CHAPTER 4

THE *COMPOTUS CORRECTORIUS*

The corpus of computistical works traditionally attributed to Robert Grosseteste include the *Kalendarium*, the *Compotus I*, the *Compotus correctorius*, and the *Compotus minor*. The authenticity of three of these works has been challenged, and only the *Compotus correctorius* remains secure from such challenges. I shall begin this chapter with a brief introduction to the genre of compotus.[1] The second section surveys the arguments for dating the computistical works of Grosseteste and the challenges to Grosseteste's authorship of the *Kalendarium* and two of the computi. This section will also explain why I have chosen to focus on only one of these works, as the only work that can be confidently asserted to be a genuine work of Grosseteste. The bulk of the chapter is an exposition of that work, the *Compotus correctorius*. The work has not been translated, and so this portion of the chapter will provide an English-language introduction to it. While the genre of compotus is relatively well-known in some circles, the content of compotus has not acheived general recognition among historians of science or the middle ages. So an important task of this chapter will be to make the contents of this medieval instructional text available to historians who do not have a technical background. I conclude with an analysis of the work, arguing against other authors that the intended audience of the work was twofold: those

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[1]Grosseteste regularly uses the term 'compotus.' Other medieval writers, as well as some modern scholars, prefer to use the term 'computus.' Because my analysis centers on Grosseteste's work, it is easier to maintain the same terms, and thus I have chosen to use the variant form compotus, except when quoting other authors or when using the term 'computus' will prevent confusion.

seeking basic instruction in compotus, and those interested in more complex aspects of the science of compotus, as well as calendar reform.

4.1. The Genre of Compotus

The compotus had existed long before Grosseteste's contribution to the field. From the second to eleventh centuries, "calendrical reckoning or computus was the context for continuing and extensive studies in the mathematical sciences of early Christian schools during the so-called Dark Ages."[2] In the monastic schools, Stevens writes, "it was *Grammatica*, *Computistica*, and *Cantica*: language, reckoning, and singing"[3] that made up the curriculum. In fact, compotus may have been the first uniquely Christian science, combining mathematical and astronomical theory from pagan sources to serve Christian ends. Stevens has argued that the computistical work in the Insular schools amounted to "concerted and significant scientific labours."[4] Compotus, he argues, was the means by which much scientific information was passed on during the early medieval period, and thus served a larger purpose than just solving calendrical problems.[5]

The essential task of the compoti was to confront a basic problem of the Christian

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[2]Wesley M. Stevens, "Cycles of Time: Calendrical and Astronomical Reckonings in Early Science," in *Time and Process: The Study of Time VII*, edited by J. T. Fraser and L. Rowell, 27–51, Madison: International Universities Press, 1993, reprinted in *Cycles of Time and Scientific Learning in Medieval Europe*, London: Variorum Reprints, 1995. The quotation is from the abstract, p. 27.

[3]Stevens, "Cycles of Time…," p. 43.

[4]Wesley M. Stevens, "Scientific Instruction in Early Insular Schools," in *Insular Latin Studies*, edited by Michael Herren, 83–111. Toronto: Pontifical Institute of Mediaeval Studies, 1981; the quotation is from p. 83.

[5]Note, however, that Faith Wallis questions whether the term 'science' is accurate; see Faith Wallis, ed., *Bede: The Reckoning of Time*, Liverpool: Liverpool University Press, 1999, p. xviii. She points out that the compotus can be seen simply as the application of other sciences to solve a particular problem.

Church, namely, the reconciliation of the solar calendar received from Roman administrative sources with the Jewish lunar calendar used from the early Christian era to calculate certain important feast days, most notably that of Easter.[6] The problem arises from the fact that the length of the solar year is not an integral multiple of the length of the lunar month. Thus the only way to reconcile the two is to adopt a cycle of some number of years in which the two correlate more closely. The reconciliation is necessary because those who assign (and celebrate) the moveable feasts operate with reference to the solar year, but the time of the celebration of the feasts must be calculated based on the lunar month. Various cycles were used in the Latin, Christian West, including 8-, 11-, 19-, 76-, 84-, 95-, and 112-year cycles.[7]

The earliest computistical works are tables and letters in which ecclesiastical officials tried to sort out the calendrical problems facing the Church. One of the earliest solutions to the problem of getting all Christians to celebrate Easter on the same date was the creation of Easter tables, which simply listed the proper date for each year, thereby bypassing the need to teach the science underlying the calculations. A few treatises of a theoretical nature were written before the eighth century, including works by Cassiodorus, Isidore, and Maximus Confessor,[8] but a turning point was reached in 725 A.D. with Bede's *De temporum*

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[6]For an extended discussion of the mathematical problems and the early history of the Christian calendar, see the section entitled "Development of the Latin Ecclesiastical Calendar" of the introduction to *Bedae, Opera de temporibus*, edited by Charles W. Jones, 3–122, Cambridge, Mass: The Medieval Academy of America, 1943; Olaf Pedersen, "The Ecclesiastical Calendar and the Life of the Church," in *Gregorian Reform of the Calendar*, edited by G. V. Coyne, et. al., 17–74, Vatican: Specola Vaticana, 1983; and the section entitled "A Brief History of the Christian Calendar before Bede" in the introduction to Faith Wallis, *Bede: The Reckoning of Time*, xxxiv-lxiii.

[7]For a comparison of the errors involved with various cycles, see Kenneth Harrison, "Episodes in the History of Easter Cycles in Ireland," in *Ireland in Medieval Europe*, edited by Dorothy Whitelock, et. al., 307–319, Cambridge: Cambridge University Press, 1982. See especially his table on p. 308.

[8]See the introduction to *Opera hactenus inedita Rogeri Baconi*, Fasc. VI, edited by Robert Steele, vii-xxvii, Oxford: Clarendon Press, 1926; the reference is to pp. xiii-xiv.

ratione.[9] Robert Steele claims that this work is the "foundation of all future treatises on the subject,"[10] though between the period of Bede's work and Grosseteste's life, Alcuin, Rabanus Maurus, and Helpericus, in the late eighth through early tenth centuries, all wrote on computistical topics.[11]

By the eleventh century, contemporary scholars were noticing errors in the calendar.[12] But despite the concern that was voiced by various authors of the period, only a handful of modern scholars have paid attention to the computistical works of the eleventh and twelfth centuries. Yet they have amassed a body of evidence that demonstrates that compotus was indeed an important contemporary concern. In the eleventh century, Gerland composed a *Compotus*, while in the twelfth century, Roger of Hereford and a certain "Constabularius" both composed original computistical texts.[13] The twelfth century, discussed in the first chapter as a time of renaissance, certainly saw advances in the science

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9The Latin edition is contained in Jones, *Bedae, Opera de temporum ratione*, and an English translation can be found in Wallis, *Bede: The Reckoning of Time*.

10Steele, *Opera*, p. xiv. The occasion which prompted Bede's composition of this text, as well as an earlier, shorter text, *De temporibus*, was the Synod of Whitby held in the kingdom of Northumbria in 664 A.D. It was at this synod that two methods of calculating Easter, as well as other ecclesiastical matters, were debated. King Oswiu eventually decided to adopt the Roman practice for setting the date of Easter, and Bede's computistical works were in large measure written to reinforce the correctness of this method. See Bede's *Ecclesiastical History*, book 3, chapter 25, for his account of the Synod.

11Steele, *Opera*, p. xv-xvi.

12Steele, *Opera*, pp. xix. Steele notes that most notably the predicted age of the moon was obviously defective, and that attempts to find a solution to the problem do not arise until the middle of the twelfth century, and made use of Jewish sources.

13Jennifer Moreton, "Roger of Hereford and Calendar Reform in Eleventh- and Twelfth-Century England," *Isis* 86 (1995): 562–586, especially p. 562. The article deals with attempts at calendar reform, and stresses that modern scholarship has not given compotus sufficient study to fully understand its place in the eleventh to thirteenth centuries. Moreton points out that none the three texts cited above has ever been printed.

of compotus.

> One of the clearest indications of intellectual revival in the early twelfth century is the large number of manuscripts of that period or shortly before which deal with the elements of arithmetical and astronomical reckoning.[14]

Yet it was only late in the twelfth century that the newly translated Arabic materials began to impact Latin computistical works, and indeed became vital to the enterprise. Roger of Hereford criticized compotists who were ignorant of Arabic astronomy.[15] And whereas Sacrobosco might have been the first to use the new material, his contemporary Grosseteste made better use of the Arabic material available at the time.[16] It is clear that Grosseteste did have in England material in Latin to draw upon, both Arabic astronomical works in translation[17] and original computistical works composed in Latin. By the latter half of the thirteenth century, computistical works, especially Sacrobosco's, were becoming a part of a standard *Corpus astronomicum*, a group of texts that could be associated with astronomical instruction in the schools.[18]

The thirteenth century was an important period in the history of compotus. During this century, a number of original computistical treatises were composed that drew upon earlier Latin material and newly translated Arabic works. In addition to the works of Grosseteste and those attributed to him, Alexander de Villa Dei, Sacrobosco, Roger Bacon,

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[14]Charles Homer Haskins, *Studies in the History of Mediaeval Science*, Cambridge: Harvard University Press, 1927, p. 83.

[15]Haskins, *Studies*, p. 87.

[16]According to Steele, *Opera*, pp. xx-xxi. Note that the dates of composition are very close. Without engaging in difficult arguments of priority, it is still safe to say that they were composed around the same time.

[17]As discussed in an earlier chapter.

[18]See Olaf Pedersen, "The *Corpus astronomicum*," pp. 73ff.

and Campanus of Novara all wrote significant treatises. Eventually, the compotus became ensconced as a topic of university study, prescribed for undergraduates as part of their study of astronomy.

4.2. Attribution and Dating of Grosseteste's Computistical Works

Before analyzing Grosseteste's major computistical work, I shall first discuss the controversy that has arisen over which computistical works are genuinely attributable to Grosseteste. The history of the debates over which works belong to Grosseteste, as well as their dates and order of composition, is a relatively complicated one. Because the stories have changed radically, I recount them here in some detail, so that those who pursue the issue in the secondary literature will understand why there are so many conflicting statements regarding Grosseteste's computistical works. I also will show, by the end of the discussion, that I have chosen to concentrate my own attention on only one of those works, the *Compotus correctorius*, because it is the only computistical text among those attributed to Grosseteste that is certainly his.

S. Harrison Thomson set forth the initial framework of Grosseteste's alleged computistical works. Thomson stated that Grosseteste had written four works, which Thomson labelled *Compotus I*, the *Kalendarium*, the *Compotus correctorius*, and the *Compotus minor*. He believed that the earliest work, the *Compotus I*, could be found only in a single document, Oxford MS Bodl. 679.[19] Thomson relied on an early ascription to Grosseteste contained in that manuscript to assign this as the first of Grosseteste's computistical works. He also argued that it predated the others computistical works because they were written in order to correct this one. Based on an examination of Oxford MS

[19] *Writings*, pp. 94–95.

Bodl., Savile 21,[20] Thomson attributed Grosseteste's interest in Arabic mathematics and astronomy to the period of 1215–1220. As mentioned earlier, however, this dating relies is suspect, and Southern's hesitation to accept this date for the Savile manuscript leaves this date as uncertain at best. But, based on that old assumption, Thomson dated this work to the period 1215–1220.

Thomson believed that, soon after writing the *Compotus I*, Grosseteste wrote the *Kalendarium*,[21] in part, at least, to correct the earlier work. The *Kalendarium* is a set of tables, a twelve-month calendar, with a set of instructions for its use. The text of the instructions varies,[22] as do the precise contents of the tables. One significant part of the tables was the use of the 'natural,' as opposed to the 'vulgar,' compotus to compute the golden numbers over the course of four nineteen-year cycles.[23] In addition, the tables listed various pieces of information for each month, including the number of days in the month, the length of its lunation, the regular and lunar regular of the month, the ferial letter, a scheme of the kalends, nones and ides of the month, the religious festivals of the month, other pieces of astronomical and calendrical information (such as the movement of the sun into a new zodiacal house and the boundaries of the moveable feasts), and the number of days of the year that have passed.[24] Moreton has shown that the tables of the *Kalendarium*

20*Writings*, p. 30ff. This manuscript has been discussed in prior chapters of this dissertation.

21*Writings*, pp. 106–107. The *Kalendarium* is printed and discussed in Arvid Lindhagen, "Die Neumondtafel des Robertus Lincolniensis," *Arkiv för Matematik, Astronomi och Fysik*, Band 11, No. 2, 1916.

22Lindhagen gives the texts of three different manuscripts; see "Die Neumondtafel," pp. 15–19.

23This problem is dealt with fully in Moreton, "Roger of Hereford and Calendar Reform."

24These terms will be explained below, in the section expositing Grosseteste's *Compotus correctorius*. Note that the information contained in manuscript copies of the tables varies.

are integral to Roger of Hereford's *Computus*, and thus must predate Grosseteste. While she acknowledges that Grosseteste could have composed the instructions for using the tables, it is by no means certain that he did so; the text varies, and his reputation certainly could have attracted undeserved ascriptions.[25] Indeed, much of the content of the tables is consistent with Grosseteste's *Compotus correctorius*, as can be seen in the next section, and his association with Hereford makes it possible that he was intimately familiar with Roger's tables. But the information is basic computistical fare, and so there is no particular reason to assume that Grosseteste must have disseminated the tables. In any event, the instructions for using them vary enough that an original version is not readily constructed. So even if we were to accept Thomson's attribution of this text to Grosseteste, we do not have access to the original version of the text.

Next in Thomson's scheme of dating came the *Compotus correctorius*.[26] He noted that this work was written specifically to correct the *Kalendarium*, probably based on the line in the text of the *Compotus correctorius* that it was "written for the correction of *our* calendar."[27] In attempting to date the work, Thomson noted that Steele, the editor of a modern transcription of the *Compotus correctorius*, suggested that it was probably written around the same time as Sacrobosco's *Compotus*, or circa 1232. Thomson argued, however, that because of the frequency with which Grosseteste refers to Arabic authors and because of his earlier argument for Grosseteste's interest in Arabic mathematics and astronomy in

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25 Moreton, "Roger of Hereford and Calendar Reform," pp. 580–581.

26 *Writings*, pp. 95–96.

27 …factus ad correctionem communis kalendarii nostri, *Comp. corr.*, p. 212, ll. 3–4; I have added the italics above to emphasize that Thomson probably was basing his argument on Grosseteste's use of "*our* calendar" to refer to a work he himself had written. If this is the case, Thomson apparently neglected the fact that the adjective *communis* would have implied a shared or communal calendar.

1215, there is no reason to date the work so late. Thomson preferred a date after the other two computistical works were written but before 1229; he based this, however, on an alleged lack of scientific writings by Grosseteste between 1229 and 1240, the period when the older tradition of biography assumed Grosseteste was completely engaged in theological scholarship.

Finally, Thomson argued, Grosseteste wrote a fourth computistical work, the *Compotus minor*.[28] This work exists in a single manuscript, Dublin MS Trinity, 441 (D. 4. 27), but Thomson was confident that its ascription to Grosseteste was accurate. Significantly, Thomson added, the work is internally dated to 1244,[29] which would imply that Grosseteste composed this work in the midst of his episcopacy. In addition, Thomson noted that it reproduces much of the *Compotus correctorius*, perhaps meaning to imply that it was written as an abbreviation of the longer *Compotus correctorius*.

Later scholars have questioned Thomson's dating scheme. James McEvoy, as we have seen, made a new effort to date Grosseteste's scientific works,[30] citing two reasons for doing so. First, no chronology was generally accepted, and two notable attempts, those of Thomson and Crombie, were heavily influenced by significant assumptions that he stated "have not always been convincing."[31] Second, the amount of scholarly work that had been done on Grosseteste in recent years afforded him a greater amount of evidence with which to frame a new chronology. He used both external evidence, such as the determination of

[28] *Writings*, p. 97.

[29] Thomson quotes a passage from f. 107b, *sed nativitate Domini elapsi sunt 1200 anni et eo scilicet 44 amplius, in quo numero sunt decies centum and decies 20*; 1200 years and 44 more have elapsed since the birth of the Lord, in which number there are ten hundreds and ten twenties.

[30] James McEvoy, "The Chronology."

[31] McEvoy, "The Chronology," p. 614.

1230 is the earliest date for any work that refers to Averroës,[32] and internal evidence, such as development of Grosseteste's thought about particular issues.

McEvoy dealt with the computistical works under the heading of astronomy and its applications.[33] Following Thomson's lead, he treated the *Compotus I*, the *Kalendarium*, and the *Compotus correctorius* as a sort of trilogy, each subsequent work written to correct the previous. He argued that each individual work is difficult to date precisely, but that we can safely assume the order of their composition, with the *Compotus correctorius* coming last. It is this final work that McEvoy felt was the most susceptible to dating.

Using internal evidence, McEvoy placed the composition of the *Compotus correctorius* between 1225 and 1230. He put forth a number of arguments restricting it to this six-year period. First, Grosseteste, in the *Compotus correctorius*, stated that the sun was created on the first day of creation, a view which he later rejected—after a study of the patristic writers—in his *Hexameron*, composed after 1235. In addition, McEvoy pointed out that certain passages anticipate Grosseteste's metaphysics of light, and thus it probably does not belong to his earliest scientific works. A third argument concerns Grosseteste's use of the creation of the world within the computistical work. The pagans, who created the calendar, had no awareness that the world was created, whereas Grosseteste consistently assumes that the calendar can be referred back to the original creation. McEvoy believed that this is an anticipation of Grosseteste's later arguments against Aristotle's assumption of the eternity of the world, arguments that were theological in nature, and thus must date after the period when Grosseteste began his natural philosophical studies, in other words, after the

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[32]McEvoy, "The Chronology," p. 615.

[33]McEvoy, "The Chronology," pp. 616ff; the computistical works are dealt with on pp. 618–20. Some of the arguments had been presented in briefer form in his *The Philosophy of Robert Grosseteste*, Oxford: Clarendon Press, 1982; see especially pp. 16 and 506–507.

mid-1220s. Finally, McEvoy noted that Grosseteste frequently exhibited a superficial understanding of Aristotle, suggesting that the *Compotus correctorius* was composed before Grosseteste's extended studies of Aristotle's *Physics*, which he left off circa 1232.

In a brief consideration of the *Computus minor*, McEvoy simply accepted Thomson's date of 1244 based on the passage quoted earlier. He suggested that this late date would complicate any chronology that assumes Grosseteste's interests to be strictly periodized.[34] Southern, only a few years later, introduced an important consideration into the dating of the works, correcting an omission by Thomson.[35] What Thomson failed to make explicit, Southern pointed out, is that the 1244 date given in Dublin MS Trinity 441 includes a marginal note. The text itself states that 1200 years have passed since the birth of the Lord, while the marginal note adds that 44 more have passed. This preserves the additional clause in the text, namely, that the amount of time is equal to ten hundreds and ten twenties. Thus Southern dated the *Compotus minor* to about the year 1205,[36] and suggested that the marginal note may imply that it was copied in 1244.

If this dating is correct, then clearly the scheme of relationships between the texts given by Thomson is incorrect. Southern responded to this problem, however, by examining the works. It was his opinion that the *Compotus I* was written first, and claimed that the

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[34]It has been shown by Jennifer Moreton, discussed below, that the *Compotus minor* is not a work of Grosseteste. Nonetheless, McEvoy's warning about periodizing Grosseteste's interests is still a valuable methodological point, even if his particular argument over the *Compotus minor* is incorrect.

[35]Southern, *Robert Grosseteste*. His discussion of the compoti of Grosseteste are on pp. 127–31. Southern uses a unique nomenclature for the works, labelling each compotus with a Roman numeral. His I corresponds to Thomson's *Compotus I*, his II to the *Compotus correctorius*, and his III to the *Compotus minor*.

[36]Based on the formula of ten hundreds and ten twenties, Southern is confident that it must fall between 1200 and 1220. Because he dates the *Compotus correctorious* to the end of that period, he places the *Compotus minor* towards the beginning.

Compotus minor was a recension of it. He argued that the first was written about 1195. He set this early date because of the elementary nature of the text, most particularly because of the sources it uses. The *Compotus I* relies mainly on outdated authors such as Gerlandus and John Beleth, and its recension, the *Compotus minor*, contains various corrections to the first.[37] Southern pointed out that, by 1200, the computistical works of Hereford were already more advanced than Grosseteste's compoti. He thus believed that his first compotus and its recension were written before Grosseteste had engaged in the study of more advanced computistical works.

The *Compotus correctorius*, Southern believes, was composed years later, and demonstrates that Grosseteste's knowledge of astronomy and compotus had advanced significantly, that "it was the work of someone swimming vigorously in the tide of modern scientific knowledge, and undertaking independent measurements and calculations."[38] His sources were no longer outdated computistical Latin authors, but were Greek and Arabic astronomers. In addition, as the quotation above implies, Southern believed Grosseteste had spent time performing original calculations and observations, thereby making this work quite different in nature from the previous two.

A few years later, Richard Dales turned to the question of the dating and order of Grosseteste's compoti,[39] explicitly noting his own deliberate omission in his earlier attempt at providing a chronology of the scientific works. He wished to respond to problems he saw

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[37]Southern admits that he has not studied the texts in sufficient detail to note all the corrections, but notes that this second version of the work is still quite elementary compared to the later *Compotus correctorius*. See *Robert Grosseteste*, pp. 128–129.

[38]Southern, *Robert Grosseteste*, p. 129.

[39]Richard C. Dales, "The Computistical Works Ascribed to Robert Grosseteste," *Isis* 80 (1989): 74–79.

with both Southern's account and Jennifer Moreton's denial of Grosseteste's authorship of all the works except the *Compotus correctorius*.[40]

Dales first dealt with the notion that the *Compotus I* and *Compotus minor* were early texts of Sacrobosco, into which he later inserted more advanced calculations to create his *De anni ratione*. Noting its similarity to many computistical works, Dales attacked the problem by trying to tease out characteristics of the *Compotus I* that suggest it is an authentic work of Grosseteste. First, he pointed to a passage in which the author notes that the dates for the solstices and equinoxes are wrong by approximately one day in 120 years, and that this problem will be treated in a subsequent work.[41] He also argued that, on stylistic grounds, the work is consistent with Grosseteste's authorship. Dales also noted the early ascription of the work, that is, before 1250, and that the ascription is merely to "master Robert Grosseteste," without reference to his bishopric. Finally, the author's promise to write a fuller work would be fulfilled by Grosseteste's *Compotus correctorius*, Grosseteste's authorship of which is not questioned. Regarding the date, Dales reiterated the arguments of Thomson regarding the Oxford MS Bodl. Savile 21, claiming that by 1215 Grosseteste was examining Arabic astronomical treatises; Dales extended the argument by claiming that the Savile manuscript shows that Grosseteste had indeed taken

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40Dales was responding to a first draft of her article which will be dealt with in detail below. Dales's article, however, was published before the final version of Moreton's article.

41Dales, "The Computistical Works," pp. 75–76. His argument is that the author of the *Compotus I* anticipated writing another, more satisfactory compotus to deal with the problems such as the one just mentioned. It is relevant that in the *Compotus correctorius*, Grossteste does not say that one day in 120 years has been lost, but discusses in the first chapter a number of possible corrections to the calendar based on different authorities' estimates of the length of the year. He also notes in the tenth chapter that the true length of the year needs to be verified, thus implying that he has not settled on a correction such as is called for in the *Compotus I*.

up some of the computistical problems he promised to address in the *Compotus I*.[42] Thus he argued that the *Compotus I* was written by Grosseteste, and that it was composed before 1215.

Dales also discussed the *Compotus minor*. Although he agreed with Southern that this work derives from the *Compotus I*, he did not believe that Grosseteste could truly be called its author. In fact, he believed that the second work was not a recension, but merely an abridgement, of the first, probably made by a scribe sometime before 1325 when the Dublin manuscript was written. The text of the Dublin manuscript, then, was not the product of Grosseteste himself, but was constructed by someone else using Grosseteste's original text. Dales was thus convinced that this particular text should not be attributed to Grosseteste.

Finally, Dales turned to the *Kalendarium*. Again he concluded that the work is probably not Grosseteste's. He wrote that the phrase "our calendar" in the *Compotus correctorius*, which Thomson assumed to refer to the *Kalendarium*, has been misunderstood, and that the phrase in fact refers only to the ecclesiastical calendar commonly in use. In addition to the fact that many of the copies of this work are unascribed, he acknowledged that Moreton has pointed out that the *Kalendarium* is identical to that used by Roger of Hereford, and thus predates Grosseteste.[43]

The most recently published work devoted to Grosseteste's computistical works is a

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[42]Dales, "The Computistical Works," p. 77. Note that Dales does not examine the contents of the Savile manuscripts in an attempt to ascertain if the works Grosseteste copied in fact addressed the problems mentioned in the *Compotus I*, but merely notes the Grosseteste was examining Arabic astronomical works by around 1215, and that this is consistent with the order of composition that he is proposing.

[43]In fact, Moreton argues that it is integral to Roger of Hereford's work, as discussed previously. See her "Before Grosseteste."

1995 article by Jennifer Moreton.[44] She dismissed the *Kalendarium* as an authentic work of Grosseteste, noting that it is contained in Roger of Hereford's *Compotus* of 1176, and indeed was integral to that work.[45] She does concede that the preface that accompanies the calendar in ascribed texts could be the work of Grosseteste.

When she came to the *Compotus I* and *Compotus minor*, Moreton introduced a significant new finding. The *Compotus I* is, in fact, found not in a unique manuscript, as had been assumed since the time of Thomson, but is found in a number of manuscripts dating from the thirteenth to fifteenth centuries.[46] Moreton referred to this common compotus as the *Compotus ecclesiasticus*.[47] Many copies of this text have been attributed to John of Sacrobosco because of the similarity of their incipits to that of the *De anni ratione*, a genuine work of Sacrobosco. The incipit of the *Compotus ecclesiasticus* is *Compotus est scientia considerans tempora distincta secundum motus solis et lune…*,[48] while the incipit

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[44]Jennifer Moreton, "Robert Grosseteste and the Calendar," in *Robert Grosseteste: New Perspectives on His Thought and Scholarship*, edited by James McEvoy, 77–88, *Instrumenta Patristica* 27, Turnhout, Belgium: Brepols, 1995. James McEvoy, in his recent addition to the Great Medieval Thinkers series, *Robert Grosseteste*, Oxford; Oxford University Press, 2000, cites Moreton when he states that "Of the three treatises on the calendar that have been attributed to Grosseteste, the *Computus* [sic] *correctorius* is the only one of certain authenticity," p. 78, and p. 197, n. 3.

[45]Moreton, "Robert Grosseteste," p. 78. She notes that the calendar covers a seventy-six-year period, rather than the typical nineteen-year period, and that Grosseteste's possible ties to Hereford during his early years are suggestive. In the *Compotus correctorius*, Grosseteste frequently utilizes a seventy-six-year period for his calculations, based on the fact that four nineten-year periods have all the possible combinations of leap years. See also her "Before Grosseteste."

[46]Moreton lists seven examples on p. 80.

[47]She noted in "John of Sacrobosco and the Calendar," *Viator* 25 (1994): 229–244, p. 237, that the title *Compotus ecclesiasticus* often appears in manuscripts with no ascription.

[48]This incipit is taken from British Library MS Add. 27589, f. 13r, one of Moreton's examples. The incipit of the *Compotus I* in Oxford MS Bodl. 679 is *Multiplex est annus, scilicet solaris et lunaris, quia secundum cursum….* The incipit is quite different—Thomson took this as a genuine work of Grosseteste because the work is ascribed to Grosseteste in the upper margin, even though it is in a different

of the *De anni ratione* is *Compotus est scientia considerans tempora ex solis et lune motibus….*[49] The ease with which catalogers could make this mistake is obvious.

The *Compotus ecclesiaticus*, Moreton argued, was a textbook for use in the new universities. Its material is basic, and, rather than dealing with the theory behind the computistical approach, its goal is simply to convey basic information about the calendar: the solar basis for the year and fixed feasts, the lunar basis for the movable feasts, and the collation of the two. She also asserted that the use of mnemonic verses to speed learning, the use of the techniques of *definitio* and *distinctio*, and frequent quotations from Ovid, Cicero and Boethius imply that the work was written for the arts student,[50] while the *Compotus correctorius* was clearly a more advanced work.

Regarding Grosseteste's authorship, Moreton was confident that he did not write this work. She questioned Dales's argument from style, arguing that most of the *Compotus ecclesiasticus* does not use the complex style that Dales attributes to Grosseteste. She also noted two errors in the *Compotus ecclesiasticus*, and argued that, even if written before his advanced training, these basic mistakes were not ones Grosseteste would have made.[51] It was her argument that Grosseteste was in fact aware of the *Compotus ecclesiasticus*, and, in his *Compotus correctorius*, provided at least one innovative solution to a problem found in

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hand—from the incipit in the British Library manuscript. I have not verified the similarity of the text to the other works Moreton lists.

49Note that the first five words are identical, and both incipits contain the phrase *solis et lune*, so the confusion between incipits is not surprising. The differences in the text, however, mean that upon close comparison the works can easily be told apart. In viewing manuscripts held in English libraries, I also discovered that the *De anni ratione* typically has a corpus of illustrations that easily distinguish it from the *Compotus ecclesiasticus*. Moreton also discusses this in "John of Sacrobosco," pp. 236–237.

50Moreton, "Robert Grosseteste," p. 81.

51Moreton, "Robert Grosseteste," p. 82–83.

the earlier work.[52] Finally, Moreton dealt with the ascriptions in the Bodley and Dublin manuscripts, arguing that both of them are problematic; either they are late, or that it is unclear whether they are in fact ascriptions to Grosseteste or rather to Sacrobosco.[53]

In light of this recent scholarship, what conclusions can we reach about Grosseteste's authorship of the *Compotus ecclesiasticus*, and the date of the *Compotus correctorius*? Beyond Moreton's brief introduction, little attention has been paid to the *Compotus ecclesiasticus*, and so it is difficult to analyze the work. However, given that the work appears frequently without ascription to Grosseteste, and that Grosseteste's name certainly could have attracted spurious ascriptions,[54] the burden of proof rests upon those who wish to claim that the work is genuinely that of Grosseteste. Dales, the only scholar to consider the question in light of Moreton's recent work, rests his attribution to Grosseteste mainly on the fact that the *Compotus correctorius* specifically addresses problems that were raised in the *Compotus ecclesiasticus*.[55] He writes that the *Compotus correctorius*

> retains many of the mnemonic verses and some of the wording of the earlier work, but its focus is on solving the most serious problems of the computus rather than providing a handy elementary manual for provincial clergy.[56]

The problematic part of this statement relies on the assumption that, unless the work is

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[52]The problem is that of the movement of the solstices in relationship to their respective feasts (Christmas Day for the winter solstice and St. John's Day for the summer). Moreton, "Robert Grosseteste," p. 83–85.

[53]Moreton, "Robert Grosseteste," p. 85–87.

[54]Which, of course, it did frequently. See Harrison's sections on Dubious and Spurious writings in his *Writings*.

[55]He also raises other issues, such as style and early ascriptions, as discussed above, but these seem intended to buttress his argument regarding the purpose of the *Compotus correctorius*, namely, to correct the problems present in the earlier work, rather than to be strong points of evidence on their own.

[56]Dales, "The Computistical Works," pp. 77-78.

intended to make corrections to his own earlier work, Grosseteste would have intended it for provincial clergy.

It is true that the *Compotus correctorius* is not an "elementary manual," as I will discuss in greater detail below, but I do not believe that its focus is "solely on correcting the most serious problems" of the compotus. Much of the work is elementary in nature, defining terms, giving practical advice on constructing tables, demonstrating how to calculate basic calendrical problems, and so forth. The work was not intended solely as a corrective to the earlier work, but also was meant to provide many of the basics of compotus in a text that could stand on its own. Thus Dales's scheme of Grosseteste writing an early work with which he was dissatisfied, and then a later work to offer corrections, is problematic. It is equally possible, as Moreton has pointed out, that Grosseteste knew of the *Compotus ecclesiasticus* as a text in circulation in Oxford during his time there. Moreton characterizes the work as one of "unimpeachable orthodoxy," in contrast to some of the contents of Grosseteste's *Compotus correctorius*, which she believes could not have been intended as "a textbook for young students,"[57] because it dealt with topics such as the possibility that the date of Easter was being calculated incorrectly. In other words, she has given a plausible theory to connect the two works: Grosseteste knew of the *Compotus ecclesaisticus*, and indeed tried to correct some of its faults, but that he was not its author.

Dales argued that the *Compotus correctorius* was the result of Grosseteste's consultation of Arabic astronomical works in order to correct the deficiencies of his knowledge when he wrote the earlier work. In other words, Dales asserted, the *Compotus ecclesiasticus* must have been written before the period when Grosseteste is known to have

[57]Moreton, "Robert Grosseteste," p. 80 and p. 85.

studied Arabic astronomy, namely, 1215–1216.[58] However, such a date relies upon the problematic dating of the Savile manuscript and neglects the connections to Hereford that Grosseteste had before this period. Of course, the activities of the early years of Grosseteste's life are difficult to know with any certainty, but clues in the *Compotus correctorius* suggest that Grosseteste was aware of the computistical activity of Roger of Hereford, namely, issues regarding the "natural" and "vulgar" compoti and the use of the seventy-six year cycle.[59] It is more plausible that Grosseteste is not the author of the *Compotus ecclesiasticus*, that his interest in compotus dates to well before 1215, and that he gained at least some of the tools needed to work in the field from works that would have been available to him at Hereford.

According to Moreton, the *Compotus ecclesiasticus* was most likely composed in the first quater of the thirteenth century.[60] To preserve Grosseteste's authorship, according to Dales's argument, Grosseteste must have written it before 1215, at which date we can be sure Grosseteste had begun to investigate Arabic astronomy. But recall that Grosseteste was associated with Hereford as early as 1195, and was at Oxford by 1225,[61] whereas Dales dates the *Compotus correctorius* to around 1225–1230. Thus to preserve his authorship of the *Compotus ecclesiasticus*, we must assume that Grosseteste wrote this elementary work during the first twenty years after his association with Hereford, a period during which he was interested in scientific matters, and yet must not have known of the computsitical works

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58Dales, "The Computistical Works," p. 77.

59As discussed in the previous section; details are in Moreton's "Before Grosseteste."

60Moreton, "Robert Grosseteste," p. 83.

61Southern, *Robert Grosseteste*; on his period at Hereford, see pp. 65ff, and on his period at Oxford, see pp. 70ff.

written by Roger. In the course of ten to fifteen years, after embarking on a study of Arabic astronomy in order to correct the problems of his earlier work, Grosseteste could only then have discovered the computistical works of Roger and incorporated them, along with his newly acquired knowledge of Arabic astronomy, into a complex computistical work. While not impossible, this scheme seems far too complicated to preserve Grosseteste's authorship of a work that does not live up to his reputation for interest in scientific matters.

My own conclusion is that Grosseteste wrote only the *Compotus correctorius*. He may also have written the instructions of the *Kalendarium*, but that issue is beyond the scope of my work here. The *Compotus ecclesiasticus*, under which heading can be included both the *Compotus I* and the *Compotus minor*, was likely familiar to Grosseteste. Its faults may have been one of the reasons that Grosseteste wrote his work, but the *Compotus correctorius* deals with a number of issues beyond those that Dales has used of evidence of Grosseteste's authorship of the earlier work. I will present more of my arguments after an exposition of the text, so that the reader can better understand the computistical issues at stake.

4.3. Exposition of the *Compotus correctorius*

As the only computistical work securely attributed to Grosseteste, the *Compotus correctorius* is a vital text for understanding Grosseteste's goals for compotus, including the teaching of compotus, which I shall argue was one of his purposes for composing this text. In the following section, I give a detailed exposition of the contents of the work; I reserve analysis of the text for the next section, so that the exposition is not overburdened with interruptions. The goal of this section is to provide the reader with a detailed summary of the contents of the work; access to the text has not hitherto been available apart from reading the work in Latin.

The *Compotus correctorius* was one of the most popular of Grosseteste's scientific works; Thomson lists 29 manuscript copies of the work.[62] No modern critical edition exists, but Robert Steele has produced a transcription of the work from Brit. Mus. Add. MS 27589, with variants from Brit. Mus. Harley 3734.[63] All of my references will be to Steele's printed version, unless otherwise noted.

In the manuscripts I have examined, the work is almost invariably preceded by a list of the 12 chapters. In Steele's printed version, the list appears as follows:[64]

> *Capitulum primum, de causa bisexti, et de modis magis verificandi kalendarium nostrum, et de racione inveniendi annum bissextilem.*
> [Chapter one, on the cause of the leap year and the ways in which it makes our calendar more correct, and on the reckoning for finding the leap year.]
>
> *Capitulum secundum, de divisione anni in quator tempora et in menses, et de divisione mensium in kalendas nonas et ydus.*
> [Chapter two, on the division of the year into four seasons and into months, and on the division of the months into kalends, nones, and ides.]
>
> *Capitulum tercium, de concurrentibus et ciclo illorum, et de regularibus solaribus, et horum conjunctorum utilitate.*
> [Chapter three, on concurrences and their cycle, and on the solar regulars and the usefulness of their conjunctions]
>
> *Capitulum quartum, de ostensione erroris kalendarii nostri in sumptione primatione et in positione cicli novodecimalis et cicli epactarum, et de modo summendi primaciones secundum veritatem.*
> [Chapter four, on showing the errors in our calendar for finding the primations and our position in the nineteen-year cycle and cycle of epacts, and on the method of setting the primations correctly.]

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[62] *Writings*, p. 96. Compare this number to the number of copies of Grosseteste's other scientific works that Harrison lists: *De forma prima omnium*, 17 (p. 98); *De impressionibus aeris*, 17 (pp. 103–104); *De intelligenciis* 17 (p. 105); *Kalendarium* 23 (pp. 106–107), though note the arguments above regarding its inauthenticity; *De sphera* 38 (p. 116). He lists no more than 13 manuscripts for any other scientific work.

[63] In *Opera hactenus inedita Rogeri Baconi*, Fasc. VI, *Compotus fratris Rogeri*, pp. 212–267, hereafter *Comp. corr.*; I will cite page numbers and, where appropriate, line numbers. All translations are my own unless otherwise noted. The volume also includes the *Massa compoti* of Alexander de Villa Dei and the *Computus* of Roger Bacon.

[64] The chapter list is on *Comp. corr.*, pp. 212–213.

Capitulum quintum, de modo extrahendi annos et menses Arabum ex annis Christi tam per multiplicationem et divisionem quam per tabulas.
[Chapter five, on the method of getting the Arab years and months from the Christian years, through multiplication and division as well as with tables.]

Capitulum sextum, de eo quod necesse est in compoto non diversificare quantitatem temporis lunationis vere a quantitate lunationis equalis
[Chapter six, on the necessity in compotus not to differentiate the time of the true lunation from that of the equal lunation.]

Capitulum septimum, de quantitate lunationis quam oportet ponere secundum doctrinam kalendarii nostri, et de generacione epactarum et regularium lunarium et horum utilitate.
[Chapter seven, on the quantity of the lunation that must be set according to the rules of our calendar, and on the making of epacts, lunar regulars and their usefulness]

Capitulum octavum, qualiter 76 anni equantur penitus 940 lunationibus, quas conputamus in illis annis per restaurationem quam faciunt dies bissextiles et lunationes embolismales, et quibus locis lunationes embolismales interponuntur in kalendario, et de invenienda etate lune in temporibus mensium per tabulas.
[Chapter eight, how 76 years are precisely equal to 940 lunations, which we calculate in those years by the restoration that bissextile days and lunar embolisms make, and where to insert lunar embolisms in our calendar, and on finding with tables the phase of the moon during the month.]

Capitulum nonum, de ratione collocandi aureum numerum in kalendario.
[Chapter nine, on the method for placing the golden number in the calendar.]

Capitulum decimum, de ostensione erroris nostri sumptione terminorum et locorum festorum mobilium, et de modo sumendi terminos et loca festorum mobilium secundum doctrinam kalendarii nostri.
[Chapter ten, on showing our errors in placing the ends and locations of moveable feasts, and on the manner of finding the ends and locations of moveable feasts according to the doctrine of our calendar.]

Capitulum undecimum, de ratione compositionis tabularum ad invenienda festa mobilia.
[Chapter eleven, on the rules for composing tables for finding the movable feasts.]

Capitulum duodecimum, de temporibus jejuniorum.
[Chapter twelve, on the periods of fasting.]

4.3.1. Chapter One of the *Compotus correctorius*

Let us look closer at the contents of the work. The first issue that Grosseteste broaches is a definition of the science of compotus itself. He states that "compotus is the science of reckoning and dividing time."[65] The science of compotus entails understanding ways of marking time that come both from the movements of the celestial bodies and from regional practices.

It is clear from Grosseteste's explanation of compotus that one who studies it will have to understand the motions of the celestial bodies, yet relatively little of this is explained in the text. For example, Grosseteste explains the daily and yearly motions of the sun, and defines the zodiac in eleven lines of the printed edition,[66] and in defining the year in the next paragraph, he uses the terms 'solstice' and 'equinox' without defining them. This implies that Grosseteste is assuming that those who use this text will already have been introduced to the motions of the heavenly bodies from some other source, perhaps from Grosseteste's own treatise *De spera*,[67] or will have someone on hand who can explain the work to them, as in an educational setting.

In addition to understanding the natural occurrences that divide time, Grosseteste also states that regional practices affect the way time is kept. For example, the names of the months are taken from the heathens.[68] Thus compotus is not merely a science that relies upon knowing the way the physical world operates; it is also an historical science. Because calendars are human creations, proper use of them requires that one understand the

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[65]Compotus est scientia numerationis et divisionis temporum. *Comp. corr.*, p. 213, l. 6.

[66]*Comp. corr.*, p. 213, ll. 23–33. There is a clear affinity with the ideas in his *De spera*, including the definition of the motion in terms of the fixed and mobile zodiac. See the previous chapter of this dissertation for further explanation.

[67]Of the 29 manuscripts of the Compotus correctorius listed by Harrision, 11 also contain a copy of Grosseteste's *De spera*.

[68]*Comp. corr.*, pp. 221–222. Before relating the origins of the names, Grosseteste states that the names are received *ab ethnicis*, p. 221, l. 17.

principles used to create them.

These two kinds of knowledge required by the compotist are made evident in Grosseteste's analysis of the length of the year in his first chapter. From its title, we know that his main objective is to explain the leap year. The sun is described as "the largest body of the cosmos, of the noblest pure substance, and the most efficacious in transmutation of nature through the strength of its light."[69] It has two motions, a daily motion by virtue of a sphere that naturally rotates once a day, and a yearly motion through the fixed zodiac,[70] an imaginary circle that marks the motion of the sun. A year is defined as the time it takes the sun to move from a given point along its yearly path and return to that same point. The length of the year was given by Abrachis[71] as 365 and one-quarter days. Thus three consecutive years are 365 days long, and an extra day is inserted into the fourth year, making it a leap year. This extra day is called the "bissextile" day because it was inserted at the sixth kalends of March, and thus six, *sextus*, was written twice in the calendar.[72]

Grosseteste then includes a diagram in the text to illustrate the motion of the sun,

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69…sol sit corporum mundanorum quantitate maximum, et puritate substancie sue nobilissimum, et fortitudine luminis sui in naturarum transmutationem efficacissimum, *Comp. corr.*, p. 213, ll. 18–21.

70There is also a moveable, or imaginary zodiac; see below.

71Dales suggests that Abrachis could be a corruption of Ali ibn Abi al-Rijal, "The Computistical Works," p. 78, but Abrachis is actually Hipparchus. In this section, because it is an exposition of Grosseteste's text, I shall preserve his Latinized names for Arabic authors. Dales provides the following correspondences: Albategni is al-Battani, Arzachel is al-Zarqali, and Alpetragius is al-Bitruji.

72…et diem intersertum in quarto anno vocant diem bissextilem, quia interserunt eum sexto kalendis Marcii, et super eandem litteram in kalendario bis dicunt sexto kalendas. *Comp. corr.*, p. 214, ll. 8–10. Kalends refers to the first day of the month, sixth kalends to the sixth day (counting inclusively) prior to that. Grosseteste will define the term 'kalends' later in the work, but takes it for granted that his readers will understand it here.

and how the insertion of a day corrects the calendar.[73] A circle is enclosed by the letters AG, and point A is the winter solstice. The sun moves from A towards the point H. If a full year is 365 and one-quarter days, then at the end of 365 days, the sun will not have returned

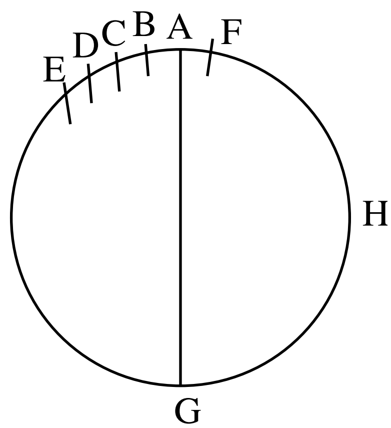

Figure 8. Illustrating the Leap Year

to point A, but will fall short by one-quarter of a day, the length BA. In the second year, it falls short by another quarter-day, the length CB; in the third and fourth years, it falls short by lengths DC and ED. In that fourth year, then, the intervals ED, DC, CB, and BA amount to one full day; adding the leap day will then bring the sun back to point A at the end of that year.

Grosseteste next notes that Ptolemy disagrees with the length of the year given by Abrachis, that in fact the year is less than 365 and one-quarter days by 1/300th of a day.[74]

73Grosseteste clearly meant for a figure to be present in the text. He writes, "I place here a diagram to make these things clear" (*ad hujus rei manifestacionem pono figuram*), *Comp. corr*., p. 214, l. 16. Indeed, either the figure itself or an empty space left for its later insertion is present in most of the manuscripts I have observed. The figure is reproduced on *Comp. corr*., p. 214; it is present in MS Brit. Mus. Add. 27589 in the lower margin of folio 77v.

74See Book 3, chapter 1 of the *Almagest* for Ptolemy's discussion of the length of the year, and for his use in that section of Hipparchus. In Toomer's translation, see pp. 137–140.

Grosseteste again uses the preceding diagram to illustrate how this would affect the position of the sun after a year. In this case, the sun moves past the expected point by 1/300th of a day. After 300 years, instead of being at point A, the sun would in fact be at point F, one full day past point A. The result, he argues, is that removing one day every 300 years will keep the calendar correct, assuming Ptolemy's length is correct.

Grosseteste notes that Albategni assumes yet a different length for the year, namely, that it is 1/100th of a day shorter than 365 and one-quarter days, the same as Abrachis and the compotists. In this case, one day out of every hundred years should be removed. Grosseteste also argues that this value is consistent with contemporary observations, namely, that the Nativity has fallen out of place in the calendar. Grosseteste writes that Scripture states that Jesus Christ was born on the winter solstice, but that we find through observation[75] that the Lord's Birth Day[76] precedes the solstice by about as many days as the number of centuries that have passed since his birth.

Yet another means of computing the length of the year comes from Thebit. Grosseteste notes that the movable or imaginary zodiac moves in relationship to the fixed zodiac with a motion of accession and recession.[77] This means that the time it takes for the sun to move from solstice to solstice or equinox to equinox will not always be the same. To know the true length of the year, one must measure the motion of the sun against one of the fixed stars, which is not subject to this motion. Thebit finds that the length of the year is

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[75]…invenimus per experimentum, *Comp. corr.*, p. 215, l. 29.

[76]Diem Natalem Domini, *Comp. corr.*, p. 215, l. 32.

[77]This theory was presented in the fifth chapter of the *De spera*. See the previous chapter of this dissertation.

actually longer than 365 and one-quarter days by the amount of 23 seconds of a day.[78] This leads to the computation that one day must be added to the calendar every 156 years, but, in addition, one day must be removed every 46,800 years to bring the sun back to its correct place.[79]

Grosseteste next discusses Aristotle and Alpetrangus, noting that the latter has "recently discovered a way that explains how it is possible to save the appearances of the progressions, stations, and retrogressions of the planets, and the reflexions and inflexions, and other phenomena, through Aristotle's method, but without eccentrics and epicycles."[80] But, notes Grosseteste, even though they use principles that come from natural philosophy, they have simply assumed the same length of the year as Ptolemy, and so present nothing new regarding the length of the year.

The application of astronomical knowledge to the question of the length of the year has been made clear. But now Grosseteste moves to a discussion of the calendar as the Church uses it. It is here that we see how "regional practices" make a difference in understanding the calendar. After briefly mentioning that the calendar could be made more accurate by figuring the length of the year more accurately, Grosseteste states that the

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[78]*Comp. corr.*, p. 216, l. 14–5. Note that 'seconds' here refers 1/3600 (or $1/60^2$) of a day. This is borne out by the calculation that follows, that in 156 years, the sun moves one full day less twelve seconds of a day: 23 x 156 = 3588, which is 12 less than 3600.

[79]Every 156 years, the calendar loses 12 seconds. To get a full day takes 300 times 12 seconds; thus in 46,800 (300 x 156) years, an extra day will have accumulated and must be removed from the calendar.

[80]Et Alpetrangius nuper adinvenit modum, et explanavit quomodo possible est salvare processus et stationes et retrogradationes planetarum et reflexiones et inflexiones et cetera apparencia per modum Aristotelis, et absque eccentrico et epiciclo. *Comp. corr.*, p. 217, ll. 21–24.

Church currently places the bissextile day[81] in the calendar every four years. To determine if a year is bissextile, one simply divides the number of years since the Incarnation of the Lord[82] by four. If it divides evenly, then the year is bissextile; if a remainder of one, two or three results, then the year is not bissextile. He notes that this is true when using the reckoning of the arts (*ars cognoscendi*), as opposed to that of the astronomers (*astronomi*). The reason for this difference is that the astronomers begin the year in March, and thus the bissextile day is in the previous year.[83]

Grosseteste also includes a shortcut to know the bissextile years without needing to divide,[84] as the method above requires. All years that are multiples of 100s and 1000s are bissextile. For the years inbetween, if the tens-digit is even, such as in twenty, forty, or sixty, then years ending in four or eight as well as those of the even tens will be bissextile; if the tens-digit is odd, then years ending in two or six will be bissextile.[85] He gives a brief verse to remember the scheme, “Pairs of numbers ten, follow 4, 8, two, 6,”[86] and then presents a

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[81]The bissextile is the extra day placed in the calendar to keep it better aligned with astronomical phenomena; in other words, to account for the fact that the length of the year is not equal to a whole number of days.

[82]…anni ab Incarnatione Domini, *Comp. corr*., p. 218, l. 6; in other words, the number of the year in question, based upon the *anno domini* nomenclature introduced by Dionysius Exiguus.

[83]Grosseteste does not provide more detail at this point regarding the difference between the reckoning according to the arts and the astronomers. The implication is clearly that his sources use two different schemes for the beginning of the year.

[84]*Comp. corr*., p. 218, ll. 20–34.

[85]De articulis autem omnis articulus denominatus a numero pari ut 20 et 40 et 60 et deinceps. De numeris compositis omnis numerus compositus ex articulo numeri inparis et binario vel senario ut 32 et 36. Et omnis compositus ex articulo numeri paris et quaternario vel octonario, et 24 et 28. *Comp. corr*., p. 218, ll. 27–32.

[86]Dena pari numero, post 4. 8. duo 6. *Comp. corr*., p. 218, l. 37.

detailed example of how this works with 20s and then 30s, and proceeding on to the 40s. Between the verse for mnemonic purposes and the didactic example, it is clear that Grosseteste expects his readers to prefer a memorization technique to a procedure for dividing the year. Even though the latter is simpler to describe, it requires more effort each time one tries to figure the problem.

4.3.2. Chapter Two of the *Compotus correctorius*

Quite abruptly, as is typical in the division of the chapters of this work, Grosseteste immediately moves into a new topic in the next chapter. The year, he writes, is divided into four seasons. Each has two complexions associated with it: summer is hot and dry, autumn is cold and dry, winter is cold and wet, and spring is hot and wet.[87] The seasons correspond to the position of the sun between the solstitial and equinoctial points. He again makes a distinction between two ways in which this can be understood. The astronomers (*astronomi*) say that the seasons begin immediately when the sun enters into the respective quarter of the zodiac. The physicians (*medici*), however, say that the seasons begin when the sun moves into the quarter and the complexions begin to take effect. Thus the beginning of a season, according to the physicians, comes at different times in various climates.

The year is also divided into twelve months, which correspond to the twelve signs of the zodiac. As the sun moves through the zodiacal signs, it also runs through corresponding effects based upon the four major complexions, hot, cold, dry, and wet. Each of these complexions has three different types of effects, thus giving twelve arrangements, one for each month, though he does not match them up.[88] He also states that he believes the months were created by following medical practice, not astronomical, so as with the seasons, there is

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[87]*Comp. corr.*, p. 219, ll. 9–10.

[88]*Comp. corr.*, p. 220, l. 31–p. 221, l. 4.

not a precise relationship between the movement of the sun and the months.

Grosseteste next moves on to a discussion of the names of the months and days, and how one refers to each day of the year based on the Roman system of kalends, ides, and nones. In a table, reproduced below as Table 5, he lists the names of the months, and the number of days, kalends, nones, and ides associated with each.[89] In addition to the tables, he

TABLE 5

KALENDS, NONES, AND IDES

Month	Days	Kalends	Nones	Ides
January	31	19	4	8
February	28	19	4	8
March	31	16	6	8
April	30	17	4	8
May	31	18	6	8
June	30	17	4	8
July	31	18	6	8
August	31	17	4	8
September	30	19	4	8
October	31	18	6	8
November	30	17	4	8
December	31	18	4	8

gives mnemonic verses for remembering all of this information. After providing an etymology for the name of each month and for the terms kalends, nones, and ides, he

[89] The table is on *Comp. corr.*, p. 220, and in MS Brit. Mus. Add. 27589, folio 80^{r} at the bottom of the second column, extending into the lower margin. I have translated the Latin words, and have not preserved the abbreviations of the manuscript. Instructions on how to use the table, as well as explanations of kalends, ides and nones follow.

explains how the system of kalends, nones and ides work. The first day of a month is called the kalends of that month. The last day of a month is the second day before the kalends of the next month, though it is normally referred to as the day before (*pridie*) the kalends of the next month; for example, the last day of January is called the day before the kalends of February. The second-to-last day of the month is the third day before the kalends of the next month; thus January 30 would be referred to as the third day before the kalends of February. This pattern repeats up to the largest kalends for a month, found in the table above. Grosseteste does not give an example, but I will provide one for clarity's sake. February has nineteen kalends. January 31 is the day before the kalends of February, January 30 is the third day before the kalends of February, January 29 is the fourth day before the kalends of February, and so on up to January 14, which is the nineteenth day before the kalends of February.

The day after the kalends of a month, in other words, the second day of the month, is referred to as the highest number of nones of that month, and each subsequent day is one less until the second nones and the nones of a month are reached. Following that is the eight ides of a month, and the numbers likewise count down to the ides of the month. Again, Grosseteste does not give an example, but I will provide one. The first day of February, as stated above, is the kalends of February. The next day is the highest nones of the month. Referring to the table above, February has four nones, so February 2 is the fourth day before the nones of February, February 3 is the third day before the nones of February, February 4 is the second day before the nones of February, and February 5 is the nones of February. Every month has eight ides, and so February 6 is the eighth day before the ides of February, February 7 is the seventh day before the ides of February, February 8 is the sixth day before the ides of February, and so on to February 13, which is the ides of February. February 14 is then the largest kalends of March; referring to the table above, we see this is the sixteenth day before the kalends of March, and the cycle begins again. Thus are all the days of the year named.

4.3.3. Chapter Three of the *Compotus correctorius*

In the third chapter, Grosseteste discusses various cycles of time-keeping periods, as well as the cycle of concurrences. He begins with a somewhat confusing explanation of why there are 24 hours in each day. Just as the sun passes through twelve combinations of complexions and effects in a year as it moves through the zodiac, so too it passes through them each day and each night. The reason for this is unclear; hence the confusing nature of the passage. Grosseteste claims that the sun passes through all twelve during the day, and all twelve again during the night, thus leading to 24 natural divisions, and thus there are 24 hours in one day.

Regarding the number of days of the week, Grosseteste again introduces a somewhat tortuous explanation. He states that the Creator has arranged the cosmos such that the seven planets[90] give forth their virtues and forces (*virtutes et fortitudines*)[91] in each successive hour. Thus in one given day, three periods of the seven planets make up 21 hours, then the first three planets each have one hour, and the next day begins with the fourth planet. Say, then, that we begin one day with the sun; the next day will begin with the moon, as it is the fourth planet in sequence after the sun.[92] Continuing to the third day, the

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[90]Note that he does not name them here, but the order of the planets is discussed shortly hereafter.

[91]*Comp. corr.*, p. 222, ll. 32–3.

[92]To put it abstractly, the next day will always begin with the planet fourth in sequence after the planet on which the previous day began. See the next footnote for an explanation of how the sequence of planets is found.

first hour will be Mars, then Mercury, then Jupiter, then Venus, then Saturn.[93] Then, on the eighth day, the first hour returns to the Sun. Thus one week of seven days is the minimum amount of time to complete a cycle of hours and planets, which he points out is also equal to 168 hours, which is the least multiple of 7 and 24. The excellence of a period of seven days is further established because this is the time God took to create the world.[94]

Thus time is naturally divided into seven-day periods, called weeks (he notes two names for the week: *ebdomada* and *septimana*). He then discusses the relationship between the year and the week. We give each day of the week a 'ferial' letter, from A to G, in order to find cycles that allow us to determine on which day of the week each year begins, and thus also on which day of the week each month begins. In a non-bissextile year of 365 days, there are 52 weeks, plus one day. Thus if a given non-bissextile year begins with, say, letter A, the year will end with A, and the next year will begin with the subsequent letter, B. We can also calculate on which day of the week each month will begin in a non-bissextile year by remembering a cycle of 12 letters that naturally arises from the fixed length of each month. Again Grosseteste provides a verse to aid the memory:

> Altitonans dominus divina gerens bonus exstat
> Gratuito celi fert aurea dona fideli.[95]

There are twelve words, each one corresponding to a month; the first letter of each word

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[93]He states explicitly that the order of planets is from the moon to Jupiter and Saturn, with Mars in the fourth place from the moon; …*a Luna per Saturnum et Jovem est Mars quartus*, *Comp. corr.*, p. 223, ll. 7–8. Using the sequence of first hours that he gives (i.e. Mercury in the fourth place after Mars, Jupiter in the fourth place after Mercury, and so on), he must order the planets in the following sequence: Moon, Mercury, Venus, Sun, Mars, Jupiter, Saturn, which agrees with his scheme in the *De aeris*. Grosseteste, however, never states that this is the sequence of the planets; he leaves the reader to figure this out from the example, or assumes that the reader has this knowledge from another source.

[94]Excellencior tamen causa et hujus cause causa est creatio mundi et ejus complecio in septenario dierum numero. *Comp. corr.*, p. 223, ll. 19–20.

[95]*Comp. corr.*, p. 224, ll. 4–5.

gives the day of the week which begins that month.[96] January begins with day A (Altitonans), and thus February and March begin with day D (dominus and divina), and so on through November with D (dona) and December with F (fideli).

Matters become more complicated with the introduction of bissextile years. Because a bissextile year has one extra day, the first day of the subsequent January will jump forward two letters instead of one.[97] To return to the same letter for the first day of January requires that a whole extra week be accrued over the course of years. So, for example, if we begin with the year after a bissextile year, that year will accrue one extra day, the next a second day, the next a third, the next a fourth and fifth day (since it must be bissextile), the fifth year a sixth day, and the sixth year a seventh day, thus making a whole week. As we continue in this fashion, accounting for whole weeks, we find that a cycle of 28 years is necessary to return to our starting point, a January beginning with the same letter and following a leap year. This 28-year period is called the 'solar cycle' (*ciclus solaris*),[98] and begins in March rather than January, as it must begin after the bissextile month, the reason for which, Grosseteste writes, will appear below.[99]

Each month is assigned a 'regular' according to the day of the week on which the

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96Grosseteste uses this mechanism, similar to an acrostich, in many cases throughout the work.

97*Comp. corr.*, p. 224, l. 18. It is interesting to note that Grosseteste here does not explicitly state why a bissextile year will add two days, even though in many places he works out the mathematics behind his statements. For example, on p. 223, ll. 22–25, he writes, "it is clear that a non-bissextile year has fifty-two weeks and one extra day. For if 365 is divided by seven, fifty-two will fall out by division, and one will remain after division" (…*manifestum est quod annus non bissextilis habet ebdomadas quinquaginta duas, et insuper diem unum. Si enim 365 dividantur per 7, exibunt in divisione 52, et remanebit unitas post divisionem*).

98*Comp. corr.*, p. 225, l. 23.

99Incipit autem iste ciclus non a Januario set a Martio, quia oportet ut incipiat in mense proximo sequente mensem bissextilem, cujus ratio inferius patebit. *Comp. corr.*, p. 225, ll. 24–6.

first day of the month falls. The regulars can be figured by beginning from their values given from 'the first year of the foundation of the calendar.'[100] In that year, March began on the fifth day of the week, and so its regular is five. We also know that March corresponds to the ferial letter D, and so D corresponds to the fifth place during that year. Because we know the letters for each month, given in the verse above, we can know on what day of the week each month begins. For example, April's ferial letter is G; when D is five, we know that G corresponds to one, and so April has a regular of one. May's ferial letter is B, which, in this example, corresponds to three, and so May has the regular of three.[101] We can likewise find the regulars for each month of the year, which will be used below for another calculation. Again Grosseteste gives a verse for memorizing these numbers, listing the twelve numbers that correspond to the regulars for the months March through February.[102]

The question of the history of the compotus again enters into Grosseteste's discussion. In discussing how intercalary days affect the regulars, he argues for a 'superior' method that "agrees with nature and reason,"[103] because it is based on a calendar that has a beginning in time, namely, the creation of the world by God, of which the heathens did not know.[104] Grosseteste's method is to begin the cycle of concurrences,

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100…primo anno fundationis kalendarii, *Comp. corr.*, p. 225, l. 29.

101*Comp. corr.*, p. 225, ll. 30–36.

102*Comp. corr.*, p. 226, ll. 1-9 (the verse is on lines 8–9). The regulars for March through February are 5, 1, 3, 6, 1, 4, 7, 2, 5, 7, 3, 6.

103Et modus iste conveniens est nature et rationi, *Comp. corr.*, p. 226, l. 18.

104…kalendarium sumpsimus a gentilibus qui de principio seculi nichil noverunt, *Comp. corr.*, p. 226, ll. 26–27.

defined below, on the same year as the beginning of the calendar; the heathens, he states, without a knowledge of the beginning of the world, and because they begin the year in March and assume that the first year has a bissextile day, start their cycle of concurrences in the midst of the natural and superior cycle that he advocates. He thus labels their method the 'inferior' one.

There is also another reason why Grosseteste favors his own system. To be able to figure out the day of the week on which the first day of each month falls in a given year, that is, to find the 'solar regulars' (*regulares feriales*), one can add the number of 'concurrences' to the regular of each month. The concurrences are the numbers of days by which the calendar jumps forward each year.[105] The sum of the regular of a month and the concurrence, if seven or less, corresponds to the solar regular for that month, that is, the day of the week on which the month begins; if greater than seven, subtract seven and the remaining number corresponds to the first day of the week on which the month begins. By beginning the year in the January of the first year of the calendar, the cycle of concurrences begins with one, and so by adding one to the monthly regulars, we can find the day of the week on which falls the first day of the month. The next year adds two, and so forth. By the heathen's method, though, the year begins in March. When one moves the beginning of the year to January, as is the Christian custom, this corresponds to the twelfth year of the cycle of concurrences according to Grosseteste's superior method.

Realizing that this has been complicated, Grosseteste then includes a table with the following columns:[106] (superior method) Year, Dominical Letter, (inferior method) Year,

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105Due to the fact that the days of the week (seven) do not evenly divide the number of days in the year (365 or 366) as discussed above.

106The full table is produced in *Comp. corr*., pp. 228–229. Steele uses only the term *Anni* in the first and third column, though he also notes a textual variant which labels them as 'Secundum Garlandum' and 'Secundum Dionysium,' respectively. I have introduced the nomenclature of 'superior method' and

Concurrence, and Monthly Regulars for each month from March to February.[107] The third column has numbers one through twenty-eight, corresponding to the twenty-eight year solar cycle mentioned above. The fourth column has the concurrence for that year, beginning with one and proceeding through the series of adding one in non-bissextile year or two in each bissextile year, and subtracting seven when the number is larger than seven. Then each month of each year has its solar regular, which is the sum of its standard regular (which he includes in the table under each month in a row above the first year[108]) and the concurrence, with seven subtracted if the number is larger than seven. The solar regular, recall, gives the day of the week on which the first day of the month falls. I have reproduced the table in Table 6 on the next page.[109]

The first column corresponds to what Grosseteste referred to as the superior cycle, which corrects the heathen method of constructing the calendar without knowledge of the creation of the world. He explains this more fully in a subsequent section of the text, and so I will explain this below. The second column gives the dominical letter for each year. Up to this point, Grosseteste has not introduced the concept of the dominical letter.[110] In a leap

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'inferior method' to differentiate between the two cycles Grosseteste has discussed. The table in MS Brit. Mus. 27589 is on folio 84^{r}, and simply uses *Anni* as the label for the relevant columns.

107The year must run from March to February in order for the concurrences to progress correctly. In a bissextile year, the concurrence changes at the addition of the leap day, which occurs between the first days of February and March.

108The regular can also be known from the method given previously, namely using the ferial letters given in the verse *Altitonans dominus divina*…, and calculating from the first year of creation in which March began on the fifth day of the week.

109The table is on *Comp. corr.*, pp. 228–229, and in MS Brit. Mus. Add. 27589, folio 84^{r}. I have translated the Latin words, and have not preserved the abbreviations of the manuscript.

110It is curious that he deals with it in this fashion. Here he seems to assume that the reader will know what the dominical letter is, and yet later in the text he will explain that it corresponds in a certain way to the solar regular of March.

TABLE 6

YEARS, DOMINICAL LETTERS, CONCURRENCES, AND MONTHLY REGULARS

Year	Dom	Year	Con-	Mr	Ap	My	Jun	Jul	Au	Se	Oc	No	De	Ja	Fe
	Let		curr.	5	1	3	6	1	4	7	2	5	7	3	6
12	gf	1	1	6	2	4	7	2	5	1	3	6	1	4	7
13	e	2	2	7	3	5	1	3	6	2	4	7	2	5	1
14	d	3	3	1	4	6	2	4	7	3	5	1	3	6	2
15	c	4	4	2	5	7	3	5	1	4	6	2	4	7	3
16	ba	5	6	4	7	2	5	7	3	6	1	4	6	2	5
17	g	6	7	5	1	3	6	1	4	7	2	5	7	3	6
18	f	7	1	6	2	4	7	2	5	1	3	6	1	4	7
19	e	8	2	7	3	5	1	3	6	2	4	7	2	5	1
20	dc	9	4	2	5	7	3	5	1	4	6	2	4	7	3
21	b	10	5	3	6	1	4	6	2	5	7	3	5	1	4
22	a	11	6	4	7	2	5	7	3	6	1	4	6	2	5
23	g	12	7	5	1	3	6	1	4	7	2	5	7	3	6
24	fe	13	2	7	3	5	1	3	6	2	4	7	2	5	1
25	d	14	3	1	4	6	2	4	7	3	5	1	3	6	2
26	c	15	4	2	5	7	3	5	1	4	6	2	4	7	3
27	b	16	5	3	6	1	4	6	2	5	7	3	5	1	4
28	ag	17	7	5	1	3	6	1	4	7	2	5	7	3	6
1	f	18	1	6	2	4	7	2	5	1	3	6	1	4	7
2	e	19	2	7	3	5	1	3	6	2	4	7	2	5	1
3	d	20	3	1	4	6	2	4	7	3	5	1	3	6	2
4	cb	21	5	3	6	1	4	6	2	5	7	3	5	1	4
5	a	22	6	4	7	2	5	7	3	6	1	4	6	2	5
6	g	23	7	5	1	3	6	1	4	7	2	5	7	3	6
7	f	24	1	6	2	4	7	2	5	1	3	6	1	4	7
8	ed	25	3	1	4	6	2	4	7	3	5	1	3	6	2
9	c	26	4	2	5	7	3	5	1	4	6	2	4	7	3
10	b	27	5	3	6	1	4	6	2	5	7	3	5	1	4
11	a	28	6	4	7	2	5	7	3	6	1	4	6	2	5

year, there are two dominical letters, one for January and February, and the other for March though December. The number written to the right in the column, which is also the prior letter in alphabetical order, is the letter for March through December, while the subesquent letter is for January and February.

Let me now digress from Grosseteste's text to present an example that explains more clearly how the table works. In the first year of the solar cycle, the inferior method year is one and the concurrence is one. To find the solar regular, the first day of each week of a month, add the concurrence, in this case one, to the regular of the month. March's regular is five, so on the first year of the cycle, March begins on the sixth day of the week (regular five plus concurrence one). April's regular is one, so its solar regular that year is two (regular one plus concurrence one) and so it begins on the second day of the week. And so on through February with regular six, and solar regular seven (regular six plus concurrence one). Note that September and December both have regulars of seven, and so adding the concurrence of one gives a sum of eight; because this is greater than seven, seven is subtracted, leaving a solar regular of one.

Moving down the table, let us examine, as a further example, inferior method year seven. Because the first year was a leap year, the concurrences of the three subsequent years each increase by one, so by the fourth year of the cycle, the concurrence is four. The fifth year, however, is a bissextile, and so its concurrence increases by two, to six. The concurrence in each of the three subsequent years will increase by one, so year six has a concurrence of seven, and year seven has a concurrence of one (subtracting seven from eight, as any concurrence greater than seven must have seven subtracted from it). The months will have the same solar regulars, that is, will begin on the same day of the week as year one because the concurrence is again one.

As a final example, take the final year of the cycle, inferior method year twenty-eight. The concurrence is six, and so the solar regulars work out as expected: the regular plus six, minus seven when the sum is greater than seven. Moving to the next year, in other words, the first year of the inferior cycle, which is bissextile, the concurrence will jump by two, namely to eight, from which seven is subtracted to get one. This is the only place in the table in which the concurrence of one occurs on a leap year, and thus signals the beginning of a new cycle.

Let us now return to Grosseteste's text. He placed after the table instructions for using it. If one knows which year of the cycle one is in, one simply goes to the proper row and can find the dominical letter and the solar regulars for each month. If one does not know which year of the cycle one is in, one takes the current year of the incarnation and adds nine, because the first year of the incarnation was the tenth year of the cycle. Divide the sum by twenty-eight. If there is no remainder, the current year is the last year of the cycle, namely the twenty-eighth year; if there is a remainder, that is the year of the cycle.

Grosseteste also presents another method for finding the concurrence for a given year. Consider which day of the week is signified by the letter F in March. Because March's regular is five, any time the concurrence is one, the solar regular for March is six, which corresponds to the letter F. Looking at the table, we see that this occurs four times throughout the cycle, once on a bissextile year, and once on each of the first, second, and third years after a bissextile. This is also the dominical letter for that year.[111] The dominical letters thus correspond in a repeating fashion to the solar regular of March: when the concurrence is one, the solar regular of March is six and the dominical letter is F; when the concurrence is two, the solar regular of March is seven and the dominical letter is E, and so on. Once again Grosseteste gives a verse to remember the correspondences:

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[111]In a bissextile year, the dominical letter of March through December is F when the concurrence is one.

> Six makes A, and B has five, C four, and D
> makes three, and E two, F one, and G also seven.[112]

Thus we have a correspondence between the dominical letter and the concurrence of the year. Then, because the leap years and the concurrences follow a repeating pattern, one can deduce which year it is by knowing the solar regular of March and when a leap year has occurred. By knowing the first day of March, which is its solar regular, one can find the concurrence and hence the dominical letter. Then, by memorizing yet another verse, one can match the dominical letter to the proper year in relation to the cycle of leap years. This new verse has twenty-eight words, each beginning with the dominical letter for the corresponding year;[113] after each fourth word, there is a punctuation mark to note that it corresponds to a leap year. Matching up the dominical letter and its proper place in relation to a leap year before or after it, one thereby determines which year of the cycle one is in.

Grosseteste ends this chapter with an explanation of his superior method of constructing the cycle of concurrences. This cycle is essentially the same as the inferior method, in that it uses the same twenty-eight year cycle by which concurrences and leap years repeat. However, because time began with the creation, the first bissextile year will not occur until the fourth year.[114] Looking at the table, one can see that the year that follows a leap year and in which the concurrence is one, the first year of Grosseteste's superior method, corresponds to the eighteenth year of the inferior cycle, and so the first year of the

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[112]Sex habet A, B quinque tenet, C quator, et D/ Tres habet, E que duas, F unum, G quoque septem, *Comp. corr.*, p. 230, ll. 3–4.

[113]Fert. ea dux cor amat. gens factor enim coluit. bis/ Ars genus est. de corde bono gignit. ferus ensis/ Dicta beant. aqua gens fons dat. cunctis bonus auctor, *Comp. corr.*, p. 23, ll. 26–28.

[114]Grosseteste does not make this explicit, but I belive this gets to the core of his argument. He stated earlier that the first bissextile year did not come until the fourth year of the beginning of the calendar. If time begins with the first year, than the insertion of a leap year should not come until the fourth year, because the calendar has not lost a full day until that year.

inferior cycle corresponds to the twelfth year of the superior cycle.[115] To find the year according to the superior cycle, one again refers to the years since the Incarnation. In this case, however, the first year of this cycle occurred on the ninth year of the Incarnation, and so one must either subtract eight or add twenty to the current year, and divide by twenty-eight. As before, if the remainder is zero, the current year is the twenty-eighth year of the cycle; if the remainder is greater than zero, it is equal to the year of the cycle.

4.3.4. Chapter Four of the *Compotus correctorius*

Grosseteste moves on to a very different topic in the fourth chapter. He is now concerned with cycles of the moon, and the predictions of when the 'primation' (*primationes*), or the beginning of a lunar cycle,[116] occurs. He begins by discussing the two kinds of months: the solar, which are the months to which we give names and by which we divide the year, and the lunar, which are of a length given by the amount of time the moon takes to complete an equal lunation (*equalis lunatio*), that is, to return to the same position in relation to the sun after it has moved through its path.[117] The time it takes for this to happen, according to Ptolemy and Abrachis, is 29 days, 31 minutes, 50 seconds, 8 thirds, 9 fourths, and 20 fifths of a day. It is important for the reader to note that the minutes and seconds do *not* refer to the units of time that we might expect. Rather, the 31 minutes refers

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[115]Note, however, that although Grosseteste labels his own system as 'superior,' he arranges the table about the inferior method; that is, the first row of the solar regulars corresponds to the first year of the inferior method.

[116]Grosseteste notes in *Comp. corr.*, p.237, ll. 1–8, that the primation can be defined as the conjunction of the sun and moon, as the Arabs do it, or from the first day of visbility, or the second, or third. In other words, the moment of beginning of the lunar cycle, the primation, can be taken by whatever point one desires.

[117]Equalis autem lunationis est reditus lune ad solem secundum utriusque cursum medium, *Comp. corr.*, p. 232, ll. 7–9.

to 31 minutes 'of a day.' A minute of a day is equivalent to 1/60th of a day; thus the term is used similarly to the way we typically use minutes as 1/60th of an hour. In other words, there are 60 minutes of a day in one day, and so 31 minutes is equivalent to 31/60ths of a day, or .51667 of a day, or 12.4 hours, or 12 hours and 24 minutes (in this last case, the minutes are what we expect, 1/60th of an hour). Likewise, the 50 seconds of a day are equivalent to 50/3600ths of a day. I have preserved the terms minutes and seconds because of their similarity to the Latin terms (*minuta* and *secunda*).

Arzachel, Grosseteste states, used a value similar to that of Ptolemy and Abrachis when he constructed his tables. He made a lunar year equal to twelve lunar months and, according to the tables, Grosseteste states, this was set equal to 354 days plus a fifth and a sixth of a day, or twenty-two minutes of a day. Working this out, Grosseteste finds that the time of an equal lunation for Arzachel is 29 days, 31 minutes, and 50 seconds of a day. This is equivalent, Grosseteste states, to the value of Abrachis and Ptolemy, except that the thirds, fourths, and fifths are dropped because they are so small compared to the large value.[118] By using Arzachel's value, Grosseteste finds that the least number of days that reduces to an integral number of lunations is thirty Arab years,[119] or 360 whole lunations, which is equal to 10,631 days; the reason for calculating this value is to compare the Arab and Christian calendars, as we shall see below.

Grosseteste proceeds with an example. If a conjunction of the middle of the sun and moon occurs on a given day, over the meridian of Paris, the same conjunction will occur at

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[118]In modern decimal values, the figure given for Arzachel's tables is approximately 29.53055556 days, while the value given by Ptolemy and Abrachis is approximately 29.53059956, giving an error of approximately .00015%. Though Grosseteste of course does not use such an analysis, his conclusion that such a small amount will make little difference in practical application is correct.

[119]An Arab year is Arzachel's year of 12 equal lunations; Grosseteste will use this nomenclature frequently after this point.

that meridian again when 10,631 days have passed. He then runs through the calculation, showing that a lunation of 29 days, 31 minutes, and 50 seconds of a day makes 354 days and twenty-two minutes of a day. Multiplying 354 days by thirty gives 10,620 days, and multiplying twenty-two minutes of a day by thirty gives eleven days; thus in thirty Arab years, there are precisely 10,631 days. Grosseteste goes on to explain how the Arabs work intercalary days into their calendar. Each year is made up of twelve months, alternating between twenty-nine and thirty days, for a total of 354 days. This leaves over twenty-two minutes of a day, just as the Christian year leaves one-quarter of a day out of each non-bissextile year. When the extra time adds up to a whole day, the Arabs add an intercalary day to the final month of the year, making both the eleventh and twelfth month be thirty days, and that bissextile year 355 days long.

Now because thirty Arab years have a whole number of equal lunations, 360, and a whole number of days, 10,631, this is a true cycle of lunations. That is, after thirty Arab years, the cycle of lunations will repeat itself. This reveals the error in the nineteen-year cycle that the Christian Church uses, because nineteen Christian[120] years are not equal to thirty Arab years, nor are they even multiples or fractions of each other. Again, Grosseteste explains this at some length. In nineteen years, if the first three years are not bissextile, there are 6,939 days. In nineteen years, there are 235 lunations, twelve in each year plus seven lunar embolisms.[121] Using the value of 29 days, 31 minutes, and 50 seconds of a day for a

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120Grosseteste refers to them as ‘our’ years. I have adopted the term ‘Christian’ years to differentiate it from the Arab years.

121Grosseteste is again assuming the reader has some basic knowledge of the calendar, because he does not explain what lunar embolisms are, nor why there are seven of them in the nineteen year cycle. He will discuss them at greater length in later chapters, but introduces the term here without definition. For the benefit of the reader: embolisms are extra lunar months that keep the lunar and solar calendars corollated with one another. In nineteen years, there are 228 lunar months (twelve per year), but the moon passes through its phases approximately 235 times; thus seven extra lunar months, or embolisms, are inserted over the course of nineteen years to keep the calendars more closely aligned.

lunation, 235 lunations work out to 6,939 days plus 40 minutes and 50 seconds of a day, which is more than two-thirds of a day. Thus at the end of a nineteen-year cycle of 6,939 days, the final lunation will not be complete until 40 minutes and 50 seconds of the next day have passed. If any one of the first three years in the ninteen-year cycle is bissextile, then there will be five bissextile days, for a total of 6,940 days in that cycle, which is too large by 19 minutes and 10 seconds of day, or about one-third of a day.

If instead we use the seventy-six year cycle, made up of four nineteen-year cycles, we find that there will always be the same number of days: 27,759. Three of those nineteen-year cycles will be over whole lunations by 19 minutes and 10 seconds of day each, for a total of 57 minutes and 30 seconds. The other ninteen-year cycle will be short of a whole lunation by 40 minutes and 50 seconds of a day. This still leaves 16 minutes and 40 seconds of a day too much; that is, in seventy-six years, there will be 940 whole lunations (that is, 235 times four), plus an extra 16 minutes and 40 seconds of a day. If we take four of these seventy-six year cycles, we find that after 304 years, 3,760 whole lunations will be completed, plus 1 day, 6 minutes and 40 seconds of a day. At the end of 304 years, the new moon will thus be over one day older than expected. After 4,256 years (or fourteen seventy-six year cycles), the full moon will fall on the day that a new moon is expected.

Grosseteste then deals briefly with the more precise value of a lunation given by Ptolemy, namely, with thirds, fourth, and fifths present. Computing the error accruing after 304 years, he finds the value to be fifty-eight minutes, eight seconds, four thirds, forty-six fifths, and forty fifths of a day, which is only slightly smaller than the value of one day, six minutes and forty seconds of day found with Arzahcel's value.

Grosseteste suggests that some might object, saying that the seventy-six year cycle produces an integral number of whole lunations,[122] which would imply that Ptolemy's and Arzachel's values are incorrect. If this were true, then the tables Ptolemy and Arzachel produced should show errors in the times of eclipses. But, states Grosseteste, we do not find any appreciable errors in the observed hours of the eclipses based on their tables.[123] He then continues his analysis of the errors of the Christian calendar. The overabundance of lunations after 304 years is 1 day, 6 minutes, and 40 seconds of a day. If that number if divided into a whole lunation of 29 days, 31 minutes, and 50 seconds, the result is 26, with a remainder of 37 minutes and 55 seconds. If we multiply 304 years by 26, we get 7,904 years, which is equivalent to 97,760 whole lunations. But according to the values used by Arzachel and what Grosseteste calls "true astronomy,"[124] that time will be 37 minutes and 55 seconds short of 97,761 whole lunations, rather than a whole number of lunations.

To coordinate the two systems would take a huge expanse of time. The Arab system has a whole number of lunations in 10,631 days, or thirty Arab years. In the Christian system, the shortest cycle of whole days is the seventy-six year cycle, which contains 27,759 days.[125] To reduce one of those to the other,[126] that is, to find a common multiple, the two are multiplied together to produce 832,770 whole Arab years and 807,956 Christian years. Now the Christian calendar assumes 940 lunations are completed in seventy-six years; if

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[122]This is, of course, an assumption of the Christian calendar, that an integral number of lunations are present in the cycles used by the Church.

[123]…ipse tabule non mentiuntur nobis in aliquo sensibili de horis eclipsium, *Comp. corr.*, p. 235, l. 30.

[124]…veritatem astronomicam, *Comp. corr.*, p. 236, l. 2.

[125]Because the ninteen-year cycles can have different numbers of bissextile years, either five or four. Only when four sequential cycles are placed together will one always have the correct number of days.

[126]…reducit simul ad unum, *Comp. corr.*, p. 236, l. 19.

that is multiplied by 10,631 days, or thirty Arab years, the number of lunations becomes 9,993,140. But if one multiplies the 360 lunations of thrity Arab years by 27,759 days, or seventy-six Christian years, one gets 9,993,240 lunations, so 100 greater than the previous calculation.

This, Grosseteste concludes, makes it quite clear that there is an error in the Christian computation of lunations, and therefore the times of primation are incorrect. Thus the cycle of epacts[127] by which one finds the age of the moon at the beginning of a month are also in error. If one wishes to know the day of primation according to "astronomical truth,"[128] then one need only know the Arab months. The Arab month begins with the conjunction of the sun and moon; if one can convert from this date to the Christian date, one can know the age of the moon at any given time. If one chooses as primation the first visibility of the moon, one simply takes the second day of the Arab month; if primation is the second day of visibility, then use the third day of the Arab month, and so on .[129] For this reason, we need to know how Christian years can be converted to Arab years, and this will be the topic of the next chapter.

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[127]This is another example of where Grosseteste assumes his reader controls calendrical vocabulary, as the epact cycle has not been defined. As with the case of 'lunar embolism,' he will return to the topic in a later part of the work, but here it has been introduced without a definition. For the benefit of the reader: the epact cycle is concerned with the days by which the solar year is longer than a whole number of lunations (e.g., one year of 365 days is eleven days longer than the 354 days of twelve lunations). The epacts also determine when lunar embolisms are inserted into the calendar; this will be discussed fully in a later portion of the text.

[128]Possumus autem cognoscere semper diem primationis secundum veritatem astronomicam, *Comp. corr.*, p. 237, ll. 1–2.

[129]*Comp. corr.*, p. 237, ll. 1–13.

4.3.5. Chapter Five of the *Compotus correctorius*

Grosseteste gives two methods for calculating the Arab year from the Christian year. The first is a mathematical calculation. Take the current year of the Lord, and subtract 621, the number of years after Christ on which the Arab calendar began. Multiply the difference by 365, add to the sum one-fourth of the original difference (in other words, the current year of the Lord minus 621), then take away 195, and add the number of days that have passed in the current year of the Lord; this will give the number of days that have passed since the beginning of the Arab calendar.[130] Multiply this value by thirty, and divide by 10,631; this will give the number of complete Arab years that have passed. Divide the remainder by thirty, and this leaves the number of days of the current Arab year. Subtract the number of days for complete months, alternating between thirty and twenty-nine days. Whatever remains[131] gives the days of the current month.[132]

Grosseteste then notes that Arzachel made tables and wrote explanations of them that allowed one to find Arab, Persian, Greek, Spanish, Egyptian, and Christian years, each from the other.[133] Using these table, Grosseteste states, he has made tables to find the Arab year and month from the Christian. He also explictly notes at this point that this will allow

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[130]Grosseteste does not explain why this formula works. The addition of one-fourth of the years is to account for bissextile days, and the 195 days account for the first Arab year starting in the midst of the Christian year.

[131]In other words, a number less than the next month in sequence, either thirty or twenty-nine days.

[132]Grosseteste does not state explicitly that the days of the month are of the Arab month, and hence are the same as the number of days since the conjunction of the sun and moon. He also does not note what to do with the fractions that can appear during the calculation.

[133]Posuit etiam Arzachel tabulas et doctrinam tabularum ad extrahendos annos Arabum, et annos Persarum, et annos Grecorum, et annos Hisspanencium, et annos Egipciorum, et annos Domini quoslibet ex quibuslibet, *Comp. corr.*, p. 237, l. 35–p. 238, l. 2.

one to find the true primations.[134] The tables are contained in Tables 7 and 8 below.[135]

To convert from Christian years to Arab years, note the current year, month, and day. Next, from the current, unfinished year, figure out the number of thirty-day months that have passed; that is, take the number of days of the present month, add one day for each

TABLE 7

THE ARABIC MONTHS OF THE YEAR

Lunar Months	Months	Days
Almuarum	1	0
Saphar	1	29
First Rabe	2	29
Second Rabe	3	28
First Gunedi	4	28
Second Gunedi	5	27
Rageb	6	27
Saabe	7	26
Ramadan	8	26
Scarihol	9	25
Dulcada	10	24
Dulhega	11	24

[134]…per annos et menses Arabum extractos habeamus veram cognitionem primationum, *Comp. corr.*, p. 238, ll. 3–5. It is curious that he notes this before he begins the explanation of the tables, but not before he gave the mathematical formula for figuring the primation. This might imply he considered the tables to be more accurate, or he may have assumed that his reader would use the tables rather than the mathematical formulation.

[135]The tables are on *Comp. corr.*, p. 239, and in MS Brit. Mus. Add. 27589, folio 88^{v} in the second column, extending into the upper and lower margins. The tables of MS Brit. Mus. Add. 27589 do not have the labels that Steele provides in square brackets; he notes they are from a different manuscript. In MS Brit. Mus. Add. 27589, the two tables are placed next to each other. I have translated the Latin words, and have not preserved the abbreviations of the manuscript.

month of thirty-one days that have passed in that year, subtract one or two days for February (if it was bissextile or non-bissextile, respectively), and thus one will know the number of thirty day months and the remaining number of days that have passed. Then, referring to Table 7,[136] find the entry for the Christian month and day that is less than the total just found, and subtract that amount from the total; this will give an amount that is left over after a complete Arab year, and thus what is left over from the completion of a lunation.

The difference that was just calculated is then used in Table 8.[137] As with the first table, find the Christian year, month, and day that is less than the difference calculated. The first column of this line will give the number of Arab years that have passed from the year given in the first table, while the difference between the previous amount and the amount given in the table for Christian years, gives the amount of time that has passed since that Arab year was complete. This will work out to a certain number of months and days. This value is then used in the latter portion of the table, again finding the amount that is less than the previously calculated difference; on this line, one finds the completed Arab month, and subtracting the months and days given for the respective Christian year leaves one with the number of days by which the current time is within an Arab month. Thus from the current Christian year, month and day, one has found the current Arab year, month and day;[138] the

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136*Comp. corr.*, p. 239.

137*Comp. corr.*, p. 239.

138One curious feature here is that Grosseteste has given the names of the Arab months in the tables. To find the age of the moon, the names are not strictly necessary, as one could simply serially subtract thirty and twenty-nine days from the calculated number of days until a number less than the next month is reached, if the only goal were to find the age of the moon. That Grosseteste includes a means to find the Arab year, month and day, both in the table and in his instructions, reinforces the notion that he finds the cultural nature of the calendar to be significant; that is, he wants not only to reach the practical goal of finding the age of the moon, he also preserves the foreign calendrical information.

day is thus the number of days that have passed since the conjunction of the sun and moon, because that always falls on the first day of the Arab month, and therefore one knows the age of the moon. The tables end the chapter.

TABLE 8

THE EXPANSION OF ARABIC YEARS

Arab Years	AD Years	Mon.	Days	Frac-tions
600	1203	7	29	2
630	1232	9	8	1
660	1261	10	17	0
690	1290	11	27	2

Arab Years Exp.	AD Years Exp.	Mon.	Days	Frac-tions
1	0	11	24	0
2 b’	1	11	23	3
3	2	11	2	2
4	3	10	21	1
5 b’	4	10	11	0
6	5	9	29	3
7 b’	6	9	19	2
8	7	9	8	1
9	8	8	28	0
10 b’	9	8	16	3
11	10	8	5	2

Arab Years Exp.	AD Years Exp.	Mon.	Days	Frac-tions
12	11	7	29	1
13 b’	12	7	14	0
14	13	7	2	3
15	14	6	21	2
16 b’	15	6	11	1
17	16	6	0	0
18 b’	17	5	19	3
19	18	5	8	2
20	19	4	28	1
21 b’	20	4	18	0
22	21	4	5	3
23	22	4	24	2
24 b’	23	3	14	1
25	24	3	3	0
26 b’	25	2	22	3
27	26	2	11	2
28	27	2	0	1
29 b’	28	1	20	0
30	29	1	8	3

4.3.6. Chapter Six of the *Compotus correctorius*

Grosseteste, in a very brief chapter six, argues that one need not differentiate between the length of a true lunation and an equal lunation. He has previously been dealing with equal lunations, or the length of time used for a lunation in the construction of the calendar, Arzachel's value of 29 days, 31 minutes, and 50 seconds. The true lunation, however, is the length of time for the actual conjunction of the sun and moon, literally, when the moon returns to the sun after following its actual path.[139] This value, because the true sun and true moon do not move uniformly, is not equal from one true lunation to the next; sometimes it is more than the equal lunation, and sometimes less. According to the *Almagest*, he states, whenever 251 lunations are complete, 251 true lunations have also passed.[140] Grosseteste claims that any discrepancy between the true and equal lunations will disappear over time, even though from one lunation to the next the difference might be noticeable. In any event, the process of measuring that difference would take too long and be too laborious for those engaged in the art of compotus. Finding the exact time of the true lunation, he leaves for those who can find the places of all the stars from the times given in astronomical tables.[141]

139…tempus lunationis vere, id est, tempus reditus lune ad solem secundum utriusque cursum verum, *Comp. corr*., p. 240, ll. 4–5.

140Quelibet tamen 251 lunationes equales adequantur precise quibuslibet 251 lunationes veris, sicut ostensum est in libro *Almagesti*, *Comp. corr*., p. 240, ll. 7-9. See Book 4, chapter 2 of the *Almagest* for Ptolemy's discussion of the period of the moon. In Toomer's translation, see pp. 174–176.

141Investigatio autem deffiniti temporis cujusque lunationis vere relinquenda est illis qui loca stellarum omnium ad data tempora per tabulas astronomicas inveniunt. *Comp. corr*., p. 240, ll. 21–24.

4.3.7. Chapter Seven of the *Compotus correctorius*

After this brief chapter, Grosseteste moves on to the seventh chapter. The topic of this chapter is the way in which lunations are dealt with in the calendar, including the number of lunations, where they should be placed, and the formation of epacts and lunar regulars. He begins by stating the premise that the calendar is false regarding the nineteen-year cycle and the cycle of epacts. Because this cycle is used by the Church, he will examine the roots of the problem.

If we assume, as did those who first set down the Christian calendar, that seventy-six years completes a whole number of equal lunations, namely 940, we would find that the length of an equal lunation is 29 days, and 31 minutes, 51 seconds, 3 thirds, 44 fourths, 47 fifths, 14 sixths, and 2 sevenths of a day.[142] This is greater than the length given by Arzachel by 1 second, 3 thirds, 49 fourths, 47 fifths, 14 sixths, and 2 sevenths of a day. The errors of using a value different from Arzachel's have already been stated in a previous chapter, he reminds the reader, but he continues on to show the error more clearly. In nineteen years, 235 lunations pass. Using the value given above, 235 lunations equates to 6,939 days, 44 minutes, 59 seconds, 59 thirds, 59 fourths, 59 fifths, 57 sixths, and 50 sevenths. He then notes that all of those minutes, seconds, thirds, and so forth, are different from forty-five minutes by only 2 sixths and 10 sevenths; this amount is so small that even over a long period no difference will be seen, and so he will use the value of 6,939 days and 45 minutes for the length of 235 lunations.

Now when nineteen years include four bissextile days, they have 6,939 days, and thus are too short by forty-five minutes. But anytime there is a nineteen-year cycle with four bissextile days, it is followed by three cycles with five bissextile days, and thus with 6,940

[142] Recall that the minutes, seconds, etc. are of a day. That is, 29 days, 31 minutes is a little more than 29.5 days.

days each. This amount is too long by fifteen minutes for each cycle, and thus over the course of seventy-six years, the lunations come out precisely equal: seventy-six years is exactly 940 lunations.[143] He then notes that this is the only possible quantity for an equal lunation if one assumes 940 lunations in seventy-six years, because dividing the numner of days in seventy-six years by 940 lunations again gives that value of 29 days, 31 minutes, 51 seconds, 3 thirds, 44 fourths, 47 fifths, 14 sixths, and 2 sevenths for an equal lunation.[144]

To place lunations into the calendar, one assumes that lunations alternate between thirty and twenty-nine days. This leaves out a small amount of time, as the length of the lunation is slightly more than 29 days and 30 minutes, but this small amount will be added back into the calendar when it begins to make a sensible difference. It will be added back by adding a day, and thus having two thirty-day lunations in a row, or by inserting a lunar embolism, the rules for which he will give below. Twelve lunations alternating between thirty and twenty-nine days account for 354 days, which falls short of a non-bissextile year by eleven days. In a given year, there are twelve lunations, and each lunation is said to belong to the month in which it ends.[145] When an extra lunation is added into a calendar, because of the extra days that each year has, it will cause two lunations to end in the same month; the additional lunation is called an embolism.

The extra days that remain at the end of the year are called the ‘epact’ of the next year; this increases by eleven each year, until a sufficient amount of time has accumulated to

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143This is no surprise, as the value he calculated for the equal lunation was based on this equality; he had not explicitly stated how he arrived at that value, but this calculation shows it to be correct based on the premise that seventy-six years have exactly 940 lunations.

144He has thus shown that the value can be determined in either direction, from the assumed length of the equal lunation or from the assumed number of days and lunations in seventy-six years.

145He gives a verse to remember this rule: “The moon is given to the month to which it is joined at its end.” *Mensi luna datur cui fine suo sociatur*, *Comp. corr.*, p. 243, l. 10.

insert a lunar embolism. Because the eleven days were extra days of a lunation, eleven days is also the amount by which the age of the moon is older on a given day of the year than it was in the previous year. Grosseteste notes specifically that the age of the moon at the beginning of a month is eleven days days more than it was at the beginning of that month in the previous year.[146] Let us now go through an example that is not in Grosseteste's text to be sure this is clear. Say that in a given year, the age of the moon on the first day of June is one. The epact of the next year is eleven, and so on the first day of June in the second year, the moon will be twelve days old.

Grosseteste then defines the 'lunar regular.' The lunar regular is the age of the moon on the first day of the month on the first year of creation. Thus each month has its own unchanging, lunar regular. Now the epact cycle begins in September, and we know that the age of the moon on the first day of September on the first year of creation was five. Thus the lunar regular of September is five. From this can be found the lunar regulars of each month in the following manner. Add the lunar regular (the age of the moon on the first day of the month) to the number of days in September. Subtract from this sum the lunation of September, and the difference gives the lunar regular for the next month. Proceeding through all the months, Grosseteste finds the following regulars: October's lunar regular is 5, November's is 7, December's is 7, January's is 9, February's is 10, March's is 9, April's is 10, May's is 11, June's is 12, July's is 13, and August's is 14. Again he gives a verse to remember these values:

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[146]Et per eosdem undecim dies etiam majoratur etas lune in principio cujusque mensis sequentis anni super etatem suam in principio cujusque mensis prioris anni. Comp. *corr.*, p. 243, ll. 15–17.

> Five is given to September and October, to November and December seven, three threes to January and March,
> February and April have 10, add one to each of the next.[147]

He also gives another verse in which the first letter of each of the twelve words corresponds to the lunar regular of each month, from September to August.[148] Now the lunation for each month alternates between thirty and twenty-nine days. For odd months, the first, third, and so on, the lunation is thirty days; and for even months, the second, fourth, and so on, the lunation is twenty-nine days. Again he gives a verse for remembering this.[149]

Grosseteste next moves on to the issue of calculating subsequent epacts. In the second year, eleven days will again accrue, making the epact for the third year twenty-two. He also notes that bissextile years will not increase the epact by an extra day; instead, the second lunation of the year will simply be made thirty days instead of the expected twenty-nine days. Thus, while the year will have one extra day, so will the twelve lunations, and only eleven days will accrue to the epact even in bissextile years. In the third year, another eleven days accrue, giving an epact of thirty-three. However, since this number is greater than thirty, an extra lunation, an embolism, is inserted into the third year, and thirty days are taken away from the accrued days, leaving an epact of three for the fourth year. He will discuss later where the embolism will be inserted.

Grosseteste then runs serially through each year. The epact for the fifth year, after eleven days accrue in the fourth year, is fourteen. In the sixth year, it is twenty-five. During the sixth year, the extra eleven days bring the total to thirty-six, so an embolism is added in

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147 Quinque Sep. Oc. dantur: No. De. septem, ter tria Ja. Mar./ Feb A. decem, sumant: Post unum cuilibet addas. *Comp. corr.*, p. 243, ll. 38–39.

148 Estuat esuriit gramen gravat igne kalendas; Igne kalendarum liquet mihi nominis ordo. *Comp. corr.*, p. 244, ll. 2–3. The fifth letter of the alphabet is ‘E’, and so September’s and October’s regulars are five, and so on through ‘O,’ the fourteenth letter, for August.

149 Inpar luna pare, par fiet in inpare mense. *Comp. corr.*, p. 244, l. 13.

the sixth year, and the epact for the seventh year is six. This leads to an epact for the eighth year of seventeen. Adding the eleven extra days gives an epact of twenty-eight days for the ninth year, but the pattern is here disrupted. Two days are "borrowed" from the ninth year, and a lunar embolism is added to the eighth year. Adding eleven to the epact of the ninth year gives a total of thirty-nine, but thirty of those days were used for the embolism of the eighth year, and so the epact of the tenth year is nine. In the eleventh year, the epact is twenty; eleven more days accrue during that year, giving a total of thirty-one, of which thirty are used to make an embolism in the eleventh year, leaving for the twelfth year an epact of one. In the thirteenth year, the epact is twelve, and in the fourteenth year, the epact is twenty-three. Adding the eleven days in the fourteenth year gives a toal of thrity-four, of which thirty are taken for an embolism in the fourteenth year, and the epact for the fifteenth year is four. In the sixteenth year, the epact is fifteen, and in the seventeenth year, the epact is twenty-six. During the seventeenth year, eleven days accrue, and an embolism is added, leaving an epact for the eighteenth year of seven. This leads to an epact of eighteen for the nineteenth year. In that final year of the cycle, eleven more days accrue, for a total of twenty-nine days. In that year, one day is borrowed from the lunation of July, making its lunation only twenty-nine days instead of the usual thirty.[150] Then in the nineteenth year, an embolism of thirty days is added, leaving an epact of zero for the next year, at which point the cycle repeats.

The cycle of epacts is nineteen years, as is the cycle of primations,[151] because the

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[150]Because it is an odd month, it normally has a lunation of thirty days, as we know from the rule previously given.

[151]Recall that the cycle of primations has to do with the age of the moon; the primation is defined as the beginning of the moon's month (either as a new moon, first appearance or some other chosen day—Grosseteste does not favor one in particular). Thus the epact is relevant to knowing the age of the moon at any given time.

primation can be calculated from the epacts and lunar regulars; the lunar regulars stay constant, and so the cycle of epacts will also be the cycle of primations. One difference, however, is that the cycle of primations is understood to run with the solar year, that is, beginning in January. The epact cycle, though, is begun in the September preceeding the January in which the primation cycle begins. This will be relevant when Grosseteste covers the rules for placing the embolism within the calendar.

Grosseteste next summarizes some of the information he has just covered. In nineteen years, there are seven embolismic years, that is, years to which a lunar embolism of thirty days is added, namely, the third, sixth, eighth, eleventh, fourteenth, seventeenth, and nineteenth years. The nineteen-year cycle is divided into the *ogdoad*, the first eight years, of which three are embolismic, and the *endecad*, the final eleven years, in which four are embolismic. Yet again Grosseteste gives a verse by which to remember which years are embolismic.[152] He also gives a verse for remembering the epact of each year,

> What the moon has on the eleventh kalends of April
> Shows the number of the epact for any year.[153]

In this case, however, the verse does not remind the reader of each subsequent epact. Instead, one has to remember a certain amount of information. On the first year of the cycle, by definition the moon is thirty days old on the eleventh kalends of April. In the second year, it will thus be eleven[154] on that day. If one performs the subsequent calculations,

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[152]Cristus factus homo levat omnia reddita trono. *Comp. corr.*, p. 246, l. 16. The first letter of each word corresponds to an embolismic year: the third year is represented by ‘C,’ the third letter of the alphabet, through the nineteenth year represented by ‘T.’

[153]Que tenet undenas Aprilis luna kalendas/ Epacte numerum monstrat per quemlibet annum. *Comp. corr.*, p. 246, ll. 21–22.

[154]Because eleven days accrue in the first year.

Grosseteste states, then one can find the epact for each year.[155] To do so requires that one know for which year of the nineteen-year cycle one wants to know the epact. To find this out, add one to the year of the Lord in question, and divide the sum by nineteen. If there is no remainder, that year is the nineteenth year of the cycle. If there is a remainder, that gives the year of the cycle of epacts, recalling that the year of the epacts begins in the preceding September.

Grosseteste ends the chapter by reminding the reader why this is useful information. By adding the epact and the lunar regular, one can find the age of the moon at the beginning of the month. If the sum is less than thirty, it is the age of the moon. If it is greater than thirty, subtract thirty and the difference is the age of the moon. Errors in this method can crop up because of the fact that the actual length of the lunation is twenty-nine and one half days, whereas the luantions of the calendar are always twenty-nine or thirty days. The exceptions to the rule of epacts and lunar regulars, as well as the placement of the lunar embolisms in embolismic years are the topics of the next chapter.

4.3.8. Chapter Eight of the *Compotus correctorius*

A basic assumption of the calendar, as previously stated, was that an equal lunation was more than twenty-nine and one half days by 1 minute, 51 seconds, 3 thirds, 49 fourths, 47 fifths, 14 sixths, and 2 sevenths of a day. When two subsequent lunations of thirty and twenty-nine days pass, twice that amount is left over. At the end of twelve lunations, of which six are thirty days long and six are twenty-nine days long, the extra amount is twelve times the original amount, or 22 minutes, 12 seconds, 49 thirds, 57 fourths, 26 fifths, 48

155This mnemonic device is fundamentally different than most of the other examples. In many of them, numbers are drawn directly from the verse, for example from a letter's position in the alphabet. In this case, though, the calculation must be performed from the first year to the year in question, so the device does little more than remind the reader that the relevant number for calculating epacts is eleven, the number of days that accrue each year. The verse also does not aid in remembering the exceptions to the pattern in the eighth and nineteenth years.

sixths, and 24 sevenths of a day. Grosseteste calls the lunations of alternating thirty and twenty-nine days 'common lunations.'[156] In nineteen years, there are 228 of these lunations, leaving an extra amount of 7 days, 2 minutes, 2 seconds, 33 thirds, 11 fourths, 29 fifths, 19 sixths, and 36 sevenths left over after that time. However, as stated in the previous chapter, one day was removed from the lunation of July to make the lunar embolism in that year thirty days, leaving the lunation of July to be twenty-nine days. This subtraction of a day from July and the addition of the day to the lunar embolism is called the *saltus lune*, the 'leap of the moon.'[157]

In the nineteenth year, then, we can say that there were twelve common lunations and a lunar embolism of twenty-nine days. The embolism is thus shorter than an equal lunation by 31 minutes, 51 seconds, 3 thirds, 49 fourths, 47 fifths, 14 sixths, and 2 sevenths of a day. Adding this amount to the previous amount found to be left over after 228 common lunations gives a total of 7 days, 33 minutes, 53 seconds, 37 thirds, 1 fourth, 16 fifths, 33 sixths, and 38 sevenths left over after 229 lunations (228 common lunations and an embolism of twenty-nine days).

There are also an additional six lunar embolisms in each ninteeen-year cycle. Because each of them is thirty days long, they are longer than an equal lunation by 28 minutes, 8 seconds, 56 thirds, 10 fourths, 12 fifths, 45 sixths, and 58 seveneths of a day. Six times this amount comes out to 2 days, 48 minutes, 53 seconds, 37 thirds, 1 fourth, 16 fifths, 35 sixths, and 48 sevenths. Subtracting this amount from the previous shortcoming leaves an extra 4 days, 44 minutes, 59 seconds, 59 thirds, 59 fourths, 59 fifths, 57 sixths, and 50 sevenths. This is essentially 4 days and 45 minutes because there is no sensible difference

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[156]…tale lunationes voco lunationes communes, *Comp. corr.*, p. 247, l. 32.

[157]Et hec subtractio unius diei de lunatione Julii et additio ejusdem diei lunationi embolismali vocatur 'saltus lune.' *Comp. corr.*, p. 248, ll. 5–7.

between them.[158]

The calculation so far has left out bissextile days. As stated previously, in a bissextile year, the extra day is simply added to the lunation of February; this leads to an extra day compared to common lunations. In a nineteen-year cycle with four bissextile years, four extra days are added during the 235 lunations (228 common lunations, six thirty-day lunations, and one twenty-nine day lunation), leaving an extra time of only forty-five minutes. Then, in each of the next three nineteen-year cycles, there are five bissextile years. In each of those cycles, the five extra days account not only for the 4 days and 45 minutes, but also add an extra fifteen minutes to each cycle. These three lengths of fifteen minutes cancel out precisely the extra forty-five minutes left over from the other nineteen-year cycle in the seventy-six-year cycle, and thus the 940 lunations in the calendar of the seventy-six years are exactly equal to the 940 equal lunations that occur in that time.[159]

Grosseteste then moves on to the rules for placing the lunar embolisms into the calendar. The first comes in the third year of the cycle of epacts, and is begun on the fourth nones of December and ends on the last day of December. Because the epact cycle begins in the prior September of the nineteen-year cycle, this embolism is actually within the second year of the nineteen-year cycle. The placement of this lunar embolism leads to two consecutive thirty-day lunations, namely, the embolism and the lunation of the subsequent January.[160] If the third year of the nineteen-year cycle happens to be a bissextile year, this

158…quia non differunt ab illis in aliquo sensibili. *Comp. corr.*, p. 248, l. 34.

159Again this is not surprising, given that the length of the lunation was figured from the assumption that 940 lunations are completed in precisely seventy-six years, and the calculations from this eighth chapter use the length of an equal lunation found from that assumption, namely, 29 days, 31 minutes, 51 seconds, 3 thirds, 49 fourths, 47 fifths, 14 sixths, and 2 sevenths.

160Grosseteste does not note this, but the previous lunation was of December, because it ended on the first day of December (the day before the fourth nones of December), and was thus of twenty-nine days.

will lead to four consecutive thirty-day lunations, the two just mentioned, plus the subsequent February (normally a twenty-nine day lunation, but made thirty with the bissextile day), and March lunations. In all cases, as we shall see, Grosseteste explicitly points out when thirty-day lunations follow each other, presumably because these will be exceptions to the rule of typical common lunations, which consist of subsequent thirty- and twenty-nine-day lunations.

The second lunar embolism begins on the fourth nones of September and ends on the kalends of October in the sixth year of the epact cycle, the fifth year of the nineteen-year cycle. Again, there are two consecutive lunations of thirty days, that of September and the embolism. The third embolism begins the day before the nones of March and ends on the day before the nones of April in the eighth year. Grosseteste notes explicitly that this is the eighth year of both the epact and nineteen-year cycles, as the periods from January through the beginning of September of a given year are the same in each cycle, while September through December occur in the year of the epact cycle that is one greater than that of the nineteen-year cycle. There are again two consecutive thirty-day lunations in the eighth year, namely, that of March and the embolism; if the year is bissextile, there will be four consecutive thirty-day lunations, those of January, February, March and the embolism. In that year, a set of exceptions to a normal rule occurs. A lunation is said to be of a month if it ends in that month. Given the placement of the embolism in the eighth year, however, the lunation for April, the lunation that must follow the embolism that followed the lunation of March, ends on the fifth nones of May, the lunation of May ends on the fourth nones of June, and the lunation of June ends on the kalends of July. In subsequent months, the rule is again followed, with the lunation of July ending in July, and so forth. This shifting of dates also causes another rule to be suspended, namely, the age of the moon at the beginning of the month cannot be found from the rule of adding the epact of the year to the regular of the month during the months May, June, and July. He adds a verse that will aid the reader to remember this, though the verse serves only to remind that the rule will fail in those months, but does not give the necessary correction.[161]

The fourth embolism occurs in the eleventh year of both cycles, begins on the third nones of January, and ends on the kalends of February. In this year, both the lunations of January and the embolism are thirty days, and, if the year is bissextile, the subsequent lunations of February and March will be thirty as well. The lunation of February ends on the sixth nones of March, and the lunation of March ends on the kalends of April. The rule for finding the age of the moon from adding the epact and the monthly regular fails for March, unless it is a leap year, in which case the rule holds.[162] Grosseteste gives a verse for remembering the exception to the rule, as well as for the exception to the exception, "Unless it is bissextile, the first fails in March in the eleventh year."[163] He also explains that the rule for finding the age of the moon on the first of March will fail when the lunation for March begins before the bissextile day is added, because if the bissextile days falls within the lunation of March, a thirty-day lunation, that lunation effectively becomes too long—thirty-one days—and so the rule fails.

The fifth embolism lasts from the fourth nones of November to the kalends of December, in the fourteenth year of the epact cycle and the thirteenth year of the nineteen-year cycle. Two consecutive thirty-day lunations occur, that of November and the embolism.

161The verse is, "July fails in the eighth year with May." *Fallitur octavo cum Mayo Julius anno*. *Comp. corr*., p. 250, l. 38. He notes immediately prior to the verse that the eighth year's epact is eleven and May's regular is seventeen, but that the moon is actually twenty-seven on the first of the month, not twenty-eight as would be expected from the rule.

162Grosseteste notes that the epact is twenty, the regular for March is nine, but the moon is twenty-eight on the first day of March. In a leap year, however, the moon is one day older, and the rule holds.

163Ni sit bissextus fallit Martem endeca primus. *Comp. corr*., p. 251, l. 14.

The sixth embolism runs from the fourth nones of August to the kalends of September in the sixteenth year. The sixth embolism needs the eleven days accruing in the seventeenth year, but because it ends on the kalends of September, he writes, it is acceptable for it to use the extra days of the seventeenth year because it ends on the first day of the seventeenth year of the epact cycle. In addition, for the same reason, the seventeenth year is said to be embolismic, even though most of the lunation occurs in the sixteenth year. This embolism, and the subsequent lunation of September, both have thirty days.

The seventh and final embolism begins on the third nones of March and ends on the third nones of April in the nineteenth year of each cycle. The prior lunation of March and the embolism are thirty days each, and, in a bissextile year, the previous January and February lunations are also thirty days each. Following the embolism, the lunation of April ends on the sixth nones of May, and the lunation of May ends on the kalends of June. The rule for finding the age of the moon from the epact and the regular fails in May and August.

Grosseteste ends the chapter with a table for finding the age of the moon. In a column, he wrote the years of the epact cycle from one to nineteen. To the left, he wrote the epact for each year. To the right, he wrote columns for each month. Above the row for the first year of the cycle, he added the regular for each month. Then, at the intersection of each year and month, he wrote the age of the moon, calculated by adding the epact for that year and the regular for that month, except in the months noted previously in the text where the rule failed. In March of the eleventh year, he placed two numbers, twenty-nine with a 'b' and twenty-eight, signifying the moon will be twenty-nine on the first of March if the year is bissextile, and twenty-eight if it is not. The table is reproduced below:[164]

[164]The table is on *Comp. corr.*, p. 253, and in MS Brit. Mus. Add. 27589, folio 95^r in the second column, extending into the upper and right margins. The table reproduced here does not indicate the scribal error of MS Brit. Mus. Add. 27589 in which the epacts and years are begun one row too high in their respective columns (the row listing the regular for each month). I have translated the Latin words, and have not preserved the abbreviations of the manuscript.

TABLE 9

EPACTS AND REGULARS

Epact	Year	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
		5	5	7	7	9	10	9	10	11	12	13	14
0	1	5	5	7	7	9	10	9	10	11	12	13	14
11	2	16	16	18	18	20	21	20	21	22	23	24	25
22	3	27	27	29	29	1	2	1	2	3	4	5	6
3	4	8	8	10	10	12	13	13	13	14	15	16	17
14	5	19	19	21	21	23	24	23	24	25	26	27	28
25	6	30	30	2	2	4	5	4	5	6	7	8	9
6	7	11	11	13	13	15	16	15	16	17	18	19	20
17	8	22	22	24	24	26	27	26	27	27	29	29	1
28	9	3	3	5	5	7	8	7	8	9	10	11	12
9	10	14	14	15	16	18	19	18	19	20	21	22	23
20	11	25	25	27	27	29	30	29b28	30	31	32	33	34
1	12	6	6	8	8	10	11	10	11	12	13	14	15
12	13	17	17	19	19	21	22	21	22	23	24	25	26
23	14	28	28	30	30	2	3	2	3	4	5	6	7
4	15	9	9	11	11	13	14	13	14	15	16	17	18
15	16	20	20	22	22	24	25	24	25	26	27	28	29
26	17	1	1	3	3	5	6	5	6	7	8	9	10
7	18	12	12	14	14	16	17	16	17	18	19	20	21
18	19	23	23	25	25	27	28	27	28	29	30	1	3

4.3.9. Chapter Nine of the *Compotus correctorius*

The ninth chapter covers the rules for placing the golden number into the calendar. The cycle of primations, Grosseteste writes, repeats after nineteen years. In the first year, it is signified by one, in the second year by two, and so on. These are called, he states, the golden numbers, the name deriving from the Roman habit of writing the numbers in gold on their calendars.[165] The usefulness of the cycle of primations is that the cycle of primations allows one to know the dates when the new moon falls in a given year. Thus the golden numbers, which correspond to the primations, will do the same.

To make this clear to the reader, let me present an example not found in Grosseteste's text. If a particular day has a golden number of one, that day will be a new moon in the first year of the cycle. If, say, a day has a golden number of seven, a new moon will occur on that day in the seventh year of the cycle. If a day does not have a golden number, then a new moon will never fall on that day.

Grosseteste notes that the first full lunation of the first year of the cycle begins on the tenth kalends of February; this year's golden number, because it is the first in the cycle, is one. Thus any year with the golden numeral of one will have a new moon on the tenth kalends of February. Once this date is fixed, all subsequent new moons can be calculated, and one can know, simply from the golden number of a year, when each new moon will fall. The usefulness of this is that the movable feasts of the Christian year, as we will see in the next chapter, are fixed based upon the lunations in a year.

The golden numbers are then placed on certain days of the calendar.[166] Grosseteste, however, does not explain this, and clearly assumes that the reader either will be familiar with the process, or will be taught the process. The means to calculate where the new moons will fall, states Grosseteste, is easily found by considering the kalends of January. In the third year, the moon is new on the kalends of January, and so the golden number on the kalends of January is three. Add to this eight, to get eleven, and eleven will be the next

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165…vocatur 'aureus numerus,' quia cum primo inveniebatur scribebatur apud Romanos aureis litteris. *Comp. corr.*, p. 254, ll. 1–2.

166This is illustrated in E. G. Richards, *Mapping Time, The Calendar and Its History*, Oxford: Oxford University Press, 1998, pp. 355–8, including Table 29.1.

golden number placed in the calendar. Add eight again to get nineteen, and nineteen will be the next number placed in the calendar. Continue to add eight and, if the next number is more than nineteen, subtract nineteen to get the next golden number to be placed in the calendar. Next he notes that anytime the number is more than eleven, the addition of eight will give a sum more than nineteen; so, rather than adding eight, eleven can be subtracted.[167] If the number placed in the calendar is eleven or less, then the next number, after the addition of eight, is placed not on the next day, but two days forward.[168] If, however, the number is greater than eleven, and thus eleven is subtracted from it to find the next golden number, the difference is placed on the next day.

Grosseteste does not provide an example, but I will again provide one for clarity's sake.[169] The kalends of January has a new moon on the third year of the cycle. Thus the golden number of three is placed next to the first of January. Adding eight to this three gives the next golden number, eleven. Because the previous number was equal to or less than eleven, the next golden number is placed two days forward, and so the golden number eleven is placed next to the third of January. Eight is added to eleven to give nineteen, and this new golden number is placed ahead two days on the fifth of January. Then eleven is subtracted to give the next golden number of eight; in this case, the new golden number is placed only one day ahead, on the sixth of January. Then the golden number sixteen is placed on the eighth of January; then the golden number five is placed on the ninth of

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167Grosseteste does not give an example, but I offer this one to clarify for the reader. Say the total happens to be fourteen; add eight, and you get twenty-two; take away nineteen and you get three. Subtracting eleven from the initial fourteen would also have given three.

168Which Grosseteste refers to as "on the third day," *die tercio*, meaning the third day including the first day where the previous number had been placed.

169The example is drawn from the table in Richards, *Mapping Time*, mentioned above.

January, and so on. Grosseteste will add some exceptions to the rules later in the chapter.

Grosseteste explains why this works in the following fashion. Eight years, without bissextile days, have 2,920 days. Any eight continuous years of the calendar, except when beginning with the ninth year of the nineteen-year cycle, have three embolismic years.[170] In eight years, the common lunations—pairs of thirty- and twenty-nine-day lunations—account for 2,832 days. Subtracting this from 2,920 days leaves eighty-eight days. The three lunar embolisms account for this time plus two extra days. Thus the new moon falls two days later, on the third day, after the eight years pass. If, however, the eight years include the last year of the nineteen-year cycle, which includes the *saltus lune*, and therefore lacks one day, only a single extra day is left after the embolisms are accounted for. So any sequence of eight years that begins on the twelfth year or later, thus corresponding to a golden number greater than eleven, includes the *saltus lune*, and thus only jumps forward by a single day.

Grosseteste then covers the exceptions to the rule. On the fourth nones of February, the golden number eleven is placed, and the golden number of nineteen immediately follows it on the third nones of February. There are only two lunar embolisms during the eight years beginning on the fourth nones of February, because the fourth embolism ends on the third nones of January in the eleventh year, and the seventh embolism does not begin until the third nones of March in the nineteenth year. Thus the ninety-nine lunations of those eight years are made up of ninety-six common lunations, two lunar embolisms, and twenty-nine (instead of the expected thirty) days. This leads to only a single extra day remaining after those eight years, and thus there is no extra day interposed between the two golden numbers of eleven and nineteen on the fourth and third nones of February.

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[170] In the ninth to sixteenth years, a span of eight years, only the eleventh and fourteenth years are embolismic. Any other consecutive span of nine years has three embolismic years.

The *saltus lune* causes six exceptions to the rules by causing there to be one less day than expected. Again, the golden number of nineteen is placed on the day immediately following a day with the golden number of eleven on the fourth and third kalends of August, the sixth and fifth kalends of September, the sixth and fifth kalends of October, the eighth and seventh kalends of November, the eighth and seventh kalends of December, and the tenth and ninth kalends of January. In these places, too, a further exception is present. Normally, the golden number following nineteen would be eight, and would fall on the next day. However, in all the places just mentioned, in other words, in the months following the third kalends of August, the golden number eight falls two days beyond the nineteen, instead of the expected one day. This is because the *saltus lune* fell in the lunation of July on the nineteenth year, and thus the eight years following the nineteenth year have one more day than expected, and must fall two days ahead.

The final exception to the rule falls on the nones of April, on which the golden number of eight is placed. This should be followed two days later by the golden number sixteen, but in fact the golden number sixteen falls on the day immediately following the nones. This happens because the lunar embolism of the eighth year ends before the nones of April, thus causing the eight years following the nones of April, which should have 99 lunations, to have 96 common lunations, plus two embolisms, plus a remaining twenty-nine days, leading to a jump of only one day for the full moon eight years later.

It also happens that two golden numbers, thirteen and two, fall on the fourth nones of December. The lunar embolism of the fourteenth year of the cycle of epacts ends on the kalends of December in the thirteenth year of the nineteen-year cycle; thus only two embolisms fall in the eight years following the nones of December. From before, we would thus expect the next golden number, two, to fall on the next day. However, the eight year period after the nones of December in the thirteenth year also includes the saltus lune, thus taking away one more day, and causing the two subsequent golden numbers to fall on the same day.

Grosseteste ends the chapter with a mnemonic device in the form of a long poem. It is twenty-two lines long, whereas most of the verses he has given for mnemonic purposes have been only one or two lines long. The poem gives the same instructions for finding the golden numbers, plus some information on the exceptions.[171]

4.3.10. Chapter Ten of the *Compotus correctorius*

The tenth chapter demonstrates that the flaws of the Christian calendar, which Grosseteste has already discussed, lead to errors in finding the correct boundaries for the movable feasts of the Christian year, but then gives the doctrine for finding those boundaries, which the Church still uses. He begins by explaining the manner of finding the boundaries of Easter, the dates on which it can be celebrated. These are based on the age of the moon at the vernal equinox. This leads to two sources of error. First, the vernal equinox is set as the twelfth kalends of April (March 21), which, Grosseteste allows, may have been the date of the equinox when the teachers of the Church first set down the rules for determining Easter.[172] In his own day, Grosseteste states, it is clear from instruments and astronomical tables that the equinox no longer falls on that day; in fact, according to the Toledan tables and the proper length of the year given there and Thebit's work on the motion of the eighth sphere, the equinox falls on the day before the ides of March (March 14).[173] Thus the first error in setting Easter lies in the fact that the true length of the

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171The verses are found on *Comp. corr.*, p 257, l. 24–p. 258, l. 5.

172…equinoctium fuit 12° kalends Aprilis in tempore priorum doctorum, *Comp. corr.*, p. 258, ll. 30–31.

173…et manifestum est tam per instrumentum consideracionis quam per tabulas astronomicas ibi non esse equinoctium in hoc tempore nostro: set secundum Tabulas Tholetanas fundatas super quantitatem anni et motum octave spere quos posuit Thebit, equinoctium vernale hoc nostro tempore est pridie idus year is not the same as that used in the calendar, which has led to the equinox falling on an earlier day of the year.

The second error lies in the use of the incorrect length of a lunation. As mentioned before, he writes, the error in the length of a lunation leads to incorrect dates for the primation. Eventually, he adds, the full moon will fall on the date of an expected new moon (a reference to an earlier portion of the text). That this error has begun to have an effect on the predictions of the age of the moon is clear from the fact that the full moon falls not on the fourteenth day of the moon, but on the twelfth or thirteenth. We know this, he states, because lunar eclipses occur before the moon is fourteen.[174]

To correct these errors, Grosseteste writes, one would need to verify the length of the year, and then incorporate this into the calendar. If this is not done, then the vernal equinox should be figured by using instruments or astronomical tables.[175] Then, using the correct length for the lunation as discussed previously, the proper boundaries for setting Easter can be found. This is the extent of Grosseteste's suggestions on correcting the calendar; he enumerates the corrections that are needed, but has not worked out the precise corrections that ought to be put into effect.

Grosseteste moves on to a discussion on the placement of the movable feasts according to the doctrine of the Church. These rules, he states explicitly, do not incorporate any of the corrections he has just suggested "because the holy Church has not yet changed

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Martii. *Comp. corr.*, p. 258, ll. 25–27.

[174]That is, before the moon is fourteen according to the Christian calendar. In other words, the moon should be full on its fourteenth day, but in fact is full on the days that the Christian calendar says it should be only twelve or thirteen days old.

[175]Modus autem verificandi hunc errorem est ut verificetur anni quantitas, et verificata ponatur in kalendario, vel etiam absque verificatione quantitatis anni cognoscatur semper dies equinoctii vernalis per instrumentum considerationis vel per tabulas astronomicas verificatas. *Comp. corr.*, p. 259, ll. 11–15.

ancient doctrine."[176] First, the vernal equinox is placed on the twelfth kalends of April. According to Rabanus, Grosseteste writes, the equinox was placed there because that is where it was in the beginning of time. Grosseteste, on the other hand, believes that it was placed there because that was its position when the teachers of the Church, who did not know the true length of the year nor of the precession of the solstices and equinoxes, first put down the doctrine.

The first task is to determine the boundaries (*termini*) of Easter. Easter falls on the first Sunday after the first full moon on or after the vernal equinox. Thus the earliest day on which Easter can fall is the day after the vernal equinox, or the eleventh kalends of April, whereas the earliest full moon can fall on the vernal equinox itself. Working backwards, this means that the first appearance (*incensio*) of that lunation, also called the Paschal moon, falls as early as the ides of March. The latest possible first appearance of the Paschal moon falls on the nones of April, leading to the latest possible full moon on the fourteenth kalends of April; if this latest full moon falls on a Sunday, then Easter is on the subsequent Sunday, causing the latest day that Easter can fall to be the seventh kalends of May. One more time, Grosseteste gives a verse to remember the boundaries, though the verse requires some calculation, rather than simply giving the dates of the boundaries.[177]

Once these boundaries are found, Grosseteste continues, the boundaries and places (*termini et loca*) of the other movable feasts are easily found. The four other movable feasts are Septuagesima, Lent, Rogations, and Pentecost. The boundaries of Septuagesima precede Easter by nine whole weeks, and the Sunday of Septuagesima falls nine weeks before Easter. The boundaries and day of Lent precede Easter by six weeks, those of Rogation

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176…quia sancta ecclesia nondum mutavit antiquam doctrinam, *Comp. corr.*, p. 259, l. 18.

177Post Martis nonas ubi sit nova luna requiras/ Que postquam fuerit bis septima Pascha patebit. *Comp. corr.*, p. 260, ll. 7–8.

precede Easter by five weeks, and those of Pentecost fall seven weeks after Easter.

Grosseteste also gives another method for finding the first boundary of Septuagesima, and thereby finding the other boundaries of the other feasts in a given year. Consider the age of the moon on the day of Epiphany. Then, beginning with that number, count the subsequent days until forty is reached. That is the first boundary of Septuagesima, and Septuagesima is celebrated on the next Sunday. If the year is bissextile, and forty is reached on a Saturday, Septuagesima is not celebrated on the subsequent Sunday; instead, that Sunday is the first boundary, and Septuagesima is celebrated on the following. Grosseteste gives a four line verse to remember this rule and its exception.[178]

Grosseteste next explains a third way to locate the feasts. The beginning of the boundaries of the feasts repeat over the course of the nineteen-year cycle; thus a system using this cycle can also be used to find the feasts if one knows which year of the cycle one is in. Each year has a particular number associated with it, called the *claves*, and each feast has a day associated with it.[179] To find the boundary of the feast, start on its relevant day and count the days up to the *claves* for that year. The days are the seventh ides of January for Septuagesima, the fifth ides of March for Easter, the kalends of May for Rogations, and the third kalends of May for Pentecost.[180] The *claves* for the first year of the cycle is twenty-six; this is verified by calculating for Easter: counting 26 days from the fifth ides of March leads us to the nones of April, which is indeed, Grosseteste confirms, the boundary of Easter in the first year of the cycle. Similarly, this method is confirmed by giving the

178 *Comp. corr.*, p. 260, ll. 30–33.

179 Each feast also has a letter associated with it, but this is not used in the computation he describes below.

180 Curiously, Grosseteste does not give the day for Lent.

proper boundaries for Septuagesima, the kalends of February, and for Rogations and Pentecost.

To compute the *claves* in subsequent years, use the *claves* of the previous year. If it is greater than twenty-one, subtract eleven; if it is less than twenty-one, add nineteen.[181] The subtraction of eleven or addition of nineteen come about because of the length of a lunation , and the difference in primation for Paschal moons in subsequent years.

One exception to the rule occurs when the calculation places the beginning of the boundary of Septuagesima on a Saturday in a bissextile year. If this occurs, Septuagesima does not occur on the subsequent Sunday, the second day of Septuagesima, but on the following Sunday, the ninth day of Septuagesima. When this occurs, it will also be the case that the beginning of the boundary of Easter will fall on a Sunday. Easter will not be celebrated on that day, but rather on the subsequent Sunday, the octave day of Easter. Grosseteste ends the chapter with verses to remember the beginning dates for the feasts and the rule for calculating the *claves*.

4.3.11. Chapter Eleven of the *Compotus correctorius*

Grosseteste devotes the eleventh chapter to the composition and use of tables to find the dates of the feasts. To create a table that gives the boundaries of each feast for each year requires a cycle of 532 years, because it must account for both the nineteen-year cycle of primations and the twenty-eight-year solar cycle; the least common multiple of the two numbers is 532. To make such a table, Grosseteste notes first that, based on the limits of the boundaries discussed previously, there are thirty-five days on which Easter can fall, namely, between the eleventh kalends of April and the seventh kalends of May. He directs the reader

[181] Grosseteste has not said what to do when it turns out that the *claves* is equal to twenty-one, but it turns out that case never occurs.

to write these in order in a descending column.[182] Next to each, in a column to the left, a sequence of thirty-five marks (*notule*) is written.[183] Next to each Easter date, in columns to the right, the dates for the corresponding Septuagesima, Lent, Rogations, and Pentecost are written.

A second portion of the table is then constructed.[184] First, one writes the numbers one through twenty-eight in a column, representing the year of the solar cycle. To the left is written each year's concurrence. In a row placed one line above the numeral one of the solar cycle, one places the numbers one through nineteen, representing the nineteen-year cycle. Above this row are written the respective epacts and claves of each year. By creating twenty-eight rows, one for each year of the solar cycle, and ninteen columns, one for each year of the ninteen-year cycle, 532 small squares (*quadrati parvi*) are formed. Next to the first year of the solar cycle and below the first year of the ninteenn-year cycle, one places the mark corresponding to the date of Easter for that year. The rest of the squares in that row, corresponding to the first year of the solar cycle falling on each of the nineteen years of the nineteen-year cycle, are subsequently filled in. Likewise, the remaining rows are filled in, using the marks corrsponding to the proper Easter date for that year. To use the table, one simply finds the square corresponding to the proper year of each cycle, and finds the mark that is written there; then the dates of all of the movable feasts can be found for that year from the first part of the table.

182This can be found at *Comp. corr.*, p. 266.

183In the example in Steele, he uses upper-case, Latin H-Z for the first sixteen marks (no I or U), and nineteen lower case Greek letters for the remaining. Other manuscripts use different systems; for example, some use numbers and other symbols, such as MS Brit. Mus. Harley 4350 and MS Oxford Digby 191, while one example, Oxford MS Bodl., Savile 21, uses Latin letters written in ink of a different color.

184Curiously, this table is usually placed before the list of dates, as in Steele's version, even though the instructions for its construction follow the instructions for the other table..

A few exceptions to the rules of the tables exist. In a leap year, the date for Septuagesima found in the table will be incorrect, and Septuagesima will actually begin on the day following the day written in the table, because the intercalary day is inserted in that year between the beginning of Septuagesima and Easter. Also in a bissextile year, if Easter falls after the eighth ides of April, Lenten Sunday falls one week later than the date written in the table.

Grosseteste also explicitly notes that, using the table, one can easily find the date of the next Easter by moving one column to the right and one row down; thus the dates of subsequent Easters are always found to the lower right. If one is at the last column, move down one row, and find the mark in the first column of that row. Similarly, if one reaches the last row, use the first mark in the next column. Finally, Grosseteste notes how many times each date for Easter appears in the 532-year cycle: the earliest and latest appear four times each; the second, third, second-to-last and the one before the second-to-last eight times each; the fourth, thirty-first and thirty-second twelves times; and the rest sixteen or twenty times. Those that appear four times in a single row recur sixteen times during the cycle, and those that appear five times in a single row recur twenty times.

4.3.12. Chapter Twelve of the *Compotus correctorius*

The twelfth, and very brief, chapter lists the fasting times of the year. Advent occupies the three Sundays before Christmas, and the first of those is always the one closest to the feast of Saint Andrew, which falls on the day before the kalends of December.[185] There are four fasts throughout the year: the first Wednesday after the feast of St. Luke, the first Wednesday of Lent, the Wednesday of the week of Pentecost, and the first Wednesday

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[185]Though it can fall before or after the first Sunday of Advent, and he gives a verse to remember this. *Comp. corr.*, p. 266, ll. 7–8.

after the Exaltation of the Cross. He again gives a verse to remember these days.[186] Fasts are also celebrated on the four vigils[187] of the six apostles: Peter and Paul, Simon and Jude, Andrew, and Matthew; again he gives a verse to remember this,[188] but no dates. There are six other festivals on which vigils are celebrated with a fast, namely, the Nativity of the Lord Jesus Christ, Pentecost, the birth of John the Baptist, Saint Lawrence, the Assumption of the Holy Virgin Mary, and the Commemoration of All Saints, and a fast is celebrated on the day of St. Mark. A verse is given to remember these seven fasts.[189] He ends by noting that, in addition to these dates, fasts set down by the Church Fathers (*patriarcharum*) are permitted.

4.4. Analysis of the *Compotus correctorius*

The most important issue for understanding Grosseteste's *Compotus correctorius* is to determine the purposes for which Grosseteste composed the work. I must emphasize the plural of 'purposes,' for indeed such a long work undoubtedly served a multitude of goals. As Edith Dudley Sylla has written, "Most science in medieval universities … may have been science for undergraduates, but it was of such a nature that the concerns of undergraduates, bachelors, and masters of arts could be merged into a single work."[190]

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[186] *Comp. corr.*, p. 267, ll. 3–4. He does not give instructions for fasting, nor does he have any discussion of the dates for the non-movable feasts, assuming the reader will have this information from some other source.

[187] That is, the day before the festival.

[188] *Comp. corr.*, p. 267, ll. 9–10.

[189] *Comp. corr.*, p. 267, ll. 17–18.

[190] In her "Science for Undergraduates in Medieval Universities," in *Science and Technology in Medieval Society*, edited by Pamela O. Long, *Annals of the New York Academy of Sciences* 441 (1985): 171–186; the quotation is on p. 183. Her evidence is drawn from the fourteenth century. I shall contend that

This is only relevant, of course, if the work was indeed written within the university community, as I claim that it was. My argument, which I shall detail below, is that we can best understand the nature of this work by examining the various purposes it serves, and then showing how these purposes coincide with, or perhaps modify, our understanding of what a university education in the early thirteenth century required.

The first point to consider is the dating of the work. As discussed previously, the date of composition for the work is usually placed between Grosseteste's study of Arabic astronomy, which began at least by 1215, and before the early 1230s. The latter date is usually argued by an appeal to one or more of three main reasons: 1) his acceptance of the bishopric of Lincoln in 1235 would have prevented him from having the necessary time to compose the work, 2) his scientific work precedes this date, or 3) ideas present in the *Compotus correctorius* are superseded by ideas in other works that can be dated to a later period.

The first reason, his acceptance of the bishopric, is suggestive, but hardly decisive. The work is rather long, certainly one of Grosseteste's longest scientific works, and it is unlikely that he would have had the time to compose the work in its entirety after accepting the manifold responsibilities of a large bishopric. Yet we do know that Grosseteste always kept himself busy, and so it is not impossible that he continued the work during this period. But I shall argue below that the text is best understood as being written for a university audience. His ties to the university were certainly reduced after taking the bishopric, whereas he was fully ensconced within that community before that time.

The second reason for dating the work before the early 1230s at the latest, as part of Grosseteste's "scientific period," is more problematic. For example, Thomson states that between 1229 and 1240, Grosseteste's interests "were almost exclusively theological and

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this understanding of medieval scientific texts is also useful for understanding texts of the thirteenth century.

pastoral,"[191] To assume that Grosseteste made the same distinction between science and theology as we do today is unreasonable. In fact, the *Compotus correctorius* has clear theological and pastoral implications, as it conveys the means to celebrate properly religious festivals and includes significant theological assumptions, such as the relevance of the creation of the world to the making of the calendar. While Thomson would like to place the composition of the work before 1229, his reason for doing so is problematic.

The third reason for dating the work before the early 1230s arises from the consideration of Grosseteste's larger corpus of works. McEvoy has a number of arguments by which he attempts to place the composition of the work before 1230, and also suggests an earliest date of composition of 1225.[192] Comparing the *Compotus correctorius* to the earlier computistical treatises ascribed to Grosseteste, McEvoy claims that it shows a greater theological interest than the other works, leading him to favor a later date given that Grosseteste's own theological studies are more intense after 1225. The other computistical works, however, can no longer be taken to be genuine works of Grosseteste, and so no relative dating can be secured. In addition, McEvoy's reliance on Grosseteste's increasing interest in theological matters falls prey to the same false dichotomy of theology and science criticized above.

To date the work later solely on the grounds that Grosseteste's interests changed from scientific to theological is untenable. McEvoy, however, does not rely only upon this principle. He also argues that his dating of the work relies on the Aristotelian material present in the *Compotus correctorius*. In particular, he points to Grosseteste's insistence on the creation as a beginning for time as an anticipation of concerns over the eternity of the

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191Thomson, *Writings*, p. 95.

192McEvoy, "The Chronology," pp. 618–620.

world, an issue that arises out of Aristotelian physics, which assumes no beginning for time. In addition, McEvoy points out some confusion in the *Compotus correctorius* between the doctrines of Aristotle and Alpetragius, the differences between which Grosseteste would better understand after more study of Aristotle. Because of McEvoy's confidence in assigning Grosseteste's study of Aristotle to the late 1220s, he dates the *Compotus correctorius* to the period 1225–1230.

Such a late date for this text is also consistent with what we have seen regarding the dates of the *De spera*.[193] Clearly, as McEvoy has shown, the *Compotus correctorius* shows a greater awareness of the tension between the Aristotelian homocentric scheme of the cosmos and the work of technical astronomy. Much of the astronomical nomenclature that Grosseteste leaves undefined in the *Compotus correctorius* was dealt with in that work. But the *Compotus correctorius* is a great deal more quantitative in its treatment, perhaps reflecting greater familiarity on Grosseteste's part with the technical material. On the other hand, compotus *requires* the use of quantitative material, which the *De spera* arguably did not.

The later dates suggested by Thomson and McEvoy both use a problematic division of theology and science. Their arguments take for granted that Grosseteste's interests divided neatly along our modern categories, moving from science to theology, though McEvoy nuances his stance with other types of evidence, such as Grosseteste's study of Aristotle. In fact, McEvoy himself notes the possibility that Grosseteste might have been teaching natural philosophy and theology at the same time.[194] Is it necessary, then, to

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193See the previous chapter of this dissertation.

194McEvoy, "The Chronology," p. 631. He also writes in his *The Philosophy of Robert Grosseteste*, p. 510, that either Grosseteste broached natural philosophical questions in his theology lectures, or held lectures in both theology and natural philosophy in the same period.

assume that his interest in compotus was left behind because he was becoming more concerned with theological study? This seems unlikely, especially because certain parts of the *Compotus correctorius* are theologically oriented. The assumption of the creation of the world and the need to base the calendar on that, and the purpose of explaining the correct ecclesiastical rules for finding festivals belie any such claim. The work can better be understood as serving functions that we would label as both scientific and theological, functions of a distinctly practical goal.

Arguments that restrict the possible dates based upon this false dichotomy are thus untenable, although McEvoy's arguments from internal evidence are still quite strong, at least for dating the work relative to other aspects of Grosseteste's knowledge and study. The dates of 1225–1230 that McEvoy assigns thus suggest that the work was written within the time he was teaching at Oxford, probably teaching both theology and natural philosophy. The latter subject would have been taught in the arts, and thus to undergraduates. Does the work, then, fit a pattern of characteristics that would have been reasonable for undergraduate students? Jennifer Moreton, as already stated, does not think the work would have been appropriate for undergraduates.[195]

I offer two responses to her argument, both methodological ways to approach scientific texts used in the medieval university. The first returns to the statements of Edith Dudley Sylla, quoted above, namely, that scientific texts could serve multiple purposes, and that the topics within them could deal with issues for a range of readers, from undergradautes to bachelors to masters.[196] In discussing Aristotelian commentaries of the fourteenth century, she also writes that this genre of literature "could play the roles of both

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[195]Moreton, "Robert Grosseteste," p. 87.

[196]Sylla, "Science for Undergraduates," p. 183.

the modern textbook and the modern research paper."[197] In other words, it could serve both as a texbook and as a presentation of more complex ideas, perhaps even ideas that were unorthodox. The *Compotus correctorius*, I will argue in more detail below, could likewise serve multiple purposes, including the introduction of basic computistical ideas and skills to undergraduates, as well as the more challenging notions of calendar reform.

The second response to challenges of the appropriateness of the *Compotus correctorius* for undergraduates lies with a methodological principle established regarding universities in a much later period. Charlotte Methuen has forcefully argued that Michael Maestlin, a professor at the University of Tübingen from 1584–1631, taught different materials to students of varied ability.[198] To the less able students, he taught the standard astronomy of the day. But, she continues, "[t]o his more advanced students he taught the more controversial topics…,"[199] in this case heliocentrism. Her evidence for this claim is based on the contents of his astronomical textbook, *Epitome astronomiae*, and surviving disputations in which more complex topics and methods were used. For Grosseteste, unfortunately, we have only the former kind of evidence, namely, his text.[200]

In analyzing the *Compotus correctorius*, I shall take as a methodological principle a hybrid of these approaches. I believe the work is best understood as a texbook to introduce

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197Sylla, "Science for Undergraduates," p. 183.

198Charlotte Methuen, "Maestlin's Teaching of Copernicus: The Evidence of His University Textbook and Disputations," *Isis* 87 (1996): 230–247.

199Methuen, "Maestlin's Teaching," p. 246.

200For more on disputations in medieval universities, see Brian Lawn, *The Rise and Decline of the Scholastic 'Quaestio Disputata,' with Special Emphasis on Its Use in the Teaching of Medicine and Science*, Leiden; E. J. Brill, 1993. For Grossteste specifically, and especially on his impact on the Franciscans, see pp. 24–28. The areas in which Lawn discusses Grosseteste's influnce do not include the computistical.

basic and essential computistical concepts that students at Oxford would need to learn. In addition, the work contains material unsuited to basic instruction, and such material could be passed over in certain circumstances, perhaps reserved for study by Grosseteste's more able students or peers. My analysis shall suggest that these various purposes are accomplished in this long and complex work, and that it is in a university context that the goals for the work are best met.

Let us first note that much of the material is, to put it simply, basic computistical information. Were this a work intended for an advanced audience already familiar with the compotus, large portions of it would be redundant information. In other words, if the work were intended only to introduce complex, and perhaps unorthodox, material, then much of the basic information would be superfluous.

It is difficult to know precisely what should be counted as 'basic,' as no modern scholar has published a general study of the compotus of the twelfth and thirteenth centuries. Instead of a standard to which we might compare Grosseteste, I have chosen to use what we might call a 'classic' work, Bede's *De Temporum ratione*, or *The Reckoning of Time*. As noted previously, Steele identifies Bede's work as a turning point in computistical studies, making it, as it were, the basis for later works. Certainly the genre had changed by the thirteenth century; compotus was no longer a general repository for various scientific information, but had become more restricted to strictly calendrical problems. In addition, Grosseteste made use of material unavailable to Bede, such as Arabic astronomy. Nonetheless, we can see that much of what Grosseteste covered was also present in Bede, and thus constitutes what we might call 'basic' computistical fare.

Bede begins his work with what Faith Wallis has termed "technical preparation,"[201] which includes counting on the fingers, the small divisions of time and the

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[201] Wallis, *Bede*, pp. 9–18.

use of duodecimal fractions. The first, counting on the fingers, had become part of a different genre of literature in Grosseteste's day,[202] though works on counting are often present in manuscripts containing computistical works. The latter portions of Bede's technical preparation were superseded by the time Grosseteste wrote his *Compotus correctorius*; Bede's divisions of hour, *puncti*, *minuta*, *partes* and *momenta*[203] are replaced by the hour, minute, second, third, etc. divisions that Grosseteste uses. Grosseteste does not, however, explain the divisions into sixtieth parts, nor does he give rules for the mathematics involved in manipulating them. In fact, he assumes his readers can do this for themselves, as he often makes use of this type of calculation, such as when comparing the times of lunations to various periods of years. The lack of explanation in Grosseteste's work suggests that the work was intended for readers already educated in the *algorismus*, the genre of literature on basic arithmetic.[204] This would include, though is not necessarily restricted to, students at the university.

The second division of Bede's work that Wallis makes is the explantion of the Julian calendar.[205] This section includes definitions of various calendrical notions, including day and night; the week; the Roman, Greek and English systems of months; the kalends, nones and ides system of dating; the zodiacal signs; the motions, phases and powers of the moon; eclipses; how to calculate the age of the moon; how to know the day of

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202For example, see an illustration of a twelfth-century manuscript, which shows how such counting was performed in John E. Murdoch, *Album of Science, Antiquity and the Middle Ages*, Charles Scribner's Sons: New York, 1984, p. 79.

203Wallis, *Bede*, p. 15.

204For more on the *algorismus*, see Guy Beaujouan, "The Transformation of the Quadrivium," in *Renaissance and Renewal in the Twelfth Century*, 463–487, especially pp. 467–470.

205Wallis, *Bede*, pp. 19–111.

the week at the beginning of the month; the equinoxes and solstices; the lengths of day and night; the seasons, elements and humours; and the year and placement of the leap year. It is clear from this list how the genre of compotus had changed by the time of Grosseteste. Bede's computistical work included a wide variety of astronomical and scientific information that Grosseteste never broaches. For example, though Grosseteste discusses the age of the moon frequently, he does not discuss the principles of its phases or eclipses in *Compotus correctorius*. Nonetheless, much of the information is of a similar nature. Grosseteste discusses the various divisions of the year (months, weeks, days); the system of kalends, nones and ides; calculating the age of the moon or the day of the week on which the month starts; and the leap year.

In Wallis's next division, "The Anomalies of Lunar Reckoning,"[206] Bede discusses the *saltus lune* and the reasons why the age of the moon may be slightly different than expected. Again, the topics are similar, though Grosseteste handles them in different ways, a development only to be expected in a work that was written five hundred years later. Wallis's fourth section of Bede's work is entitled "The Paschal Table."[207] Again, much of the information is similar to that found in Grosseteste, including sections on the nineteen-year cycle, lunar embolisms, the epact, the concurrences,[208] and the placement of Easter. Bede's work contains two final sections, which Wallis labels "The World Chronicle,"[209] a long chapter chronicling the years since creation and relating various biblical, Greek and

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206Wallis, *Bede*, pp. 113–119.

207Wallis, *Bede*, pp. 121–156.

208Which Bede calls the solar epact. See Wallis, *Bede*, p. 136ff.

209Wallis, *Bede*, pp. 157–237.

Roman events in a common calendar, and "Future Time and the End of Time,"[210] a section on what can be expected in the future according to Christian prophecy. These two sections have no counterpart in Grosseteste's *Compotus correctorius*.

If we use Bede as a standard, then, we can see that Grosseteste's work contains the standard fare of computistical information. Bede's work includes a great deal of material beyond what Grosseteste found relevant to include; Bede's work incorporates quite a bit of biblical exegesis and additional scientific information, for example. But there is relatively little in Grosseteste that does not have a precedent in Bede's work. Grosseteste's work is more strictly limited to calendrical matters than Bede's, but is clearly meant to teach the basics of compotus, as well as more complex ideas.

Because Bede's work predates Grosseteste's by five centuries, no straightforward comparison will allow us to establish that Grosseteste's work is meant to teach basic computistical material. Other clues, however, suggest that teaching the basics is one of the goals of the work. One example comes at the very beginning of the work: the table of contents. The table of contents is repeated in virtually all of the manuscript editions of the text. It functions as a prototypical form of an index. The title of each chapter clues the reader to the place in the text where the information they seek can be found. This is a rather primitive form of an editorial device to enhance the use of the text; in most cases, the chapter is only identified in the text by a large capital letter or a rubric when a new chapter begins—there is no consistent use of chapter numbers in the margin of each page, for example. Nonetheless, the identification of chapter topics allows the user to find information without searching through the whole text and without knowing the text intimately.

The chapters are of very unequal length. In the modern, printed edition of Steele, chapters vary in length from less than a page to over ten pages. If this text was intended for

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[210]Wallis, *Bede*, pp. 239–249.

use in the classroom, the chapters do not represent lectures. In combination with the chapter headings, however, the varied length of the chapters would allow the teacher to move around to various topics, while maintaining the ability of a the reader to find relevant information more easily. The arrangement of topics in this way also accounts for the periodic instances, noted in the exposition of the text above, where Grosseteste uses a term that has not yet been defined, but will be defined later in the text. The ability to move around the text instead of treating it linearly is also consonant with the notion that certain portions of the text might be too advanced for beginning students. Moving around the text, a teacher would be able to skip over portions of the text that he found inappropriate to his audience.

The notion that the text could be used in this way, as one through which students were guided rather than one read as a straightforward, linear work, faces some difficulties of proof. In the first case, it is not clear where students obtained the work. Clearly if this scenario was indeed used, the text had to be copied nearly completely before use by the student, and could not have been presented as lectures. This is not a particularly significant issue because the text is probably too long for such a procedure, given that relatively little time would typically have been devoted to a work of compotus in an undergraduate career. In my survey of manuscripts in England, I found no evidence that the works had been written down in this way. I found no evidence of *pecia* marks, for example, and so the means by which students would have obtained the work is still an open question.[211]

One relevant issue, however, is the consistency with which tables appear in the text. Among the manuscripts that I viewed, tables almost invariably appeared. For example, a

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[211]For information on the *pecia* system, see Graham Pollard, “The *Pecia* System in the Medieval Universities,” in *Medieval Scribes, Manuscripts and Libraries*, edited by M. B. Parkes and Andrew G. Watson, 145–161, London: Scolar Press, 1978. The *pecia* system was one in which students would borrow a portion of a text for copying, then return it before borrowing the next portion. Texts copied in this way typically include marks where the portions begin and end, thereby revealing when a manuscript was created in this way.

survey of seven manuscripts[212] produced the following results. The table of kalends, nones and ides from Grosseteste's second chapter appear in all seven. The table of regulars and concurrences of the third chapter appear in six of the seven;[213] only Cambridge University Library MS Pembroke 278 lacks the table. The table of chapter five for finding the Arab years and months are missing in two of the seven, the Pembroke manuscript that lacks the previous table, and the Savile manuscript. The Savile manuscript, however, does contain the Toledan Tables from which this information was taken. The table of epacts and regulars found in chapter 8 is again present in six of the manuscripts, lacking only from the Pembroke manuscript. The tables of the 532-year cycle and the boundaries of the movable festivals from the eleventh chapter is present in four of the manuscripts; the 532-year cycle alone is present in the St. John's manuscript,[214] and both are missing from the Pembroke and Harley 3735 manuscripts.

Thus we can see that the tables were an integral part of the text. With the exception of the tables to find the Arab year, directions are given in the text for the construction of

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[212]The manuscripts are: British Museum MSS Harley 3735 and 4350, Cambridge University Library MSS Kk. I.1, Pembroke 278 and St. John's 162/F. 25, and Oxford Bodl. MSS Digby 191 and Savile 21. The text on which Steele based his edition, British Museum MS Add. 27589, also includes all tables. I have chosen these as representatives of a cross-section of manuscript versions, but always using texts that are of the thirteenth or early fourteenth century. This survey is by no means complete, but the results are suggestive.

[213]In Cambridge University MS St. John's 162/F. 25, this and all subsequent tables appear after the text.

[214]This is particularly odd, as the 532-year cycle is relatively useless without a table to decipher what the thrity-five symbols mean. That is, the first table alone simply gives the reader a symbol for any relevant year, but that symbol alone does not convey any information without the other table. It is relevant that the tables in the St. John's manuscript appear after the text; perhaps a page has gone missing from the manuscript.

each table.[215] We know relatively little about how masters conveyed information to students in a lecture. The common picture is that the master lectured, and the students copied his words. With the *Compotus correctorius*, however, we may be forced to modify this image when it comes to the creation of the tables for the text. Either the text was copied outside of lecture, which certainly cannot be ruled out, or the tables were seen as an integral part of the text. Perhaps, then, the exercise of copying the text included following the directions for making the tables. There are variations among the tables, some of which Steele has noted in his printed version. The manuscripts surveyed above also demonstrate that the symbols used for the 532-year cycle table vary.

Where, then, does this information on the tables leave us? Any account of how the text was copied must take into account the consistency with which the tables are retained. It seems more likely that students were copying the texts from another copy, than that they were copying it during lecture, because it would have been difficult for the master to convey the table to students. On the other hand, the tables might suggest some variations in teaching procedure from the typical picture of the medieval university lecture.

This discussion, however, depends on the fact that the *Compotus correctorius* was actually used within the university for teaching the basics of compotus. That the text included instructions for creating the tables also suggests that the text was meant to teach the basics of compotus. With the exception of the tables for finding the Arab year, all of the information contained in the tables can be calculated from information in the text.[216] By

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[215]Yet even in this case, the same information, the age of the moon, can be found without the tables. Grosseteste provides a calculatory method for finding the Arab date, and thus the age of the moon, in addition to rules for using the tables. Therefore, even if the tables are missing, the information they provide can still be calculated.

[216]In addition, one would need to know one instance of which year of the Lord corresponded to which year in the nineteen-year cycle, and at least one instance of the date of Easter on a particular year. Grosseteste probably takes it for granted that such information is readily available. In addition, it is worth

including both the table and the instructions for constructing it—not just using it—Grosseteste has provided a useful means to teach the computistical information to a variety of audiences. For those who need only to use the information, the tables provide the necessary numbers. At the same time, the construction of tables can further enhance the learning experience of a student who constructs his own table. The instructions also function to ensure that the tables can be checked for accuracy, and that they can be reproduced if necessary.

Other elements of the text also suggest that it was meant to teach the basics of compotus. The frequency of mnemonic devices is consistent with a text meant for teaching. In numerous instances, a brief verse is presented explicitly to aid the memory. The verses are not necessary to the text itself, as they do not offer any new information; they simply offer an additional way to order, reatin, and access information. The nature of the mnemonic devices are consonant with the goals of teaching.

The tables, too, fulfill a function similar to that of mnemonic devices, but instead of giving the student a means to remember information, tables condense the information into a more manageable form. All of the information contained in the tables is calculable from the information in the text and a little general knowledge of the dating of years. Tables offer a shortcut to finding information, while the text still remains to explain how the information was derived.

Other features also suggest a university setting. Grosseteste begins the work by defining the subject, "Compotus is the science of numbering and dividing time."[217] This definition is refined by adding the different means by which it is divided, "through signs and differences given by the motion of celestial bodies, and also … by regional

noting that, although the tables for finding the Arabic year, month and day cannot be reconstructed from information in the text, the end result—the age of the moon—can be found using a calculation given in the text.

[217] Compotus est scientia numerationis et divisionis temporum. *Comp. corr.*, p. 213, l. 6.

practices."[218] Beginning the work in this fashion defines both the science and the basis of the knowledge. This is a typical scholastic approach: to define clearly the topic the work is to cover, as well as to discuss the sources of information. In this case, other fields of knowledge will be necessary, namely, astronomy, to know the motions of the celestial bodies, and history, to know the various regional practices. This forms the relationships between the science in question and different areas of knowledge.

The detail that he offers regarding the regional practices also suggests a university setting in that he conveys a great deal of information that is not necessary to the purely practical goal of using of the calendar.[219] For example, the meaning of the names of the months taken from the pagans does not assist one in using the calendar. The inclusion of this kind of material certainly has precedent in earlier computistical works; Bede has an extended discussion of the names of the months, for example.[220] So perhaps this material is simply a holdover from the an older style of compotus. But the genre had changed in many other ways; Grosseteste's work, for example, is much more focussed on the calendar, without as much attention being given to other sciences as Bede had done.

That Grosseteste did retain information on regional practices is thus significant, and cannot simply be dismissed as a retention of older forms. Instead, I believe it is best understood to form a part of a broader educational goal that Grosseteste has for the work,

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218…per signationes et differentias quas dant eis motus celestium corporum, et iterum … eis cultus regionum. *Comp. corr.*, p. 213, ll. 8–10.

219On the other hand, some of his arguments about regional usage will be more significant to his arguments about the reform of the calendar, because he felt that calendar was founded on an incorrect basis, namely, not from the year of creation. Thus, in that case, with which I shall deal more fully below, the regional developments are a necessary part of his argument.

220Wallis, *Bede*, pp. 46–50, for the Roman months. Bede also discusses the Greek and English names for months on pp. 51–54.

namely, to introduce students of the compotus to the history of the material itself. Such a goal seems best understood within a setting of a broad, liberal education instead of merely practical training. Thus a university community, where knowledge is valued for its own sake, in addition to offering practical training, seems the proper setting for Grosseteste's work.

That the text was intended for use in a university setting is also suggested by some of the information that is not present in the text. In particular, Grosseteste assumes that the reader has some knowledge in two particular areas: arithmetic and astronomy. He does not teach the reader how to perform arithmetical calculations, though he does occassionally walk the reader through some of his calculations, for example, when he correlates 940 lunations with seventy-six years, or demonstrates the inequality of the length of lunations in the Christian cycle and the value given by Arzachel. In the case of astronomy, Grosseteste discusses briefly the cause of the year, i.e., the sun's motion through the zodiac, but leaves much unstated. For example, in discussing the equivalence of the week and seven days, he uses an argument based on the order of the seven planets,[221] but defends neither the fact that there are seven planets, nor their order; he is taking it for granted that the reader knows this.

Arithmetic and astronomy are, of course, both quadrivial arts, and thus formed part of the basis of education in the Middle Ages. The liberal arts were an important component of education inside the universities, especially before the broader field of philosophy became more significant over the course of the thirteenth and fourteenth centuries. The assumption of arithmetical and astronomical education on the part of his readers thus cannot, by itself, offer absolute proof that Grosseteste intended his work to be for university students. In fact, on the basis of this point alone, the work could potentially be intended for

[221]That is, the moon, Mercury, Venus, the sun, Mars, Jupiter, and Saturn. These bodies are the planets in ancient and medieval cosmology because they are the bodies that move in relationship to the fixed stars.

anyone with an education advanced enough to have included the quadrivial subjects. As discussed in the second chapter, Grosseteste may have been teaching before he came to Oxford, and his interest in astronomical matters certainly predates the period when we can be certain he was at Oxford.

This introduces an additional complication, or perhaps a modification, of what we can say concerning Grosseteste's intended audience. Because the date of compostion of the work is still impossible to pin down precisely, we must be open to the possibility that the work was written before 1225. This could mean that it was written before Grosseteste arrived at Oxford, and thus his intended audience was larger than just the students of a single university.

I have stated elsewhere that I approach the work as one written to fulfill more than one purpose. On the one hand, I have argued that much of the material is basic computistical information intended to teach students how to work with and understand the calendar. But in addition to so much of the material that is intended for basic instruction, there are also certain features of the work that go beyond the standard fare of computistical instruction, standard, that is, in comparison to the "classic" work discussed above, Bede's *Reckoning of Time*. Now to say that Bede's work represents a standard must be understood correctly. Bede's work was five centuries old at the beginning of the thirteenth century, and other computistical treastises has been written in the intervening period, as was discussed in an earlier portion of this chapter. However, no modern study has made a careful study of twelfth- and thirteenth-century computistical developments, and so comparisons are difficult to make. I am not, however, aware of any other computistical work before Grosseteste that includes the material I will discuss below, and that is also intended for basic instruction. In other words, I believe that Grosseteste's *Compotus correctorius* is the first computistical work to incorporate new methods that were available only by the beginning of the thirteenth century and that was intended for use in an educational setting. Works such as Roger of

Hereford's compotus seem to be concerned with particular issues, such as calendar reform, while works of basic instruction, such as the *Compotus ecclesiasticus*, failed to use the developments of recent generations.

Certain aspects of Grosseteste's work are different from, say, Bede's work, because of the time in which he lived, and the work that others before him had done. It is difficult, again because of the lack of scholarship, to know precisely what was new in Grossteste's treatment; I shall point out a few features of the work that make use of other work that had developed in the decades before he wrote his work. The uniqueness of his presentation, I shall argue, lies in its presentation to a university community.

What aspects of the *Compotus correctorius* distinguish it from older treatments of compotus? Perhaps the primary difference lies in its use of Arabic and Greek materials to solve problems involving errors in the calendar. Two problems in particular could be overcome, in theory at least, by using the more accurate astronomical knowledge contained in his sources: the problems of incorrect dates for solstices and equinoxes, brought about by an incorrect length for the year, and the problem of incorrect values for both the age of the moon and the date of eclipses, brought about by an incorrect value for the length of a lunation. Both problems with the Christian calendar, as Grosseteste found it, could potentially be solved by using new information, unavailable to writers of compotus in England before the twelfth century.

Let us examine the problem of the length of the year first. In his first chapter, Grosseteste discusses the various values that astronomers have used for the length of the year. It is probably significant that the only diagram Grosseteste includes in the work helps to explain the length of the year. Not only does the diagram explain the fairly basic fact of the bissextile year; it can be used to explain the minor differences between the real length of the year and that which is assumed as a reason to include an extra day every four years. He credits Abrachis with the basic value of 365 and one-quarter days for the length of the year, noting that this is also the value the computists use; hence it is the value assumed for the calendar.[222] Ptolemy, he says, puts it at 1/300th of a day less than that, while Albategni gives a value of 1/100th of a day less than the standard computistical value. The latter value, Grosseteste claims, best accords with the errors of the solstices that have been observed.[223] His basis for this is that the Scriptures say that Christ was born on the winter solstice, but that now Christmas precedes the solstice by about as many days as centuries since his birth.[224]

Following his explanation of Albategni's length for the year, Grosseteste considers the solution he found in Thebit's works. Thebit, Grosseteste tells us, took into account the difference between the movable and fixed zodiacs to determine that the time between one solstice and the sun's return to the soltice can vary. Taking this into account, and using a fixed star as the point of comparison, Thebit calculated that the year's length is greater than 365 and one-quarter days by twenty-three seconds of a day.[225] Aristotle and Alpetrangius, Grosseteste writes, although they use a natural philosophical explanation for the movement of the sun different from that employed by the astronomers, simply use the value of the length of the year used by Ptolemy.

Thus Grosseteste has suggested three measurements for the length of the year

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222He equates the value of Abrachis and the computists at *Comp. corr.*, p. 215, l. 21.

223The error in the solstices is known *per experimentum nostri temporis*, *Comp. corr.*, p. 215, ll. 29–30. Note that *experimentum* can be accurately translated as "observation" only if taken in the general sense of experience, not in the precise sense of experimentation.

224Quia secundum scripturam, Dominus noster Jesus Christus natus fuit in solsticio hiemali; nunc precedit solsticium Diem Natalem Domini circiter tot dies quot centenarii annorum ab ejus nativitate transierunt. *Comp. corr.*, p. 215, ll. 30–32.

225This calculation was discussed in more detail in the previous section.

different from the value used by the compotists: that of Ptolemy (and Aristotle and Alpetrangius), that of Albategni, and that of Thebit. But he ends his discussion by stating that "these are the methods by which our calendar might be made more correct,"[226] and then proceeds to an explanation of the standard, computistical method of having one leap day every four years, as the Church dictates. In the end, he offers no value as the preferred one for the correction of the calendar, though his statement about Albategni's value being most closely in accord with observation is significant. In fact, though, he puts them all on an equal footing when he lumps them together at the end of the discussion. Even more importantly, he is careful to put the alternative values at arms length, so to speak, by immediately following his discussion with a presentation of the orthodox way to insert bissextile days and figure bissextile years according to the method prescribed by the Church.

By ending his discussion with the proper ecclesiastical method for handling the bissextile year, Grosseteste accomplishes two things. First, he avoids any implication of impropriety by refusing to state that one particular value is better than the standard computistical value. Because the standard value of 365 and one-quarter days is prescribed by the Church, to state that the value is wrong could be construed as unorthodox. Grosseteste is careful not to do this, and, to drive the point home, immediately follows his discussion of alternative values by presenting the method that the Church uses to handle the bissextile year. Second, Grosseteste accomplishes the task of teaching the basic computistical information to his reader. While he suggests both the need and the means to reform the calendar, he ends the chapter by presenting instructions for handling the calendar

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[226]Hii igitur sunt modi quibus kalendarium nostrum posset magis verificari, set quia sancta ecclesia solius bisextilis diei interposicione adhuc contenta est, exposicionem kalendarii secundum usum ecclesie, Deo adjuvante, prosequemur, dicentes secundum usum sancte ecclesie anni quantitatem esse ex 365 diebus et quarta diei integra, que minucia cum quarto anno pervenit ad integrum diem, in eodem quarto anno, ut supradictum est, interseritur. *Comp. corr.*, p. 217, l. 34–p. 218, l. 4.

as it exists. This portion of the text is most useful for the reader who is approaching the topic for basic computistical instruction. The sections of the first chapter relevant to the potential reform of the calendar could be treated separately, if at all. On the other hand, the more advanced reader, who already knows how the bissextile year works, is presented with more complex ideas better suited to a more sophisticated audience.

In addition to the length of the year, Grosseteste also includes sections on the proper length of lunations, the time it takes for the moon to complete its phases. The age of the moon—its place within its cycle of phases—is significant for more than one reason. For one thing, knowing when a moon is new or full is essential for predicting ecplises of the sun or moon. More significantly, the moon's age at the vernal equinox is relevant to the computation of the proper date for Easter, and thus all the other movable feasts of the Church calendar. If the moon's age does not agree by observation with what the calendar predicts, then there is the distinct possibility that festivals could be celebrated on the wrong dates.

In the fourth chapter, Grosseteste introduces the Arab years found in the tables of Arzachel. These years are lunar years, made up of twelve lunar months. The months alternate between thirty and twenty-nine days, making the year 354 days long. However, because the length of a lunation is not an integral factor of 354 days, the year is actually too short, and thus an intercalary day is occasionally added to a twenty-nine day month, making that year bissextile, and thus 355 days long.

The length of a lunation is vital to Grosseteste's remaining analysis. He takes it for granted that the length used by Arzachel is correct. Ptolemy and Abrachis, he states, assume a length of 29 days and 31 minutes, 50 seconds, 8 thirds, 9 fourths, and 20 fifths of a day for a lunation. Arzachel, Grosseteste writes, drops the thirds, fourth, and fifths, and uses the value of 29 days and 31 minutes, 50 seconds of a day.[227] In one Arab year, that is, twelve lunations, this length of the year is too short by twenty-two minutes of a day.[228] In thirty Arab years, however, this yearly error works out to eleven whole days.[229] Thus, according to the value Arzachel uses for a lunation, an integral number of whole lunations is completed precisely every thirty Arab years. At 354 days per year, plus eleven interacalary days, this works out to 10,631 days.

The Christian calendar, however, uses the nineteen-year cycle. Grosseteste shows that this cycle is not compatible with the length of a lunation used by Arzachel. I shall not run through Grosseteste's computations again,[230] but instead merely remind the reader of Grosseteste's conclusions. Every nineteen-year cycle has 235 lunations; but using Arazachel's value for a lunation, we find that 235 lunations does not work out to an integral number of days. In addition, we cannot consider simply the nineteen-year cycle, but must consider the seventy-six year cycle.[231] But even when this is done, we find that an integral number of lunations has not passed in that time. In fact, we find that seventy-six years is too long by 16 minutes and 40 seconds of a day. This error will accumulate with every seventy-

227The error introduced by the thirds, fourths, and fifths is indeed minor, as shown in the previous section where this topic was covered.

228That is, 22/60ths of a day, or a little over 1/3 of a day.

229Each year accumulates twenty-two minutes of a day; in thirty years, this works out to 660 minutes of a day (22 x 30=660). This is equal to eleven whole days (660/60=11), which days are distirbuted throughout the thirty-year cycle as intercalary days.

230I have already done so in the previous section; the reader may refer to the exposition on Grosseteste's fourth chapter to see the computations.

231Because the bissextile year comes every fourth year, four sequential nineteen-year cycles must be considered. Two sequential nineteen-year cycles can have a different number of days, depending on whether they have four or five bissextile years, but seventy-six sequential years always have the same number of bissextile years, and thus the same number of days: 27,759.

six year cycle; Grosseteste drives this home by pointing out that, after 4,256 years have passed, we will see a full moon when we expect a new moon.

Grosseteste then deals with potential objections to his analysis. If one uses the value of a lunation given by Abrachis and Ptolemy, the error in a seventy-six year cycle is still 14 minutes, 32 seconds, 13 thirds, 46 fourths, and 40 fifths of a day. This is a bit smaller than the error that results from Arzachel's value, but is still appreciable. If one objects that Arzachel's or Ptolemy's values are incorrect, Grosseteste writes, then their tables must show errors in the time of eclipses.[232] In fact, we can observe that "these tables do not deceive us regarding the observed hours of eclipses."[233]

Therefore, to know truly the age of the moon, we cannot rely upon the Christian calendar, because it has been in error regarding the length of the lunation. To know the real age of the moon, he writes, we must instead rely upon "astronomical truth."[234] This can be found by using the Arab calendar, because they use the proper length of a lunation.[235] It is for this reason that Grosseteste spends the fifth chapter explaining how to convert the

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232Grosseteste also notes that one might object because Ptolemy, in the second chapter of the fourth book of his *Almagest*, discussed possible errors in calculating the length of the lunation. In Toomer's translation, see p. 178, for Ptolemy's remarks about Hipparchus's methods for calculating the length of the lunation. Ptolemy, following these remarks, notes that due care must be given to carefully observing the eclipses. Grosseteste's own insistence on observing astronomical phenomena may thus be due in part to his reading of Ptolemy.

233…ipse tabule non mentiuntur nobis in aliquo sensibili de horis eclipsium. *Comp. corr.*, p. 235, l. 30.

234…veritatem astronomicam, *Comp. corr.*, p. 237, l.1.

235Grosseteste does not suggest that astronomical truth is to be found through observation, as we might expect. Observation functioned in this argument only to show a lack of error in the Arabic reckoning, not to establish new information. Observation is on the side of the Arabs, and thus their values and tables should be used.

Christian date to the Arabic date, and thereby to know the true age of the moon on a given date.

Grosseteste begins the seventh chapter by again noting that the nineteen-year cycle of the Christian calendar is in error regarding the length of a lunation. However, the nineteen-year cycle is what the Church prescribes, and thus he will spend the rest of this chapter, as well as chapter eight, explaining how to coordinate the solar year and the lunar months through the use of epacts and embolisms, as thereby to know the age of the moon according to this method. The whole analysis, he states explictly, will rely upon the assumption that an integral number of lunations is precisely finished in seventy-six years.[236]

Grosseteste then spends these two long chapters presenting the basic computistical methods for dealing with lunar months within the solar year. As we have seen before, this information is of a straightforward nature, and would be most useful to the reader who requires basic instruction in the calendar. Grosseteste does not return to the subject of errors in the calendar until the tenth chapter, when he is discussing the placement of movable feasts. The errors discussed above—the incorrect length of the year and of a lunation that the Christian calendar uses—both contribute to errors in calculating the date of Easter. First, the time of the vernal equinox is set as the twelfth kalends of April.[237] But, Grosseteste writes, "it is clear, taking into account either instruments or astronomical tables,

236Quia tamen sancta ecclesia ciclis illis utitur, expositionem kalendarii nostri quoad ciclos illos cum Dei adjutorio prosquemur, supponentes cum illis qui ciclos predictos primo posuerunt quod 76 anni nostri, quorum quilibet non bissextilis constat ex 365 diebus…; et hac suppositione ponita pro radice, super eam fundabimus doctrinam consequentem concordantem radici ponite. *Comp. corr.*, p. 241, ll. 5–12.

237That is, March 21.

that the equinox does not fall there in our time."[238] Using the Toledan tables for the length of the year and the method of Thebit discussed in his first chapter,[239] he writes, the equinox falls on the day before the ides of March.[240] This difference of seven days corresponds to what would be expected if the person who first set down the rules for finding the boundary of Easter set the twelfth kalends of April as the equinox, and an incorrect length for the year caused the movement of the winter solstice in the manner stated in the first chapter.[241]

In addition, the age of the moon shows errors as well. According to the premise that an integral number of lunations is complete in seventy-six years, the cycle of primations should maintain the age of the moon correctly. That is, if the primations of the moon occur when expected, then we should observe the moon to be full on the fourteenth day of the lunar month. Instead, Grosseteste claims, the moon is full on the thirteenth, or even the twelfth, day of the lunar month.

Thus two parameters relevant to setting the date of Easter, the date of the vernal equinox and the age of the moon at that time, both have errors. The means to correct this, Grosseteste writes, lie either in verifying the length of the year and using this value for the calendar, or by verifying the day of the vernal equinox by the use of instruments or

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238…manifestum est tam per instrumentum consideracionis quam per tabulas astronomicas ibi non esse equinoctium in hoc tempore nostro. *Comp. corr.*, p. 258, ll. 25–27.

239Note again that, though Grosseteste has mentioned instruments as a possible means to find the equinox, he favors the use of tables made based upon Arabic methods.

240That is, March 14.

241Et constat quod si equinoctium fuit 12° kalendas Aprilis in tempore priorum doctorum, qui primo tradiderunt doctrina de inveniendo termino Pascha, quod in hoc tempore nostro non est equinoctium eodem die, immo necesse est nunc equinoctium precedere diem illum per rationem eandem quam diximus in capitulo primo de antecessione solsticii hiemalis. *Comp. corr.*, p. 258, ll. 30–35.

astronomical tables.[242] He immediately follows this suggestion, as we have seen is his pattern in other places, by stating explicitly that, because the Church has not adopted any new method, he will next explain how to perform the computistical calculations according to proper doctrine, which he proceeds to do for the remainder of the text.

We have seen a distinct pattern in his use of the Arabic material. He discusses Arabic and Greek astronomical works that have been available in England for only a few generations. He presents his findings from these works that suggest that the Christian calendar has errors, and that the means for correcting them lie with this new astronomical material. To establish that errors exist, he claims that observational evidence shows that certain astronomical pheneomena are not occurring when expected, and that the errors are consistent with the use in the Christian calendar of incorrect numerical values. The proper values are contained in the new materials, and thus the Christian calendar can be corrected by using them. In all cases, though, he does not stop with the suggestion merely to correct the calendar, but proceeds to cover fully the computistical methods that students of compotus would need to learn.

I thus see two distinct goals for the *Compotus correctorius*. On the one hand, Grosseteste is presenting basic computistical information consistent with a readership that is learning compotus for the first time. On the other hand, he also presents newly available material for the correction of the calendar. Clearly the audience for these two goals is unlikely to be the same person. One who is learning compotus for the first time is in no position to assess Grosseteste's material on errors in the calendar and the need for reform. On the other hand, a person sophisticated enough in computistical matters to understand the

[242]Modus autem verificandi hunc errorem est ut verificetur anni quantitas, et verificata ponatur in kalendario, vel…cognoscatur semper dies equinoctii vernalis per instrumentum consideracionis vel tabulas astronomicas verificatas. *Comp. corr.*, p. 259, ll. 11–15.

problems and the solutions would not need to be presented the basic computistical doctrine that the Church approves. The work thus fits Sylla's description of a medieval scientific text for use in a university, cited at the beginning of this section, as a work that addresses "the concerns of undergraduates, bachelors, and masters of arts … [in] a single work."[243]

Was the *Compotus correctorius* composed while Grosseteste was at Oxford, for the express purposes of teaching compotus and proposing calendar reform? Two problems confront us when trying to answer this question. First, the dates when Grosseteste was at Oxford are not clearly established. Second, the likely dates of compostion overlap with years where we are unsure of Grosseteste's location. I think it is clear that the work was written, in part, to instruct students in the basics of the art of compotus. The work is intended, then, for an educational setting. But because of the problems with establishing precise dates, we are unable to state confidently whether the original intended setting was Oxford. As we saw in the second chapter, Grosseteste could have been teaching in the arts before he came to Oxford. Thus it is possible that the work was written for some other educational setting. The work does not contain the sophisticated Aristotelian thought that Grosseteste would develop during his study at Oxford. Thus it seems plausible, at least, that he wrote the work before embarking upon that course of study.

Clearly he must have already studied Arabic and Greek astronomical work in translation before writing the *Compotus correctorius*, but his study of Arabic material precedes the dates by which we can securely place him at Oxford. Thus, while that the work may have been written outside Oxford, the setting for which it seems to have been written was certainly an educational one. It is plausible, then, that Grosseteste was teaching sophisticated computistical, and probably astronomical, material before he arrived at Oxford. In either case, the *Compotus correctorius* would have found an audience at Oxford,

[243]Sylla, "Science for Undergraduates," p. 183.

whenever Grosseteste arrived there and taught students in the arts.

This was an important development in the incorporation of Arabic and Greek scientific material into the Latin educational system. On the level of introductory computistical information, this is not very apparent. Students who read just the material on basic, orthodox computistical material, if indeed the text was read or taught in portions, would not have been aware of this. But on the level of calendar reform, the picture is quite different. Here the Arabic and Greek material is indispensable; the reforms that Grosseteste envisions will come directly from those materials. As often as he suggests that observation of astronomical phenomena is useful, he insists that the new scientific material already holds the solution to the problems that observation reveals or demonstrates.

The practical benefits of the new science are immediately obvious: it can be used to correct errors in the calendar, which in turn has important theological implications. In the case of astronomy taught to undergraduates, for example, the benefits of the new material are not so clear. That is, basic instruction in astronomy, such as that found in Grosseteste's *De spera*, discussed in the previous chapter, did not have an immediate "payoff;" whereas students may better understand what is occurring in the sky, the usefulness of this is not self-evident. It becomes useful, in the medieval context, when students proceeded to use the information in other contexts, such as in biblical exegesis or astrology,[244] as well as for the general purpose of understanding the created world. In the case of compotus, on the other hand, the benefits are presented in the same text. As I suggested previously, we can consider the possibility that the text could be used to teach students different things. For those students who grasp the basics of compotus, Grosseteste can then present them with problems he has identified, as well as the means to correct these problems he has found

[244] As was seen in the previous chapter, however, the astronomy of *De spera* had little obvious connection to astrology.

through the study of the new science.

Grosseteste has thus taken the new sciences, recently translated into Latin, and incorporated them into a basic text for university teaching. The benefits of the new science could be presented to the university audience, either to sophisticated undergraduates or to his peers. Compotus at Oxford, then, whether the work was originally written for that setting or was just eventually taught there, was a means by which the new science of the Arabs and Greeks was both incorporated into the curriculum of the young universities and was demonstrated to have usefulness to the Western, Latin world.