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ALGORISMUS IN GKS 1812 4to

Transcription and Translation

Introduction

THE *ALGORISMUS* is an Old Norse prose translation of the *Carmen de Algorismo* of Alexander of Villedieu (c. 1170–c. 1240). The two earliest witnesses to this translation are found in AM 544 4to, a part of Hauksbók, and GKS 1812 4to. These versions are very close to one another and, possibly, to the original, perhaps being only once or twice removed.[1] Notwithstanding the similarities, the orthography and context of the copy in GKS 1812 is notably different from that of the Hauksbók copy. Whereas previous transcriptions of the *Algorismus* have been based on the version in Hauksbók, this paper provides a transcription of the *Algorismus* as it appears in GKS 1812, as well as an English translation.

The *Carmen de Algorismo* is a rendering, in Latin hexameter, of the techniques for working with the Indo-Arabic system of writing numbers.[2] It is itself a descendant of twelfth-century Latin translations of a ninth-century Arabic treatise written by Muḥammed ibn Mūsā al-Khwārizmī (c. 780–c. 850).[3] This work of al-Khwārizmī, known by its Latin title, *De Numero Indorum*, introduced Western Europe to the techniques of arithmetic which came to be referred to as the Indian calculus or *algorism* (derived from the author's toponym). Written in the first half of the thirteenth century, the *Carmen de Algorismo* helped spread the methods of

1 Kristín Bjarnadóttir and Bjarni V. Halldórsson, "The Norse Treatise Algorismus," *Actes du 10ème Colloque maghrébin sur l'histoire des mathématiques arabes* (Tunis: Association Tunisienne des Sciences Mathématiques, 2011), 69, and "Algorismus: Hindu-Arabic Arithmetic in GKS 1812 4to," *A World in Fragments: Studies on the Encyclopedic Manuscript GKS 1812* 4to, eds. Gunnar Harðarson with Christian Etheridge, Guðrún Nordal, and Svanhildur Óskarsdóttir (forthcoming), 189.

2 The *Carmen Algorismo* appears in *Rara Mathematica* on pages 73 to 83.

3 For background on these works, see *Muḥammed ibn Mūsā al-Khwārizmī: Le calcul indien (Algorismus)*, ed. André Allard (Namur, Belgium: Société des études classiques, 1992).

the Indian calculus widely throughout Western Europe.[4] It describes the methods, or algorithms, for the operations of addition, subtraction, duplation (that is, the doubling of a number), mediation (that is, the halving of a number), multiplication, division, and the extraction of both square and cube roots. To this the Old Norse *Algorismus* adds a section on a geometric progression between the cubes 8 and 27, connecting the sequence 8, 12, 18, 27 with the four elements of earth, water, air, and fire. The latter is an echo of a theme which dates back to at least the *Timaeus* of Plato. Although widely discussed in neoplatonic writings during late antiquity, as well as during the revival of platonism in the High Middle Ages, the connection between this geometric progression and the four elements has not been found in any other known versions of the Indian calculus.[5]

Numerous scholars have analyzed the text of the Old Norse *Algorismus* and, in particular, explicated the algorithms which it presents. Although similar to our modern methods for arithmetic, the presentation of these algorithms in the *Algorismus*, typically given without examples, is often obscure. In recent years, Kristín Bjarnadóttir and Bjarni V. Halldórsson have written extensively on the text itself and comparisons between the manuscripts in which it appears,[6] Otto Bekken has written on the historical and educational value of studying old arithmetical texts such as the *Algorismus*,[7]

4 Suzan Rose Benedict, *A Comparative Study of the Early Treatises Introducing into Europe the Hindu Art of Reckoning* (Concord: The Rumford Press, 1914), 12; André Allard, "The Influence of Arabic Mathematics in the Medieval West," *Encyclopedia of the History of Arabic Science*, ed. Roshdi Rashed, vol. 2 (London: Taylor & Francis, 1996), 523–24.

5 See, for example, William of Conches, *Guillelmi de Conchis: Glosae Super Platonem*, ed. Édouard A. Jeaneau (Turnhout: Brepols, 2006), 110–11. For a discussion of the sequence itself in the context of the Indian calculus, without reference to the four elements, see, for example, *Petri Philomeni de Dacia in Algorismum Vulgarem Johannis de Sacrobosco Commentarius*, ed. Maximilianus Curtze (Copenhagen: A. F. Høst & Fil. Bibliop. Reg., 1897), 74–75. For a more recent edition, see Petrus de Dacia, *Petri Philomenae de Dacia et Petri de S. Audomaro Opera quadrivialia*, ed. Fridericus Saaby Pedersen (Copenhagen: Societas Linguae & Litterarum Danicarum, 1983).

6 See, for example, Kristín Bjarnadóttir and Bjarni V. Halldórsson, "Ritgerðin Algorismus – samanburður handrita," *Vísindavefur: Ritgerðasafn til heiðurs Þorsteini Vilhjálmssyni sjötugum 27. september 2010* (Reykjavík: Hið íslenska bókmenntafélag, 2010) and "Algorismus: Hindu-Arabic Arithmetic."

7 See, for example, Otto B. Bekken, "Algorismus of 'Hauksbók': An Old Norse Text of 1310 on Hindu-Arabic Numeration and Calculation" (Agder: Agder distriktshøgskole, 1986).

and Abdelmalek Bouzari has detailed the origins of the Indian calculus and its path from Baghdad to Iceland.[8]

The Manuscripts

A complete copy of the *Algorismus* appears in three manuscripts: in addition to the copies in GKS 1812 4to, folios 13v–16v, and AM 544 4to, folios 90r–93r, there is a copy in AM 685 d 4to, folios 24v–29r. A fragment of the text appears in AM 736 III 4to, folios 4r–4v, as well. AM 544 may have been copied between 1306 and 1308.[9] GKS 1812 is a composite manuscript. Written over a length of time stretching from the twelfth to the fourteenth centuries, it consists primarily of computational and related texts, along with maps, diagrams, and illustrations.[10] It is traditionally divided into four sections, each identified with a different scribe. The section which contains the *Algorismus* has been dated to the latter part of the first half of the fourteenth century and so is not much younger than the Hauksbók copy.[11] The other two copies are significantly younger: AM 685 d is most likely from the second half of the fifteenth century,[12] and AM 736 III is thought to be from the middle of the sixteenth century.[13] Kristín Bjarnadóttir and Bjarni V. Halldórsson have argued that the copies of the *Algorismus* in AM 544 and GKS 1812 are only once or twice removed from the same original, while the copies in AM 685 and AM 736 are drawn in part from the same stem but are significantly further from the original.[14]

8 Abdelmalek Bouzari, “The Calculus of Al-Khwārizmī,” *A World in Fragments: Studies on the Encyclopedic Manuscript GKS 1812 4to*.

9 Gunnar Harðarson and Stefán Karlsson, “Hauksbók,” *Medieval Scandinavia: An Encyclopedia*, eds. Phillip Pulsiano and Kirsten Wolf (New York: Routledge, 2016), 271–72.

10 Gunnar Harðarson, “Medieval Encyclopedic Literature and Icelandic Manuscripts,” *A World in Fragments: Studies on the Encyclopedic Manuscript GKS 1812 4to*, 27–29.

11 Haraldur Bernharðsson, “Scribes and Scribal Practice in GKS 1812 4to,” *A World in Fragments: Studies on the Encyclopedic Manuscript GKS 1812 4to*, 63.

12 “AM 685 d 4to,” *ONP: Ordbog over det norrøne prosasprog* (Copenhagen: Den Arnamagnæanske Kommission), https://onp.ku.dk/onp/onp.php?m135.

13 “AM 736 III 4to,” *ONP: Ordbog over det norrøne prosasprog* (Copenhagen: Den Arnamagnæanske Kommission), https://onp.ku.dk/onp/onp.php?m136.

14 Kristín Bjarnadóttir and Bjarni V. Halldórsson, “The Norse Treatise Algorismus,” 75, and “Algorismus: Hindu-Arabic Arithmetic in GKS 1812 4to,” 189.

The Old Norse translation of the *Algorismus* was edited by P.A. Munch[15] in 1848 and Finnur Jónsson and Eiríkur Jónsson[16] in 1892–96. Both of these editions were based on the copy in Hauksbók, which has subsequently formed the basis for further study of the text. This copy is attributed to an Icelandic scribe, often referred to as "the first Icelandic secretary," in the employ of Haukr Erlendsson.[17] The *Algorismus* appears in the manuscript between two sagas, with *Fóstbrœðra saga* preceding it and *Eiríks saga rauða* following.

In contrast to the context of the copy in AM 544, the *Algorismus* in GKS 1812 appears immediately after a diagram illustrating some inscribed geometrical figures and precedes a short passage describing the division of a Latin unit of measurement, the *as*, into fractional parts. The leaves of the manuscript measure 210 mm by 140 mm.[18] Folios 13v through 16v have between thirty-two and thirty-five lines per page. The copy is attributed to a scribe who was most likely either Norwegian or at least trained in Norway, although he often uses Icelandic spellings, such as *hlutum*, *oiofnn*, *henni*, *hin*, and *hinum* (rather than the Norwegian forms *lutum*, *uiofn*,[19] *henne*,[20] *in*, and *inum*), and writes in a cursive style compatible with Icelandic script of the time. Haraldur Bernharðsson conjectures that this scribe "may have been trained in the scribal milieu associated with the royal chancery and St. Mary's Church in Oslo in the first half of the fourteenth century."[21] There are a number of arguments to support this claim. For example, Haraldur points to the scribe's use of the ligature "ꝏ" for "æ" as typical for a scribe working in that setting.[22] Moreover, the consistent distinction between

15 P. A. Munch, "Algorismus, eller Anviisning til at kjende og anvende de saakaldte arabiske Tal, efter Hr. Hauk Erlendssons Codex," *Annaler for nordisk oldkyndighed og historie* (1848): 353–75.

16 *Hauksbók*, eds. Finnur Jónsson and Eiríkur Jónsson (København: Thieles Bogtrykkeri, 1892–96).

17 "AM 544 4to: Hauksbók; Iceland and Norway, 1290–1360," *handrit.is* (National/University Library of Iceland), https://handrit.is/en/manuscript/view/en/AM04-0544; Otto B. Bekken and Marit Christoffersen, "Algorismus," *Medieval Scandinavia: An Encyclopedia*, 8.

18 "GKS 1812 4to, 13v–16v," *handrit.is* (National / University Library of Iceland), https://handrit.is/en/manuscript/view/is/GKS04-1812.

19 Although he uses this form once, in 14r/27.

20 Although he uses this form once, in 14r/31.

21 Haraldur Bernharðsson, "Scribes and Scribal Practice in GKS 1812 4to," 112.

22 Op.cit., 110. Here Haraldur cites Eivind Vágslid [=Vågslid], *Norske logmannsbrev frå millomalderen: Ei skrifthistorisk etterrøking av logmannsbrev frå Oslo, Uppland, Skien, Tunsberg,*

the vowels "œ" and "ǒ" makes it highly unlikely that it was written by an Icelandic scribe of this time.[23] Additionally, the scribe's use of "r" with a superscript tittle above it to denote "ir", as in "fingr'" for "fingir" (that is, *fingr*), reflects "the regular notation in documents written in the period 1320–30 at the royal chancery in Oslo and the closely associated St. Mary's Church."[24] The use of the "œ" ligature is seen in such words as *næst* and *bæði*, written as *nœſt* and *bœðe* in GKS 1812 but *nęſt* and *będi* in Hauksbók. Other Norwegian influences are seen in words such as *hleypr*, written *lǒypir* in GKS 1812 but *hleypr* in Hauksbók, as well as words in which *g* is written *gh*, such as *merkingh* in GKS 1812 for *merking* in Hauksbók. However, the Norwegian influence gives us no indication as to where the text was composed. Moreover, the scribe who copied the *Algorismus* collaborated with the scribe who copied another section of the manuscript, and the evidence points to the latter scribe having been Icelandic.[25]

The Transcription

The following transcription of the *Algorismus* from GKS 1812 4to is based on the black-and-white images at the Institut for Nordiske Studier og Sprogvidenskab in Copenhagen which were taken in 1982.[26] Color images are now available at *handrit.is*, a digital library at Landsbókasafn Íslands – Háskólabóksafn in Reykjavík; however, all but the last two of these images

Borgarting og Bohuslän (Oslo: Det Norske Videnskaps-Akademi i Oslo, 1930), 39, and Didrik Arup Seip, *Palæografi: B Norge og Island*, Nordisk kultur 28B (Stockholm: Albert Bonniers forlag, 1954), 121.

23 Op.cit., 110–12.

24 Op.cit., 112. Here Haraldur cites Didrik Arup Seip, *Norsk språkhistorie til omkring 1370*, 2. utgave (Oslo: Aschehoug, 1955), 137–39, and Jan Ragnar Hagland, *Riksstyring og språknorm: Spørsmålet om kongens kanselli i norsk språkhistorie på 1200- og første halvdel av 1300-talet* (Dragvoll, 1984), 161–62.

25 For more detail on the history of GKS 1812 4to and medieval Iceland encyclopedic works, see Gunnar Harðarson, "Medieval Encyclopedic Literature and Icelandic Manuscripts." For more on the scribes of GKS 1812 4to, see Haraldur Bernarðsson, "Scribes and Scribal Practice in GKS 1812 4to."

26 "GKS 1812 4to, 13v–16v," *digitalesamlinger.hum.ku.dk* (Institut for Nordiske Studier og Sprogvidenskab), http://digitalesamlinger.hum.ku.dk/Home/Samlingerne/33608.

have significant areas where the background is very dark, making it very difficult, and often impossible, to read the text itself.[27]

The transcription follows the guidelines of Menota at the diplomatic level.[28] As such, the transcript keeps the original punctuation, expands abbreviations, indicates certain types of errors, and distinguishes between the forms of letters only when they might have a phonological difference. In particular, a scribal addition above the line is denoted ˋtextˊ, a scribal addition in the margin is denoted ˏtextˎ, and a scribal correction is denoted ˫text˫. A dittography is denoted ˫text˧ and an addition by the editor is denoted ⟨text⟩. Text that is illegible but is identifiable from the context is denoted [text]. The letters “f” and “ꝼ”, “t” and “ꞇ”, and “r” and “ꝛ” are not distinguished. The letters “d” and “ꝺ” are not distinguished but are distinguished from “ð” although it is frequently difficult to ascertain the difference between the latter two. The letters “u” and “v” are distinguished although the scribe appears to use them interchangeably. Consonant ligatures for “pp” and “kk” are expanded silently. The letters “ſ” and “s” are distinguished since a positional difference can be observed in their use. Typically, “ſ” is seen in frontal and medial positions and “s” in final positions, but there are exceptions. For examples, we see a final “ſ” in *uerpilſ* in 13v/27 and 15v/18 and 20, and lio*ſ* in 16v/6, while *subdupli* in 15r/33 and *sem* in 16v/6 both have a frontal “s”. Additionally, an initial capital “s” is written “S”, as in *Setta* in 13v/24 and *Seaunda* in 13v/25. Abbreviation symbols are expanded with italics, suspensions are expanded in parentheses, small capitals are not expanded, and all accents and punctuation are shown. For this transcript, we have expanded the “er/ir” abbreviation with “ir”. So, for example, “fior'” is expanded as “fior*ir*” and “fingr̉” is expanded as “fing*i*r”. We have indicated folio and line numbering within the text and have divided the text into sections as indicated by the scribe (either by a drawing of a hand pointing to the right, blank space, or the use of a large capital letter).

We have transcribed the Medieval *ghubār* numerals, that is, , , , , , , , , , , in the modern form, namely, 0, 9, 8, 7, 6, 5, 4, 3, 2, 1. This

27 “GKS 1812 4to, 13v–16v,” *handrit.is*. The enhanced readability of the black-and-white photographs may indicate that the photographer used ultraviolet illumination, although no special technology is noted in the registration.

28 “Menota Handbook 3.0,” *Menota Nordic Text Archive* (Menota, 2019), https://www.menota.org/HB3_ch4.xml.

transcription is consistent with the diplomatic edition principle of ignoring orthographic differences that have no consequences in interpreting the text. Yet it has the disadvantage of making the text look more familiar to us than it really is.

The Translation

The translation tries to be as literal as possible while still being rendered in smooth English. The line between “literal” and “smooth” is not a clear one, yet it is clear that a literal word-for-word translation would make the text more opaque to an English reader than it really is, while an overly polished translation would make the text read much like a modern primer in arithmetic.[29]

The text refers to each of 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 as a *stafr*, which we have translated as “character.” As numbers, each of 2 through 9 is referred to either as a *fingr* or a *figura*, which we render as “digit.” A multiple of 10 is called a *liðr*, which we render here as “article.” The words *fingr* and *liðr* are literally “finger” and “joint,” and are themselves literal translations of the Latin *digitus* and *articulus*. These words are indicative of the ancient form of calculating with fingers.[30]

In some places we have translated *leiða* as “to multiply,” which, although not literal, is indicted by the context and seems to be a direct translation of *ducere* in the Latin versions. The text refers to subtraction in two ways, initially as *afdráttr*, a literal translation of the Latin *subtrahere* (“to draw off”), but most frequently as *taka af*. We have translated the latter as “take away”; although it is a less formal way to say “subtract” in English, it is literally correct and maintains the distinction between *taka af* and *afdráttr*. Moreover, it is analogous to the use of the Latin *demere* (“to take away” or “subtract”) in the *Carmen de Algorismo*.

The *Algorismus* calls the symbol for nothing, , a *cifra*. The various versions of the Indian calculus refer to this symbol in numerous ways. For example, in his commentary on the *Algorisumus Vulgaris* of John

29 The algorithms for performing the operations of arithmetic in the *Algorismus* are, except for some details of implementation, essentially those still taught in primary schools today.

30 See, for example, Menso Folkerts, “Early Texts on Hindu-Arabic Calculation.” *Science in Context* 14, nos. 1-2 (2002): 13.

of Sacrobosco (c. 1165–c. 1256), Peter of Dacia (c. 1250–c. 1310) wrote: "Decima vero 0 dicitur teca, circulus, vel cyfra, vel figura nichili, quoniam nichil significat."[31] [But the tenth, 0, is called *teca*, circle, or cipher, or figure of nothing, because it signifies nothing.] Peter supposes the word *teca*, or *theca*, to be derived from the name of an iron used to brand thieves, but it may simply come from its resemblance to the Greek letter θ.[32]

We are aware of several translations of the Old Norse *Algorismus* into modern European languages. Munch provided a translation into Danish along with his edition;[33] Otto Bekken and Marit Nielsen translated the text into Norwegian;[34] and Kristín Bjarnadóttir has published a version in modern Icelandic orthography.[35] All of these were based on the copy in Hauksbók. We are not aware of any previous translations into English of any versions.

Conclusion

The intent of this paper is two-fold: first, to provide a transcript of the second of two early witnesses to the Old Norse *Algorismus* and, second, to present an English translation. Although normalized editions of the versions of the *Algorismus* in Hauksbók and GKS 1812 would differ in only a few places, a diplomatic transcript of the latter version is of historical interest in underscoring the distinctiveness of the text and in illustrating the variance in fourteenth-century Icelandic script. In addition, the English translation will make this important work more easily accessible to the international research community.

31 *Petri Philomeni de Dacia in Algorismum Vulgarem Johannis de Sacrobosco Commentarius*, 2.

32 David Eugene Smith and Louis Charles Karpinski. *The Hindu Arabic Numerals* (Boston: Ginn & Company, 1911), 61.

33 Munch, "Algorismus, eller Anviisning til at kjende og anvende de saakaldte arabiske Tal, efter Hr. Hauk Erlendssons Codex."

34 Otto B. Bekken, Marit A. Nielsen, and Steinar Thorvaldsen, *Algorismus i Hauksbok: En norrøn regnetekst fra 1300-tallet* (Tromsø: Eureka Digital, 2010).

35 Kristín Bjarnadóttir, "Algorismus: Fornt stærðfræðirit í íslenskum handritum," *NETLA* (2004), http://wayback.vefsafn.is/wayback/20201017180549/https://netla.hi.is/greinar/2004/001/index.htm.

Algorismus in GKS 1812 4to, folios 13v–16v Diplomatic Edition

[13v] Liſt þeſſi heit*ir* algoriſmus. hana funðo fyſt índu*er*ſk*ir* me*n*n m*eð*[36] tíu ſtofu*m* |[2] er ſua eru ritadir ·0 ·9 ·8 ·7 ·6 ·5 ·4 ·3 ·2 ·1· hín fyſtí ſtafu*ir* m*er*k*ir* |[3] eín j fyſta ſtað. En annar tua. En þriði. þría. Ok huer eftt*ir* þui ſem |[4] ſkipad*ir* er alt til hins ſiðarſta[37] er cifra heit*ir*. *ok* ſkaltu þeſſa ſtafuí fra |[5] hǫgre hende upp hefuia ok rita till vínſtri hanðar ſem ebreiſku. |[6]

ˏh.ˎ Hver þeſſi ſtafu*ir* m*er*k*ir* ſik einfalligha í fyrſta ſtað En ef han e*r* j |[7] aðrum ſtad þa m*er*k*ir* h*a*n .x. ſinnum ſealfuan ſik. Ok j huern ſtað e*r* þu |[8] ſet*ir* nokkora þeſſa fig*ur*u. þa m*er*k*ir* hon avalt tíu hlutu*m* meira j þ*ei*m |[9] ſtað e*r* till uinſtri hanðar veít. helð*ir* en í nœſta ſtad adr. Cifra m*er*k*ir* |[10] ekki fir ſik en hon gerír ſtað. *ok* gefu*ir* adrum figurum merkingh |[11]

ˏ.þ.ˎar nœſt hǫyrir þ*at* till at vita þrenna grein ſtafuanna *ok* allrar to|[12]lu. þui at aul tala mínne en tíu. heit*ir* fing*ir*. En ſu tala oll e*r* tegu*m* /[13] ge*n*gn*ir*. heit*ir* lið*ir*. huart ſem hon e*r* meiri eð*ir* mí*n*ni. En ſu tala e*r* alt |[14] e*r* ſaman lið*ir* *ok* fing*ir*. heit*ir* ſamſett tala. |[15]

ˏE.ˎf þu uilt rita nokkora tolu. þa hyg. þu at. ef þat e*r* fíng*ir*. *ok* ríta |[16] j fyſta ſtad eina hu*er*ia fig*ur*u ſlika ſem þarf a þeſſa leíð .8. En ef þu uilt |[17] lid. rita. þa ſettu cifru fir*ir* fig*ur*u. a þeſſa lund .70. Vilt þu ſamſetta |[18] tolu rita. þa ſettu fig*ur*u[38] fir*ir* lid. ſem her .65. |[19]

ˏh.ˎ*uer*ia tolu er þu ritar þa er hon íof*n*n ef tígu*m* ge*n*gn*ir*. ed*ir* jaf*n*n fíng*ir* e*r* umf*ra*m |[20]

En oll tala e*r* oiof*n*n. ef oiaf*n*n fing*ir* er umf*ra*m Jafnn*ir* fing*ir* eru fiorír. |[21] 2.4.6.8. En oiafnn*ir*. aðrir fior*ir* .3.5.7.9. En ein[39] er huarki þuí at |[22] h*a*n e*r* eigi tala held*ir* uphaf[40] allrar tolu.[41]

J. ſeau ſtaðí e*r* ſkípt |[23] greínu*m* þeſſar liſtar. Heit*ir* hin fyſta uid*ir* laghningh. Annur afdratt*ir* |[24] Þriðia tuefaldan Fiorda helmínga ſkiptí. Fimta margfaldan Setta |[25] ſkíptíngh. Seaunda at taka rot vndan. oc er ſu

36 **13v/1** m*eð*] *Hauksbók has* ok skipvdv med.

37 **13v/4** ſiðarſta] *there is an* "ir" *abbreviation mark over the* "r".

38 **13v/18** fig*ur*u] *Hauksbók has* fingr *(digit), which is correct.*

39 **13v/21** ein] *possibly* eɪɴ; *Hauksbók has* ein*n*.

40 **13v/22** uphaf] *the* "h" *appears to have an abbreviation symbol*.

41 **13v/22** tolu] *white space may have been left for the insertion of a hand pointing to the right to indicate a new section, as seen in line 30 below. In contrast, Hauksbók has section titles.*

m*eð* tueim*ir* greínu*m* |26 Annur e*r* at taka rot vndan fir*ir* ſkỏyttri tolu. En onnur greín er |27 þat at ðragha rot undan atthyrndrí tolu þeirrí e*r* u*er*pilſ uoxt hefu*ir* |28

ˏFˎra e*n*ní hỏgre hendi ſkalt þu af taka *ok* vidlegía *ok* ſkipta j helmi*n*|29ga. En fra uinſtri hendi ſkal þu tuefalda *ok* ſkipta *ok* margfalda |30 Oc ſva dragha vndan rot huaratueggio. ☞

Ef þu uilt adra tolu |31 uid adra leggía. þa rita ifu*ir* uppí ena meiri toluna. oc ſet ena |32 mínne tolu iamf*ra*m till e*n*nar hỏgre handar. Ok leg þa Fíguru **[14r]** fyrſt up uid toluna er utarſt e*r* til hỏgre handar oc ef ſu tala oll ſama*n* |2 er fing*ir*. þa rita han j ſama ſtað. En ef talan uerd*ir* ſamſett þa rita |3 j fyrſta ſtad fing*ir*. En legh uid*ir* lidin þa toluna ſem j nœſta ſtad e*r* ad*ir* |4 En ef lid*ir* u*er*d*ir* af uidlagning. j fyrſta ſtad þa rita þar cifru: En legh |5 lidin uid þa tolu er nœſt ſtend*ir* ef þar er nokkur tala ella ríta h*a*n þar |6 ein ſaman. En ef þar er cifra þa tak hana brot. En ſet lidin þar nið*ir* |7 Legh ſidan aðrar fig*ur*ur uid at ſlikum hœtte. ☞

Ef þu uilt adra tolu |8 af annarre taka. þa rita tue*n*nar tolur. ſem i uid*ir*-lagningh. *ok* ſet íam|9nan ena minne tolu und*ir*. ellighar ia*m*fna. þa tak þu af enne fyrſtu |10 fig*ur*u þa tolu ſem vnd*ir* ſtend*ir* ef þat ma. oc rita ef nokkot e*r* eftt*ir* j ſama |11 ſtad. ella ſet þar cifru. En ef þu mat eighi ena fyrſtu fig*ur*u af taka |12 oc e*r* ſu tala meiri e*r* und*ir* ſtend*ir*. þa tak þu ein af nœſtu fig*ur*u. oc gae |13 þerſſ. at hon geri tio j fyſta ſtadenu*m*. Tak þa af þ*ei*m alla tolu þa ſem |14 und*ir* e*r*. *ok* i ſama ſtad þat ſem af lỏyp*ir*. En ef cifrur ſtanda uppí ifu*ir* |15 þa tak ein af þ*ei*rri fig*ur*u e*r* nœſt ſtend*ir* cifru*m* *ok* rita nio. Þar ſem cifru*m*[42]. |16 ⸠ſtoðo⸡ ⸌voru⸍. alt þar till er þu kem*ir* j þan ſtad e*r* þu uilt af taka. Ok tak þu |17 af þ*ei*m tiu ſem þarf. *ok* rita j ſama ſtad þat er lif*n*nar.

Ef þu uilt |18 tuefalða nokkora tolu. þa rita fyrſt ſlika tolu ſem þeer likar. Þar nœſt |19 tuefalda þu. þa fig*ur*u er meſt ueit till uinſtri handar *ok* rita j nœſta ſtad |20 þat er af lỏyp*ir* ſua ſem j uid*ir*lagníngh en ef ſemis ſtend*ir* ifu*ir* uppi |21 j yðſta ſtad þa legh uid ein. Þui at þar uar ad*ir* io*m*fn[43] tala e*r* j helmi*n*ga uar ſkift[44] |22

42 **14r/15** cifru*m*] *context indicates this should be* cifrur.

43 **14r/21** io*m*fn] *should be* óiofn. *This is clearly an error, which appears as well in Hauksbók (but not in AM 685 d 4to). The text is referring to the case in which the given number was the result of halving a previous number, resulting in a remainder of one-half. Hence the original number must have been odd.*

44 **14r/21** ſkift] *added below the line.*

En ef þu uilt helmíngh af taka rita ſlika tolu ſem þu uilt |[23] *ok* tak af helm*m*ingh en*ní* fyſtu fig*ur*u ef hon e*r* iofn. En ef hon uar oiofn þa |[24] ſkípt j helmí*n*ga þui e*r* af einu*m* lǒyp*ir* *ok* tak vp ein en rita ifu*ir* uppi þan |[25] ſtaf e*r* helmngh[45] hu*er*slutar m*er*kir ok uer kollu*m* ſemís *ok* ſua e*r* gior .. en ſet |[26] cifru j ſtadin.[46] þar nooſt tak af annarre fig*ur*u helmi*n*g at ſama hootte ef |[27] hon er iofn. En ef hon e*r* uiofn. þa tak af helmíngh af þuí e*r* iamt e*r*. oc |[28] af up þan *ok* ger af h*onu*m fim j nooſta ſtad þui at þat e*r* helmi*ng*ir af |[29] tío En ef j adru*m* ſtad ſtend*ir* ein þa tak han up *ok* rita fim j nooſta |[30] ſtad. en ſet þar cifru. ſem h*a*n ſtoð. Ek*k*i gerir cifra nema nokkur |[31] fig*ur*a ſtande till uinſtri handar he*n*ne. Far ſidan fram at ſliku*m* hootte |[32] huerſſu margar ſem Fig*ur*ur ero.

Ef þer likar at margfalda **[14v]** ˏadraˎ toluna j adra. rita tuennar raðir ſtafuanna m*eð* þ*ei*m hootti at hín |[2] yzſta figura þ*eir*rar tolu er þu marghfaldar ſtandí undír fyſta |[3] ſtaf ennar ǒfre tolu. en til vínſtri handar allar aðrar fra þ*eir*ri þoor |[4] ſem und*ir* eru. þar nooſt ſkalt þu hugſa hu*er*ſſu mikít ena meiri fig*ur*u |[5] ſkortír a tíu. þa er þu uilt marghfalda. Ok ſua marghar ein*n*gar |[6] ſem aſkortír a tíu. ſua opt ſkalt þu ena mínní toluna þaa er þu |[7] uilt margfaldda taka af tíghum hennar. *ok* at þu ſkilir þ*e*tta marg|[8]faldda ſeau *ok* níu . Nío ſkortír eín a tío. þuí tak þu eína ſeau af |[9] ſeautighum. þa uerda eftt*ir* þrír *ok* ſextíghí. þ*at* eru ſeau ſínnum |[10] níu. At ſlíku ſkapi mat þu aðrar tolur rǒyna. Margfalda hína |[11] fyſtu Fig*ur*u retligha j allar þoor er unð*ir* ſtanða. *ok* rita ifu*i*r hu*er*ri |[12] Fig*ur*u þa margfaldan er hon hefu*ir* oc til uinſtrí ˏhandarˎ þat ſem eigi ma |[13] ifui*r* henní ⟨standa⟩ í nooſta ſtad m*eð* uidlaghníng rettrí. *ok* þa er þeſſi fig*ur*a |[14] er margfolðut foor ena yzſtu af þ*ei*m ſem und*ir* ſtanda. Vnd*ir* nooſtu |[15] fig*ur*u *ok* margfaldda uíd þan ſua ſem vid en*n* fyrra: *ok* ef margfalddan gefu*ir* |[16] þer líd ſet cífru ifu*i*r uppi *ok* ſkipa lidnum till vínſtri handar. En ef |[17] booðe u*erð*ir af. margfaldd*ir* fíng*ir* *ok* lið*ir*. þa ríta fíng*ir* ífu*ir* þ*eir*ri ˫talu˧ Fig*ur*u |[18] er þu margfalddadír. en lid j en*n*ooſta ſtað. En ef fíng*ir* eín u*er*d*ir* af mar|[19]gf(aldan) þa ríta h*a*n ifu*ir* uppí. Ef cifra e*r* i en*n*e ǒfre tolu þa laup ífu*ir* hana |[20] þuí at ekkí er hennar margfalddan. Þerſſ ſkal en *ok* gá. at taka af |[21] fig*ur*ur þoor ſem uppí eru ífu*ir* ſettar íamſkíot hu*er*ía ſem þu. hefu*ir* marg|[22]faldat. *ok* rita þan fíng*ir* j ſtad hu*er*rar ſem till hǒyrír ed*ir* cífru |[23] ef þat er rettarra. En legh þat uid

45 **14r/25** helmngh] *should be* helmingh (helming *in Hauksbók*).

46 **14r/26** ſtadin] *is missing context. Here, and in Hauksbók, some text is missing. The instruction to* ſet cifru j ſtadin *evidently refers to the case when a one is in the first place*.

hínar er till vínſtra uegs |[24] ſtanda ſem af lỏyp*ir*. ef cifra ſtend*ir* ífu*ir* þ*eir*ri fig*ur*u e*r* þu margfalðar |[25] þa tak hana af. ef fing*ir* u*er*d*ir*. oc margf*allda*.[47] ella ſtanðe hon kyr |[26]

Ef þu grunar huart þu hefu*ir* ret margfaldað. þa ſkipt j |[27] ſund*ir* alla toluna vm margfalðan. þ*at* er ſu tala er und*ir* ſtod. oc |[28] mant þu fa hína ſomu tolu oc fyrſt hafðír þu.☞

Ef þu uilt |[29] ſkípta j ſund*ir* tolunne þa rita tue*n*nar raðír ſtafanna *ok* ríta vnd*ir* |[30] ena mínne toluna. *ok* ſkal en meírí tala uera h*a*lfu meírí eð*ir* þriu |[31] ſlik. eð*ir* meírí mun*ir*.

Set þu ena Fre*m*rrí[48] fig*ur*u þa er unð*ir* ſtend*ir* |[32] gengt enne fyrſtu. ífu*ir* uppí. *ok* aðrar til hỏgre handar iamfram |[33] ſem þ`ꝏ´r enðaſt er und*ir* ſtanda. þar nꝏſt hugſa þu vm hu*er*ſſu opt hin |[34] fyſtí fíng*ir* er i oc einu*m* ỏfra. ſua at íafn opt ſe þꝏr er fylgía **[15r]** henní hu*er* j þ*eir*ri tolu e*r* ifu*ir* ſtend*ir* *ok* ſet þu þan fíng*ir* gengt enne |[2] yzſtu fig*ur*u er undr ſtend*ir* *ok* þo uppi ífu*ir* baðar raðír . Tak ſidan ena |[3] fyrſtu af enní fyrſtú fig*ur*u *ok* þar nꝏſt hu*er*ia at hendi íafn opt af e*n*ne |[4] ỏfrí taulu. En ef ein tala er und*ir* þa tak hana af en*n*e ỏfre ┤ en*n*┤n├ ├ |[5] tolu*n*ne. Þar nꝏſt flyt alla tolu þa e*r* un-d*ir* ſtend*ir* vm eín *ok* fín |[6] annan quocíens *ok* ſet þan hía hinu*m* fyſta *ok* tak hína neðre tolu ſua |[7] opt af enne ỏfre *ok* ger at ſama hꝏtte ſua opt ſem þarf. Ef þu |[8] mat eígí ena ├neðr*i*┤ tolu eð*ir* fig*ur*u fínna j enne ỏfre þa ſet þan |[9] fíng*ir* er und*ir* ſtend*ir* fremſt*ir* nꝏſt en*ní* fyrſtu *ok* aðrar at ſama |[10] hꝏtti tíll hỏgre handar *ok* fín ſidan quociens ept*ir* ſliku*m* hꝏtte ok |[11] fỏr aftt*ir* fig*ur*ur ſem þarf *ok* ríta alla ſama q*uo*ciens ifu*ir* uppí ſua m*arg*a |[12] ſem þarf. En ef cifra ſtenð*ir* niðri unð*ir* þa laup ifu*ir* hana. þui at |[13] ekki ma henní ſkipta. Þa er þu kem*ir* vnd*ir* ena yðſtu fig*ur*u. oc |[14] hefu*ir* hí*n*nne[49] ſkipt mat þu ekki leng*ir* ſkipta. oc gꝏt þu þa þ*eir*rar |[15] tolu e*r* eft*ir* ſtend*ir* ef hon e*r* nokkur. Ef þu uilt p*ro*fua huart þu |[16] ſkiptír ret þa margfalda þa tolu er und*ir* ſtod uid q*uo*cie*n*s. Oc |[17] ma*n*t þu fa ſomu tolu ok fyſt hafðír þu. En ef nokkot líop f*ra*m af j |[18] ſkíptíngh þa leg þ*at* uíd ſíðan e*r* margfaldað e*r* *ok* ma*n*t þu fi*n*na hína ſomu ˏtoluˎ |[19]

ˏÞˎa er þu leiðir eína hu*er*ía tolu *ok* margfalddar í ſealfua |[20] ſik. heit*ir* ſu tala ferſkỏyt ed*ir* quadrans. oc en fyſta tala ſu e*r* |[21] þu margfalðar heit*ir* rot.

47 **14v/25** oc margf*allda*] *possibly should be* af margfalldan *(Hauksbók has* oc margfallda *as well).*

48 **14v/31** Fre*m*rrí] *apparently corrected from* meírí.

49 **15r/14** hínnne] *Hauksbók has* henni.

oc e*r* hu*er* tala rot unð*ir* nokkoro`ri´ tolu |22 En eígí er hu*er* tala ferſkǒyt. Ef þu uilt rot fí*n*na und*ir* nokkor|23rí tolu. þa ríta fyſt ſlika tolu er þer likar. ok i enu*m* fyſta víofn|24nu*m* ſtad rita und*ir* fing*ir* þan er þu leidír j ſealfuan ſik. ok takí |25 af þat e*r* ifu*ir* uppi e*r* eð*ir* ſua ſem nœſt ma h*a*n ganga. Siðan tuefal|26da þu þan ſama fíng*ir*. oc heit*ir* þat dupl. tak þa up fíngrín. oc |27 heít*ir* h*a*n ſubðupl. gœt þu ſubdupls. en ríta dupl í nœſta ſtað ef þat |28 er fíng*ir*. en ef líð*ir* e*r* þa rita þar ſem fíngrín fyrrí ſtoð *ok* ſet cí|29fru fir*ir*. ella fíng*ir*. ef ſamſet tala. Fín ſiðan nyían fíng*ir* oc ⟨leið⟩ h*a*n |30 j ðupl. oc tak af enne ǒfre tolu þa tolu e*r* þu margfaldadír. Sida*n* |31 margfalda þu fíng*ir* j ſealfuan ſik *ok* tak þa tolu af enne ǒfre |32 gengt ſealfuu*m* h*onu*m. þar nœſt tuefalda þu fíngrín *ok* gœt ha*ns* med |33 fyrra ſubdupli. *ok* ſet dupl j nœſta ſtað ſem fyr. Fín þar nœſt |34 nyian fíng*ir* *ok* leid j duplín bœðe ſamt. *ok* flyt*ir*[50] duplet fyrra **[15v]** at hinu duplí um eín ſtað. *ok* leg þar uid ef þar ſtod lid*ir* fírír |2 af hinu duplinu. Margfalða þa nyian fíng*ir* j bœðe ðuplin. ok |3 tak þa tolu af en*n*e ǒfre gengt duplino. Ger at ſama hœtte |4 ſua opt ſem þarf. *ok* leid nyian fíngrín j aul duplín. *ok* flyt þau |5 eft*ir* aualt vm eín. þar til er þu kem*ir* j en*n* ydſta ſtad. Ef upp |6 geng*ir* oll ſu talan er þu ritadir i fyrſtu*n*ne. þa uar ſu tala |7 ferſkǒyt. En rot vnd*ir* þ*eir*ri tolu eru fing*ir* allir ſama*n* þ*ei*r |8 er þu tuefalðaðir. m*eð* ſidarſta fíngrinu*m* þ*ei*m e*r* þu fant. |9 Margfalda þu rotína j ſealfua ſik *ok* mant þu hafua hina |10 ſumu[51] tolu ſem j fyſtu ef þu g*er*dír ret. Ef af lǒyp*ir* tolu*n*ne |11 nokkot þa er þu dreghr rotina undan. þa uar ſu tala eígí fer |12 ſkǒyt *ok* leg þu þa tolu uid hina er þu margfalddír rotina till |13 oc man þu fa ena fyſtu toluna *ok* er ſu tala ol ſama*n* rotín oc |14 af laup rot meiri tolu. En ef fyſti ſtad*ir* þ*eir*rar tolu er þu |15 ritadir uar iafn þa fín fíng*ir* und*ir* nœſtu fig*ur*u *ok* margfal|16ða a ſomu leid. ☞

Ef þu margfalðar retligha þa leid fer |17 ſkǒytta tolu j ſealfua ſik. *ok* ſu tala e*r* af þ*eir*ri margfaldan cem*ir* |18 heit*ir* cubícus ed*ir* u*er*pilſ tala. hun er alla uega íam mikil. En |19 rotin und*ir* cubico uar en ſama. *ok* ferſkǒyttrar tolu. huer |20 rot er[52] nokkorrar uerpilſ tolu ed*ir* cubící en eígí er hu*er* tala |21 cubic*us*.

50 **15r/34** flyt*ir*] *Hauksbók has* flyt *here, which is the correct imperative.*

51 **15v/10** ſumu] *Hauksbók has* ſomu, *that is,* sǫmu, *here, as does GKS 1812 elsewhere.*

52 **15v/20** hver rot er] *text is corrupt. The correct reading, namely,* hver tala er rot, *is found in Hauksbók. Here* ".b." *is written above* rot *and* ".a." *is written above* er, *indicating that the word order should be inverted.*

Ef þu uilt finna ⟨rot⟩[53] vndir cubíco. hugſa hu*er*ſſu mikil |[22] tala er. *ok* hu*er*ſſu margir ſtadír ero. Fín þar nꝏſt fing*ir* |[23] j enu*m* fremſta þuſunda ſtað. Þuſunda ſtaði kollum uer |[24] þa alla er um þuſundir eínar bríotaſt. þat er en fiordí |[25] oc en ſeau⟨n⟩dí *ok* en tiundí *ok* en þrettandí ok af afalt |[26] lỏyp*ir* ifu*ir* tua ſtadi.

Fra uinſtrí hendi ſkal þu þ*e*tta |[27] uerk uphefuía. leid þan fíng*ir* er þu fant j ſik cubice |[28] þat er tuiſ*v*ar ſinnu*m* margfaldað fyrſt j ſealfan ſik |[29] oc annat ſín j þa tolu e*r* þar kom af. *ok* þar nꝏſt [ta]k af |[30] ỏfre tolu þeſſa tolu alla gengt fíng*rin*u*m* þ*ei*m ſealf[um]. Oc |[31] þrefalda þar nꝏſt fíngrín. *ok* hoppa ifu*ir* eín ſtad m*eð* þa |[32] tolu *ok* ſet j þridía ſtað fir*ir* hínu*m* þa toluna ef þat er |[33] fíng*ir*. En ef þat er lid*ir* ſet þar cífru en lidín j nꝏſta |[34] ſtad. En ef ſamſet tala er þa ſet fíngrín j ſama ſtad. |[35] en líd et nꝏſta. Þar nꝏſt fín nyían fíng*ir* j nꝏſta ſtad **[16r]** þrefaldrí tolu er tripl heitir *ok* leid h*a*n m*eð* hinni fig*ur*u er fyſt fant þu |[2] Ok uer kollum ſubtripl oc a hỏgra uegh henni j triplit m*eð* margfal|[3]ðan. *ok* þar nꝏſt leid han ein ſaman i þa tolu er af margfaldan kom |[4] oc uer kollum productum. Tak þa þeſſa tolu alla ſamt af en*n*i ỏfrí |[5] gengt þui er tripl ſtod. þui nꝏſt le*i*d fing*ir* þan ſama i ſealfuan ſik cu|[6]bice. oc tak þa tolu af e*n*ni ỏfri gengt ſealfum fingrinum. Tak þan |[7] fing*ir* af *ok* þrefalda her ſem e*n*n fyrra *ok* fin þa nyian fing*ir*. Leið |[8] h*a*n m*eð* baðum ſubtriplinn oc triplin ſamt. oc flyt afalt triplin |[9] fornari ept*ir* ſem þu gerir i mi*n*na rotardrat uið dupl. nema her |[10] ſkalt þu afalt ifu*ir* ein ſtad hoppa en leggia þo at ſama hꝏtte tripl |[11] uid tripl m*eð* rettri uidlagningh Far fram at ſliku hofui meðan |[12] þarf oc þu kem*ir* j yðſta ſtad. En þat ſkalt þu m*eð* mikilli uanðuircð |[13] huxa þa er þu finn*ir* fing*ir*na at þ*ei*r taki eigi ſua mikit af ỏfri tolu |[14] at ſu tala hafin[54] eigi ſtað er þu margfaldar triplin till. eð*ir* hín |[15] onnur e*r* þu margfaldar fingrin till þan ſiðarra. Varðueit þu afalt |[16] ſubtripl m*eð* tripli. gꝏt þeſſ ok ef cifrur koma. j ſubtrípl at engi e*r* |[17] margfaldan ed*ir* þrefaldan þ*eir*ra. en halda þꝏr ſtoðum ſinu*m* meðan nok|[18]kur fig*ur*a er till hỏgre handar þ*ei*m. Ok er þat vuanðast j vid*ir*laghníng |[19] tripls. afalt fer þat ſem fyr er rítat j viðrlogho liſt.

Fíng*ir* allír |[20] ſamt þ*ei*r e*r* ſubtripl voro *ok* yztir fíng*ir* m*eð* ero rot en*n*ar meirí tolu |[21] þ*eir*rar er þu ritaðir fyſt ef up gek oll talan j af drꝏttinum *ok* marg|[22]falda þu ſubtriplin j ſealfuan ſik cubíce. *ok* mun þu finna hína fyrſtu |[23] tolu. En ef aflíop nokkot tolunní j afdrꝏtti. þa er ſu tala eígi

53 **15r/21** ⟨rot⟩] *Hauksbók has the same omission.*

54 **16r/v14** hafin] *Hauksbók has* hafi.

cubíc*us* |24 En þo er aflaup þat m*eð* ſubtríplum rót nokkurs cubící. Oc ef þu mar|25gfaldar rót ena mínní. cubice. oc leg uíd þa tolu er af margfaldan |26 kem*ir* aflaupít. oc mant þu fa fyrſtu tolu er þu rítaðír Oc nu rí|27tum u*er* at ſinne eigi fleíra þar af.

Þeſſar eru fíngra margfal|28danar ferſkǒyttrar. af. 3. 9. quaðratus. af 2 4. Af .4. 16. |29 quaðratus af. 5 25 quadrat*us*. Af .6. 36. q*ua*drat*us*. Af .7. .49. q*ua*drat*us* |30 Af .8. 64. q*ua*dratus. Af .9. 81. q*ua*drat*us*. Oc er ſu liſt till at fi*n*na fíng*ra* |31 margfalda*n*ir ſem ritud er fyr. Þeſſi e*r* fing*ra* margfaldðan cubice |32 3 rot 27. cubus. 2 rot 8. cubus. 4. rot 64 cubus 5 rot .125. |33 cubus .6. rot 216. cubus. 7. rot .343. cub*us*. 8. rot 512. cubus |34 9 rot 729 cubus.

Huer ferſkǒyt tala hefu*ir* tuꝏr mꝏlíng|35gar þat er breíd *ok* lengð. En cubicus tala hefu*ir* þre*n*na mꝏlíngh. þat **[16v]** er breíd ok lengð *ok* þycð ed*ir* hꝏð. Oc þui kalla ſpekíngar hu*er*n ſynilighan |2 likama m*eð* þeſſi tolu ſaman ſettan. at h*a*n hefu*ir*. jamnan[55] þeſſa mꝏlíngh |3 þrenna.

Með þui at elif[56] ſpeki. oc ein gud uilde heimin ſyinlighan *ok* |4 likamlighan ſkapa. þa ſetti han fyrſt tuꝏr ennar yðſtu hofuðſke*m*pn|5nur eld *ok* jord. þui at ekki ma nat*ur*ulighа ſynilight vera uttan þꝏr |6 Þar sem eldd*ir* gerir liof ok rǒringh. En jord ſtaðfeſti ok hald. En |7 m*eð* þui at þau hafua þrenna víam*n*na huiligleika *ok* gangſtadlígha |8 þa. uar nat*ur*uligh naudſyn at ſetia nokkot milli þ*eir*ra þat e*r* ſamþyktti |9 þ*eir*ra vſꝏtti. Ok ſem fyr er ſaght at eldd*ir* *ok* jord *ok* þat alt ſem likam|10light er er[57] m*eð* þrefaldre tolu er uer kollum cubicum ſaman ſet |11 þa ritum u*er* þeſſa tua cubus. Ritum u*er* jordina þeſſa leið. Tuiſuar |12 ſinnu*m* tueir tuiſuar. 248.

En eldin ſua þryſuar þrír þryſ|13uar. 3927.

En m*eð* þui at ekki eít mídſkeid ma milli þeſſarra |14 talnna eí*n*na þat er jamre luttegníngh hǒyrír till huartueggia. |15 ok engra annarra tueggia cuba. þa finnu*m* u*er* tuꝏr lutfellíngar |16 tolur a þeſſa lunð. leidum rot enſ meira cubs j quadratum ens |17 mí*n*na[58] cubs þat er tuyſua tueír þryſuar. 24. 12. Oc rot enſ min*n*a |18 cubs j quadratum ens meira cubs þeím[59] er þryſuar þrír tuyſuar |19 .39. 18. Þeſſar tuꝏr tolur hǒyra íafnt til tueggía hin*n*a enu ydſtu cu|20ba. þuí at ſeau *ok* .xx. hafua j ſer. 18. *ok* helmíngh af .18. En .18. hafua |21 j ſer .12. *ok* helmíngh af .12.

55 **16v/2** jamnan] *Hauksbók has* avallt.
56 **16v/3** elif] *Hauksbók has the correct* eilif.
57 **16v/10** er er] *Hauksbók has* er. þa er.
58 **16v/17** mínna] *appears to be corrected from* meíra.
59 **16v/17** þeím] *Hauksbók has* þeim *as well, but both Finnur Jónsson and Munch correct to* þat.

Sua hafua ok .12. j ſer .8. *ok* helmíng |[22] af .8. at ſama hꝏtti ſkalt þu afalt luttekníngar fi*n*na millí |[23] tueggía cuba.

Sua ſkipadí gud tue*n*nar hofutſkepnur millí eldz |[24] *ok* íarðar. lopt *ok* vatn. oc hefu*ir* uatn tua huiligleika af íorð oc |[25] tuꝏr tolur. En af elddí eín huiligleik *ok* eína tolu.

En lopt |[26] hefu*ir* tua huilighleika af eldí *ok* tuꝏr tolur. En eín af íorð ok |[27] eína tolu. Oc er eldd*ir* þuí lettarí en lopt ſem .27. eru meí|[28]rí en .18.

En lopt þuí lettarí en uatn ſem .18. eru meírí en .12. |[29] vatn þui lettara en jorð ſem .12. eru meirí en .8.

Þetta ⟨er⟩ ful|[30]lígar at ſkilía[60] j þ*eir*ri fig*ur*u er her er ſiðar gor oc kollud er cubus |[31] PErFectus

Translation of the *Algorismus* in GKS 1812 4to

[**13v**] This art is called *algorismus*. First discovered by men of India, they used ten characters, which are so written: 0 9 8 7 6 5 4 3 2 1. The first character denotes one in the first place, the second two, the third three, and each according to how it is placed until the last, which is called a *cipher*. You shall write these characters from right to left as in Hebrew.

Each character denotes itself simply in the first place. But if it is in the second place, then it denotes X times itself. And in each place that you place some figure, then it always denotes ten parts more with respect to that place which points to the left, relative to the next place before. The cipher denotes nothing in itself, but it creates a place and gives the previous figures signification.

Next it is appropriate to know a three-fold distinction of the characters and of every number. Every number which is less that ten is called a digit.[61] Every number which is made from groups of ten is called an article,[62] whether it is bigger or smaller. But a number that is both an article and a digit is called a compound number.[63]

If you want to write some number, then examine if it is a digit and

60 **16v29–30** Þetta ⟨er⟩ fullígar at skilía] *Hauksbók has* Ma þ⟨et⟩ta fvlligaʀ skilia.

61 Literally, "finger."

62 Literally, "joint"; Latin "articulus."

63 *Samsett tala*, literally "composite number," is rendered as "compound number" to avoid confusion with the conventional definition of a composite number.

write in the first place any figure such as needed, for example, 8. But if you want to write an article, then put a cipher before the figure, like this: 70. If you want to write a compound number, then set the figure[64] before the article, as here: 65.

A number is even if is made from groups of ten or if an even digit is in the front. A number is odd if the digit in front is odd. There are four even digits: 2, 4, 6, and 8. And the other four are odd digits: 3, 5, 7, and 9. But one is neither [even nor odd] because it is not a number but rather the origin of all number.[65]

There are seven branches of this art. The first branch is called addition, the second subtraction, the third doubling, the fourth dividing in half, the fifth multiplication, the sixth division, and the seventh to take a root. And there are two branches for this: One is to take a root of a squared number and another type is to extract a root from an octagonal number[66] which has the shape of a cube[67].

From the right you should take away from, add, and divide in half. From the left you should double, divide, multiply, and also extract both types of root.

If you want to add one number to another, then write the larger number above and set the smaller number even to it on the right. Then first add the figure [**14r**] up to the number which is farthest out to the right. And if this entire number is a digit, then write it in the same place. But if the number is a compound, then write the digit in the first place and add the article to that number which is in the next place before. But if an article results from the addition, then write a cipher in the first place and add the article to that number which stands next if some number is there, or, else, write it there alone. But if there is a cipher there, then remove it and set the article down there. Then add the other figures in the same way.

If you want to take one number away from another number, then write the two numbers as in addition and always set the smaller number below, otherwise even. Then you take away from the first figure the number that stands below if it is possible and, if something is left, write that in same

64 Hauksbók has "fingr" ("digit") here.

65 "Unity is the natural starting point of all number," from Nicomachus, *Introduction to Arithmetic*, ed. Martin Luther D'Ooge (New York: The Macmillan Company, 1926), 192.

66 Literally, "eight-cornered number" (*átthyrnd tala*).

67 *verpill*, or, in German, *Würfel*.

place, or, else, put a cipher there. But if you cannot take away the first figure as that number which stands below is greater, then take one from the next figure and carefully note that this makes ten [added to the figure] in the first place. Then take from this the entire number as is below and [write] what remains in the same place. And if ciphers stand over above, then take one from that figure which stands next to the ciphers and write nine where the ciphers were, all the way until you come to the place where you want to take away from. And you will take from them ten as needed and write what is left in the same place.

If you want to double some number, then first write such number as you like. Next you double that figure which is farthest to the left hand and write in the next place that which remains as in addition. But if *semis*[68] stands over above in the outermost place, then add one since before there was an even[69] number which was divided in half.

But if you want to take half of a number, write such number as you want and take half of the first figure if it is even. But if it was odd, then divide in half that which remains from one less, take up the one and write over above that character which denotes half of any part,[70] which we call *semis* and make so , and [if it is one, remove it and][71] put a cipher in that place. Next take half of the second figure in the same way if it is even. But if it is odd, then take half from that which is even and just under that and make from this five, which is half of ten, in the place next to that. But if one stands in the second place, then take it up and write five in next place and put there a cipher where the one stood. A cipher does nothing unless some figure stands to the left of it. Now proceed forward in such way for as many figures as there are.

68 Latin for "a half-unit"; see Charlton Thomas Lewis and Charles Short, eds. *Latin Dictionary*. (Oxford: Clarendon Press, 1969).

69 This is clearly an error, which appears as well in Hauksbók (but not in AM 685 d 4to). The text is referring to the case in which the given number was the result of halving a previous number, resulting in a remainder of one-half. Hence the original number must have been odd ("óiofn"), not even ("iofn").

70 "Take up the one" refers to the one removed from the initial odd number. In some texts of the Indian calculus, the remainder one is written above the final digit of the result; here, a *semis* is written instead.

71 This text is missing both in GKS 1812 and in Hauksbók but is needed to explain that this instruction applies only to the case in which the first digit is a one.

If you wish to multiply [**14v**] one number by another, write the two rows of characters in that way that the outermost figure of that number which you multiply stands under the first character of the upper number, and each of the others of the lower number are to the left. Next you shall consider how much the larger figure which you want to multiply lacks from ten. And as many units as are lacking from ten, that is how often you should take the smaller number, that you want to multiply, from that number of tens.[72] So that you understand this, multiply seven and nine. Nine is one less than ten, therefore you take one seven away from seventy, and then sixty-three remains. That is seven times nine. In the same manner you can attempt other numbers. Multiply the first figure correctly with each figure which stands under and write above each figure the multiple that it has, and to the left that which cannot be over it in the next place using correct addition. Then when this figure is multiplied, move the outermost of those that stand below under the next figure and multiply with that as with the first. And, if multiplication makes it an article, set a cipher over above and arrange the article to the left. But if both a digit and an article result from the multiplication, then write the digit over that figure which you multiplied and the article in the next place. But if only a digit results from the multiplication, then write it over above. If a cipher is in the upper number, then skip over it because nothing is a multiple of it. And also take care of this, that you remove those figures as are put above as soon as you have multiplied each, and write that digit in the place as belongs to each or a cipher if that is correct, and add that to that which stands to the left side as remains. If a cipher stands over that figure which you multiplied, then remove it if it becomes a digit after multiplication,[73] otherwise leave it standing in place. If you doubt whether you have multiplied correctly, then divide apart the whole multiplied number with that number which stood under. And you will get the same number as you had first.

If you want to divide apart some number, then write the two rows of the characters and write the smaller number underneath. The larger number must be two, three, or more times greater. Set the foremost figure that stands under aligned with the first above and the others to the right, continuing as long as the ones underneath last. Next think about how

72 The text does not mention for which cases this is a useful aid for multiplying digits.

73 The text has *oc margfallda*, as does Hauksbók, but *af margfalldan* would make more sense.

often the first digit also is in the upper number so that equally often those which follow [**15r**] it are each in that number which stands over. Set that digit aligned with the outermost figure which stands under and yet above both rows. After that take the first from the first figure and each after the other equally often from the upper number. But if one number is under, then take it from the upper number. Next move each number that stands under over by one [place] and find another quotient. Set that by the first and take the lower number as often from the upper. Do that the same way as often as needed. If you are not able to find the lower number or figure in the upper, then set the foremost digit which stands underneath next to the first and others in same way to the right and then find the quotient in such a way, and move along the figures as needed. And write each of the quotients together above so many as needed. But if a cipher stands under, then skip over it because one cannot divide by that. Then when you come under the outermost figure and have divided it, you can no longer divide and then be careful to observe that number which remains, if it is anything. If you want to prove whether you have divided correctly, then multiply that number which stood under with the quotient and you will get the same number that you had at first. And if something remained after the division, then add that afterwards to what is multiplied and you will find the same number.

When you take any number and multiply it by itself, that is called a square, or a quadrate, and the first number which you multiply is called a root. Each number is the root of some number, but not every number is a square. If you want to find the root of some number, then first write such number as you like. And in the first place, which is odd, write under it the digit which you multiplied by itself, and take from that which is above or such as comes next to it. After that you double that same digit and that is called a duple. Then take away the digit and that is called subduple. Note the subduple and write the duple in the next place if it is a digit, but if it is an article write it where the digit stood formerly and set a cipher before it, or else a digit if it is a compound number. After that find a new digit, multiply it with the duple, and take from the upper number that number which you multiplied. After that multiply the digit by itself and take that number from the upper aligned over it. Then next double the digit, note it together with the former subduple, and set the duple in the next place as before. Then find the next new digit, multiply it with both duples at once, move the former duple [**15v**] towards the other duple by one place, and add it there if an article remained there from that duple. Then multiply a new digit with both the duples and take that number from the upper aligned to the duple. Do this in the same way as often as needed, multiply the new digit with all the duples, and move those always over one until you come to the outermost place. If all of that number is used up which you wrote at the beginning, then that number was a square. And the root of that number is made up of the digits all together which you doubled together with the last digit which you found. Multiply the root by itself and you will have the same number as at first if you have worked correctly. If some of the number remains after you extract the root, then that number was not a square. And you add that number to that which you multiplied the root and you will get the first number. And that number together, the root and remainder, is the root for the larger number. If the first place of that number which you wrote was even, then find a digit under the next figure and multiply in the same way.

If you multiply correctly, then multiply a square number with itself and that number which comes from this multiplication is called a *cubicus*, or cubic, number. It is the same size on all sides. Moreover, the cube root is the same as for the square number: Each number[74] is the root of some cubic number, or *cubicus*, but not every number is a cube.

If you want to find a cube root, note how big the number is and how many places it has. Then find the nearest digit in the farthest of the thousands place. We call places of the thousands all those which break only into thousands. That is the fourth, the seventh, the tenth, the thirteenth, and always jump over two places.

You shall start this work from the left. Multiply that digit which you found with itself cubically. That is twice multiplied, first by itself and a second time by that number which came from there. And next take from the upper number this entire number aligned with that digit itself and next triple the digit, skip over one place with that number, and set that number in the third place before it if it is a digit. But if that is an article, set there a cipher and the article in the next place. And if it is a compound number, set the digit in the same place and the article the next. Next find a new

74 Hauksbók has *tala* here, which is missing in GKS 1812.

digit in the next place, [**16r**] treble the number, which is called a triple, and multiply it with the figure which you found first, and which we call subtriple, and to the right of it multiply it with the triple. And then multiply it alone with that number which came from the multiplication, which we call the product. Then take this number as a whole from that upper one aligned over where the triple stood. Next multiply that same digit in itself cubically and take that number from that aligned over the digit itself. Take that digit and triple it here as the former and then find new digit. Multiply it with both the subtriple and the triple together and always move the older triple along as you do in smaller root extraction with duple, except here you shall always skip over one place and add still that same way triple to triple with correct addition. Continue in such way as long as needed and you come to the outermost place. And you shall with great care attend to, when you find the digits, that they not take so much from upper number that that number has[75] no place when you multiply the triple or the other numbers when you multiply the later digit. Always keep subtriple with triple. And note that if ciphers come in a subtriple, nothing is a multiple or triple of them, but they keep to their own places as long as some figure is to the right of them. And what is least difficult is the addition of a triple, so that it always goes as written before in the addition art.

All the digits together, those which were subtriples and the outermost digits too, is the root of the larger number of that which you first wrote if the subtractions used up the whole number. And you multiply the subtriples by themselves cubically and you will find the first number. But if there is some remainder to the number after subtraction, then that number is not a cube. But still the remainder, with the subtriples, forms the root of some cube. And if you multiply the root of the smaller cubically and add the remainder to that number which comes from the multiplication, you can get the first number which you wrote. And now we write at the present no more about this.

These are the digits squared: 3 squared is 9, 2 squared is 4, 4 squared is 16, 5 squared is 25, 6 squared is 36, 7 squared is 49, 8 squared is 64, 9 squared is 81. And the art to find the digits multiplied is as written before. These are the digits cubed: 3 cubed is 27, 2 cubed is 8, 4 cubed is 64, 5 cubed is 125, 6 cubed is 216, 7 cubed is 343, 8 cubed is 512, 9 cubed is 729.

75 GKS 1812 has *hafin* here, but Hauksbók has *hafi*.

Each square number has two dimensions, that is breadth and length. But a cubic number has three dimensions, that [**16v**] is breadth, length, and thickness or height. And therefore the sages say every visible body is put together with this number for it always[76] has these three dimensions.

Since eternal wisdom, the one God wanted to create a visible and bodily world, then he first made two of the outermost elements, fire and earth, because nothing can be naturally visible without them, as fire makes light and movement, but the earth is steadfast and unmoving. And since they have three unequal and opposite qualities, it was then a natural necessity to set something between them which reconciled their differences. And since, as said before, fire and earth, and every such thing that is of a bodily nature is composed out of a three-fold number, which we call cubic, then we write for this two cubes. We write the earth this way: twice times two twice, 2, 4, 8. But fire so: thrice three thrice, 3, 9, 27.

And since in this case no single mean[77] can be between these numbers, with only it being in equal proportion to both and of no other two cubes, then we find two proportional numbers in this manner: We multiply the root of the greater cube with the square of the smaller cube, that is twice two thrice: 2, 4, 12. And the root of the smaller cube with the square of the greater cube, that is thrice three twice: 3, 9, 18. These two numbers belong equally to the outer two cubes since seven and 20 has in itself 18 and half of 18, and 18 has in itself 12 and half of 12. And so has 12 in itself 8 and half of 8. You shall in the same way always find proportions between two cubes.

Thus God arranged two elements between fire and earth: air and water. And water has two qualities from earth and two numbers, but from fire one quality and one number. And air has two qualities from fire and two numbers, but one from earth and one number. And fire is as much lighter than air as 27 is greater than 18. And air is as much lighter than water as 18 is greater than 12. Water is as much lighter than earth as 12 is greater than 8.

This is to be more fully understood in that figure which is made here later and is called the *cubus perfectus*.[78]

76 GKS 1812 has *jamnan* here, but Hauksbók has *avallt*.

77 *miðskeið*

78 This work is derived from my MA thesis in Medieval Icelandic Studies at the University of Iceland. I would like to thank Gunnar Harðarson for his encouragement, suggestions, and careful reading of the transcript and translation. His corrections have greatly improved

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ÁGRIP

Algorismus í GKS 1812 4to: Uppskrift og þýðing

Efnisorð: *Algorismus, Carmen de Algorismo,* GKS 1812 4to, Hauksbók, stafrétt útgáfa

Í þessari grein er birt stafrétt útgáfa þeirrar gerðar *Algorismus,* norrænnar þýðingar á *Carmen de Algorismo* eftir Alexander de Villadei (um 1170–um 1240), sem er að finna í alfræðihandritinu GKS 1812 4to 13v1–16v31. Sú gerð hefur ekki áður verið prentuð en hún hefur ýmis sérkenni, einkum skriftarfræðileg, svo og nokkur lesbrigði, sem greina hana frá þeirri gerð sem áður hefur verið gefin út og byggist á AM 544 4to sem er hluti Hauksbókar. Einnig er hér birt fyrsta enska þýðingin á Algorismus svo vitað sé.

SUMMARY

Algorismus in GKS 1812 4to: Transcription and Translation

Keywords: *Algorismus, Carmen de Algorismo*, GKS 1812, Hauksbók, diplomatic edition

This article provides a diplomatic edition of the *Algorismus*, an Old Norse translation of the *Carmen de Algorismo* of Alexander of Villedieu (c. 1170–c. 1240), found in the encyclopedic manuscript GKS 1812 4to 13v1–16v31. This version has not been published previously. It has various characteristics, most notably in the script as well as in some readings, which distinguish it from previous editions that were based on AM 544 4to, a part of Hauksbók. Also, included here is, as far as is known, the first English translation of the *Algorismus*.

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