for its special scientific language,

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58 The same is apparently true for Chinese, whose writing system gives it a natural tendency to brevity.

59 More on this technique in chap. 10 §5 above and Roelli (2014a). In early Church texts, this was very different; although there was a wide spectrum from verbatim to very free translations, the *verbum de verbo* type is hardly ever encountered (Gleede 2016: 356).

60 Such as *mahākāvyā-tragādi-kāmādi-stutikāvyāni* for Ἐποποιία δῆ καὶ ἡ τῆς τραγῳδίας ποίησις, ἔτι δὲ κωμῳδία καὶ ἡ διθυραμβοποιητική (1.2, p. 238).
which goes so far as to give cases specialised scientific functions in the sentence.\footnote{More on this \textit{Nominalstil} in Jacobi (1970); see also Staal (1995).} For instance, causes are indicated by a bare ablative. A normal speaker or reader of the language who is unaware of these special rules will be unable to understand anything in such a text. A similar heavily nominal style can be observed in German, but it resorts more to compounding and, unlike Sanskrit, does not go so far as re-engineering its syntax.\footnote{Otto Jespersen already noted this similarity in 1924 (quoted in Gordin 2015b: 37).}

It can be concluded that Euclid is much easier to translate than Aristotle due to several factors. Not only is Euclid’s content more easily accessible to non-Greeks than the Greek art forms studied by Aristotle’s \textit{Poetica}; it would also seem that a highly formalised language using a small and well-delineated vocabulary and simple syntax also helps a lot in this respect. However, Euclid’s highly formalised language can even be formalised and compressed much further, as is indeed done in modern mathematics. Thus, these two statements amount to the same thing:

\begin{equation}
\sum_{i=0}^{n-1} ar^i = a \frac{r^n - 1}{r - 1}
\end{equation}

On the other hand, in the human sciences, texts are still written in a much less formalised language today, although it is definitely also a highly specialised kind of language with many foreign words (especially Greek and Latin ones) and often still a complicated and non-repetitive syntax which is used to mimic in language complex structures from the field studied. A German example:

\begin{quote}
Im Fortgang nahmen dann jedoch Einstellungen überhand, welche die ‘fortwährende Normenentfaltung’ nicht mehr erkennen, jedenfalls nicht mehr anerkennen wollten, und damit – wohl ohne daß man es wollte, und ohne daß man es merkte – diese zählebige Tradition lebhafter Fortentwicklung zum Verklingen brachten.\footnote{From Stotz (1996–2004: I, §9.11 = vol. 1, p. 35).}

‘In the course of time, however, attitudes prevailed which no longer recognised, or at least no longer wanted to acknowledge, the “progressive unfolding of norms” and thus – prob-}

\[\ldots\]
ably without wanting to and without even noticing it – it made this persistent tradition of lively further development fade.’

In translating such texts, one faces two problems, one concerning vocabulary and one of syntax and nuances. *Normenentfaltung* may be renderable by ‘unfolding of norms’, but other nuances can in no way be preserved in the English: consider *zählebig* turning into a mere ‘persistent’ without the connotation of ‘life’, or the closeness of *erkennen* and *anerkennen*. The same is true for the musical connotations of *Verklingen*. The first problem can thus be solved relatively easily by taking over the foreign words missing in the target language and hoping that readers will understand them, or alternatively by forming calques (as I did in the example). The next chapter will give further examples of each approach. The second problem is much more tricky, as has been seen in the examples from Aristotle’s *Poetica* in this chapter. What we see here may be a difference between natural and human sciences: that the former are much more easily formalised.

On the whole, it would seem that different languages had to master different problems in order to express Greek science. Science can be seen as a web of strictly defined scientific entities. The entities need names when translating into a language not yet familiar with the science in question, but the web must also be recreated. The former task is relatively straightforward and can be accomplished by loaning or calquing (as the tables above have shown). The latter option is, in general, to be preferred, as loaned words tend to remain foreign material in the target language that is not well integrated into its semantic web. Think of the famous Russian *бутерброд*, which does not have to contain butter at all. Indeed, in our examples, later translations have tended to use the calquing more profusely than the former. The web of these new concepts takes time to become established in the target language. Often, this web’s internal organisation also has to be changed; for instance, Latin could not use the article to denote lines, points, or circles the way Euclid did in Greek. The next chapter considers the debt of modern vernacular scientific terminology to scientific Greek and Latin.

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64 The word’s meaning moved to ‘sandwich’ as users did not understand the part mentioning ‘butter’. The Russian Wikipedia defines: ломтик хлеба или булки, на который положены дополнительные пищевые продукты (‘a slice of bread or bread roll onto which further alimentary products are put’; https://ru.wikipedia.org/wiki/бутерброд, November 2020).