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Time Intervals in *1 En.* 72:8–32

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Abstract: *1 En.* 72:8–32 contains the monthly scheme of the change in the length of the day and night within the schematic year of 364 days. The scheme uses two basic units to measure the time difference in the length of the nychthemeron between solstices: one 'part' and the fraction 1/9. Each nychthemeron is divided into 18 'parts', and the regular factor of monthly variation is one 'part'. Modern scholarship has failed to explain the meaning and function of the fraction 1/9 and the origin of the division of the nychthemeron into 18 'parts'. The first part of this study explains the meaning of the fraction 1/9 in the monthly *computus* and its relationship to one 'part'. The second explores the division of the nychthemeron into 18 'parts' compared to Table C, which is part of Tablet XIV of the Babylonian astrological compendium *Enūma Anu Enlil*.

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Except for the introductory verse, chapter 72 of *1 Enoch* describes the sun's movement in a schematic year composed of 364 days. The monthly movement of the sun in its six gates on the eastern and western horizons is correlated with the changing length of daytime and night between solstices (months III and IX), divided into 18 'parts'. Although various attempts have been undertaken to explain the origin of the division of the nychthemeron into 18 'parts', and one 'part' as the factor in the monthly change, no unequivocal solution has been found. Scholars have not been able to demonstrate the existence of an astronomical tradition in the ancient Near East that divided the combined length of the day and night into 18 'parts'.[1]

In addition to that, *1 En.* 72:8–32 exhibits a random use of the fraction 1/9 to denote the difference between the length of the day and night in a month. In v. 10, the difference between the daytime (10 'parts') and nighttime (8 'parts') is 'one-ninth' (1/9), which correctly corresponds to the difference of 2 'parts', the latter being 2/18 of the nychthemeron. However, in v. 28a, the fraction 1/9 is said to be equal to 'one part', which amounts to 1/18 of the length of the nychthemeron; in this case, the equation is not mathematically correct.

1 For a review of scholarship on this problem, see H. Drawnel, "Early Babylonian Astronomy and the Duration of the Nychthemeron in 1 En. 72:8–32," *RevQ* 36/2 (2024) 231–247, § 1.

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The first part of the study analyses the use of the fraction 1/9 in *1 En.* 72:8–32, which calculates the change in the duration of the nychthemeron with recourse to the monthly factor of 1/18. The ensuing conclusion is that the author of *1 Enoch* 72 operated with two factors of monthly change: 1/18 measures the progression or diminution in the length of the day or night from one month to the next, while the fraction 1/9 is a factor of the monthly change in the duration of the daytime/nighttime compared with that of the night/day.

To explain the meaning of the 1/9 fraction, it will be helpful to refer to Table C, which is part of Tablet XIV of the Babylonian astrological series *Enūma Anu Enlil* (EAE). It contains a list of the bi-weekly change in the duration of the nychthemeron in the schematic year, composed of 360 days, and the monthly change in EAE XIV Table C and tablet BM 17175 + 17284 is that of 20 shekels.[2] Next, we will adapt the Babylonian calculation to the Aramaic astronomical tradition, in which the sexagesimal system has been transformed into 18 'parts', with one 'part' corresponding to 20 shekels in the Babylonian calculation and 'one-ninth' corresponding to 40 shekels in the same tradition. The adaptation is analogous to that found in the monthly pattern of lunar visibility periods in 4Q208 and 4Q209 and the lunar visibility periods in an ideal equinoctial month in Table A of the same EAE Tablet XIV.

1. Relationships between One 'Part' and One-Ninth

The central part in the structure of each month in *1 En.* 72:8–32 provides the reader with twofold information about the day and night:[3]

a. the changing relationship between the day and night;[4]
b. the length of the day and night.[5]

While the first section occasionally uses the fraction 1/9 and one or two 'parts', section *b* lists the duration of the day and night with recourse to 'parts' only. The combined daytime and nighttime calculated in section *b* always amounts to 18 'parts', interpreted as time units in a nychthemeron. Additionally, the monthly interval of change in the length of the day and night is one 'part', while the number of 'parts' denoting the length of the day and night oscillates at solstices between 6 (shortest day/night) and 12 (longest day/night) 'parts'.

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2 See Drawnel, "Early Babylonian Astronomy," §§ 2 and 3.

3 For the discussion of the literary structure of *1 En.* 72:8–32, see H. Drawnel, "The Literary Structure and Schematic Clauses in 1 En. 72:8–32," *DSD* 32/1 (2025) 45–74, § 1 and Tables 1–3. While working on the paper, I had a fruitful discussion on chapter 72 of *1 Enoch* with Olivier Dardare, Institut Catholique d'Arts et Métiers, Lille, France. I would like to heartily thank him for his critical reading of especially § 1 of this study and for the creation of figures 1–4.

4 I.10a; II.12a; III.14a; IV. 16a; V.18a; VI. 20a; VII.22a; VIII – absent; IX.26a; X.28a; XI.30a; XII.32a. In this study, the Roman numbers denote months and Arabic notations – verse numbers in chapter 72 of *1 Enoch*.

5 I.10b; II.12b; III.14b; IV.16b; V.18b; VI.20b; VII.22c; VIII.24; IX.26b; X28b.; XI.30b; XII.32b.

The Ethiopic text expresses the grammatical structure of the time units in section *b* similarly: the noun *kəfl* 'part' in singular usually follows the cardinal number (6 through 12), and the entire syntagma appears in the accusative of time. For example, in month I (v. 10b), the daytime is ten 'parts' (*ʿāśarta kəfla*), and the night is eight 'parts' (*samanta kəfla*). There are some additional 'parts' attested in section *a* (day to night): 'one part' (*kəfla ʾaḥada*, IV.16a) and 'two parts' (*kalʾeta kəfla*, V.18a). In one case, in section *a*, the noun *kəfla* – 'part' has been substituted by the synonymous *ʾəda*: 'two parts' (*kəlʾe ʾəda*, II.12a), the two terms being synonymous and thus interchangeable.

Table 1. *1 En.* 72:8–32 – 18 units (fractions of the nychthemeron), one 'part' (1/18) – factor of monthly change (section *b* in the literary structure)

Month and number of days	Daytime	Nighttime	4 cardinal days
I 30	10 (10/18)	8 (8/18)	
monthly change	+1 (1/18)	–1 (1/18)	
II 30	11 (11/18)	7 (7/18)	
monthly change	+1 (1/18)	–1 (1/18)	
III	**12 (12/18)**	**6 (6/18)**	**Summer solstice**
monthly change	–1 (1/18)	+1 (1/18)	
IV 30	11 (11/18)	7 (7/18)	
monthly change	–1 (1/18)	+1 (1/18)	
V 30	10 (10/18)	8 (8/18)	
monthly change	–1 (1/18)	+1 (1/18)	
VI 31	**9 (9/18)**	**9 (9/18)**	**Autumnal equinox**
monthly change	–1 (1/18)	+1 (1/18)	
VII 30	8 (8/18)	10 (10/18)	
monthly change	–1 (1/18)	+1 (1/18)	
VIII 30	7 (7/18)	11 (11/18)	
monthly change	–1 (1/18)	+1 (1/18)	
IX 31	**6 (6/18)**	**12 (12/18)**	**Winter solstice**
monthly change	+1 (1/18)	–1 (1/18)	
X 30	7 (7/18)	11 (11/18)	
monthly change	+1 (1/18)	–1 (1/18)	
XI 30	8 (8/18)	10 (10/18)	
monthly change	+1 (1/18)	–1 (1/18)	
XII 31	**9 (9/18)**	**9 (9/18)**	**Vernal equinox**
monthly change	+1 (1/18)	–1 (1/18)	

What is of interest for the interpretation of the parts in chapter 72 is that the two terms in the singular, *kəfl* and *ʾəd*, are usually part of the periphrastic fractional notations in *Gəʿəz*, where the fraction number is an ordinal number.[6] Although in section *b* the noun *kəfl* follows or precedes[7] a cardinal and not an ordinal number, section *a* equates the regular fractional notation *tāsʿəta ʾəda* – 'one ninth' with 'two parts' (V.18a), thus interpreting 'parts' from section *b* as fractions. This is not unusual, since the 'parts' in section *b* are fractions of the nychthemeron, whose length corresponds to 18 units, as can be inferred from the calculation. It is, therefore, correct and in line with the approach found in the Ethiopic text to interpret the cardinal numbers, followed by the noun 'parts' in section *b*, as fractions of the duration of day and/or night. The actual notations of the syntagma 'cardinal number + *kəfl* ("part")' could be interpreted as denoting the numerator[8] with the denominator '18 parts', which is implied or omitted.[9] Unfortunately, the Aramaic text and its Greek translation are missing, but the Ethiopic text adduces enough information about the 'parts' being fractions to make this assumption plausible.

Table 2. Measuring the duration of the day and night in *1 En.* 72:8–32 (sections *a* and *b*)

1st part of the year: 'day longer than night/it decreases'						
Section *a*			**Section *b***			
Month and days	**Verse**	**Day–night relationship**	**Verse**	**Day**	**Night**	**Combined length**
I 30	10a	double amount (*kāʿəbata*) = one-ninth (*tāsʿəta ʾəda*)	10b	10	8	18 (= 1)
II 30	12a	2 parts (*kəlʾe ʾəda*)	12b	11	7	18 (= 1)
III 31	14a	double (*kāʿəbata*) the night	14b	12	6	18 (= 1)
IV 30	16a	decreases by 1 part (*kəfla ʾaḥada*)	16b	11	7	18 (= 1)
V 30	18a	decreases by 2 parts (*kəlʾeta kəfla*)	18b	10	8	18 (= 1)
VI 31	20a	the day equal to the night				

6 J. Tropper – R. Hasselbach-Andee, *Classical Ethiopic: A Grammar of Gəʿəz* (Languages of the Ancient Near East 10; University Park, PA: Eisenbrauns 2021) 107, § 4.3.3.1.

7 Vv.14b 'part 11'; cf. 16a 'part 1'; 28a 'part 1.'

8 Cf. the notation of the composite fraction 6/7 in 73:8: *sədəstu wasabʿātu* (ms. *q sābʿatu*) *ʾəda* 'six sevenths,' where the numerator *sədəstu* is a cardinal number.

9 In Classical Arabic, the fractions with their denominator between 11 and 20 were written in a periphrastic way, with the help of the noun 'parts,' pronoun *min* (lit. 'from'), and cardinal numbers, e.g. 'three parts out of twenty parts' (3/20), cf. W. Wright, *A Grammar of the Arabic Language*, 3 ed. (Cambridge: Cambridge University Press 1979) I, 264, § 336. In the Greek version of the metrological section of the *Visions of Levi* (v. 37), the same grammatical construction appears, although the denominator is smaller than 11: τὰ πέντε μέρη ἀπὸ τῶν ἓξ μερῶν, 'five parts out of six parts' (5/6), cf. H. Drawnel, *An Aramaic Wisdom Text from Qumran: A New Interpretation of the Levi Document* (JSJSup 86; Leiden: Brill 2004) 138, 287.

2nd part of the year: 'night longer than day/it decreases'						
Section *a*			Section *b*			
Month and days	Verse	Night–day relationship	Verse	Night	Day	Combined length
VI 31			20b	9	9	18 (= 1)
VII 30	22a	longer than	22c	10	8	18 (= 1)
VIII 30	[24a]	—	24b	11	7	18 (= 1)
IX 31	26a	double (*kā ʿbata*) the day	26b	12	6	18 (= 1)
X 30	28a	one-ninth (*tās ʿəta ʾəda*) = 1 part (*kəfla ʾaḥada*)	28b	11	7	18 (= 1)
XI 30	30a	decreases	30b	10	8	18 (= 1)
XII 31	32b	The day equal to the night	32a	9	9	18 (= 1)

The following notes examine several cases in section *a*, 'parts' being understood as fractional notations. The usual form for an Ethiopic fractional notation is attested in X.28a, in a comment on the length of night and day, where the night lasts 11 'parts', one 'part' less than in the preceding month: 'the night decreases in its length by a ninth (*tās ʿəta ʾəda*), that is, one part (*kəfla ʾaḥada*).'

Since the length of night decreases by 'one part' in relation to the preceding solstitial month (IX), scholars have wondered how the fraction of 'a ninth' or 'one-ninth' can correspond to 'one part', whose value was correctly identified as the fraction 1/18 of the entire length of the nychthemeron.[10] From the purely mathematical perspective, such an equation is not possible.

It is not immediately evident why the Aramaic author/redactor introduces the fraction 1/9 into the discussion here and elsewhere in section *a*, which, however, is not uniform. What is discernible in the literary structure of section *a* is a shift in the text from measuring the length of the day and night to measuring one part of the nychthemeron, be it day or night. Leaving aside solstices and equinoxes, the Ethiopic text mentions only night or day in following: II.12a (day), IV.16a (day), V.18a (day), X.28a (night), XI.30a (night). Wherever such a situation occurs, and the clause cites the fraction of 1/9 or 'one/two parts',

10 R.H. Charles, *The Book of Enoch or 1 Enoch: Translated from the Editor's Ethiopic Text* (Oxford: Clarendon 1912) 155, n. to v. 28, considered the fraction of 'a ninth' to be corrupt, for it cannot correspond to the monthly change of 1/18; in his edition of the text, he identifies 'a ninth' with the half moon, cf. R.H. Charles, *The Ethiopic Version of the Book of Enoch: Edited from Twenty-Three Mss. together with the Fragmentary Greek and Latin Versions* (AO.SS 11; Oxford: Clarendon 1906) 136, n. 18. The way he arrived at that identification is a mystery. J.C. VanderKam notes that instead of 'a ninth', attested by the best manuscripts, other mss. read 'one part', an expected reading. He, therefore, assumes a confusion between 'ninths' and 'eighteens', which had to be explained by the gloss 'that is, one part' to clarify their meanings ("1 Enoch 72–82: The Book of the Luminaries," *1 Enoch 2: A Critical Commentary on the Book of 1 Enoch, Chapters 37–82* [eds. G.W.E. Nickelsburg – J.C. VanderKam] [Hermeneia; Minneapolis, MN: Fortress 2012] 426). Note, however, that the reading of 'a ninth' is the *lectio difficilior*, supplanted by 'one part' in other mss. (β group).

the text discusses the length of one part of the nychthemeron without explicitly establishing its relationship to the other part.[11] Yet some relationship to the second part of the nychthemeron, however implicit, must be taken into account to arrive at proper interpretations of the numerical entries.

This is precisely the case in X.28a: 'the night decreases in its length by a ninth (*tās ʿəta ʾəda*) [in relation to the daytime], that is, one part (*kəfla ʾaḥada*) [in relation to the preceding month].' The diminution in the nighttime is 1/9, i.e. 2/18, which is the difference between the day and night in month IX (12–6; 6 'parts') and month X (11–7; 4 'parts'). The temporal value of one 'part' (1/18) signifies a reduction in the nighttime as compared to the preceding month (month IX – 12 'parts'; month X – 11 'parts'). Thus, the two fractions in X.28a measure the temporal difference in the duration of the night with recurrence to two different time measurements in the *computus* of the month in *1 En.* 72:8–32.[12] Equating the two fractions (*zə-wəʾətu*, 'that is') denotes the same process of nighttime decrement, but not the numerical correspondence between 1/9 and 1/18.

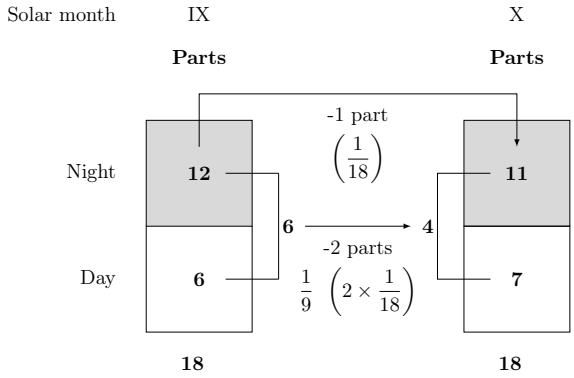


Fig. 1. *1 En.* 72:28a – variation in the duration of the night and day, month IX to X

Chapter 72 testifies to the second case, in which the length of half the nychthemeron is counted separately from that of the whole nychthemeron. Verse 18a states that 'the daytime decreases by 2 parts (*kəlʾeta kəfla*)' [in relation to the night], yet the difference in the daytime between month IV.16b (11 'parts') and V.18b (10 'parts') is of one 'part' only.[13]

11 See Drawnel, "The Literary Structure and Schematic Clauses in 1 En. 72:8–32," §§ 1.3. and 2.1.

12 When commenting on the explanatory clause 'that is, one part' in 72:28, J. Flemming wrote: 'Die Glosse [...] hat nur Sinn bei der Lesart 'ein Neuntel." [The gloss [...] is meaningful only with the reading 'a ninth'] (*Das Buch Henoch: Äthiopischer Text* [TUGAL 7.1; Leipzig: Hinrichs 1902] 94, n. to l. 2); see J. Flemming – L. Radermacher, *Das Buch Henoch: Herausgegeben im Auftrage der Kirchenväter-Commission der Königlich Preussischen Akademie Der Wissenschaften von Joh. Flemming und L. Radermacher* (GCS 5; Leipzig: Hinrich 1901) 94. Unfortunately, he does not develop his explanation any further.

13 For this reason, Charles marks the ordinal 'two' as corrupt and conjectures 'one part' instead (*The Ethiopic Version of the Book of Enoch*, 134, n. 40).

Unlike X.28a, the decrement of the daytime is here interpreted solely in relation to the duration of the nighttime in comparison with the same relationship in the preceding month IV, and not in relation to the sole length of the daytime in the same preceding month.[14] Since in month IV the daytime-nighttime relationship was 11:7 (4 'parts' of difference), it diminishes by 2/18 in month V (10:8, 2 'parts' of difference).[15] The factor of change is 2/18, that is 1/9 as in X.28a.

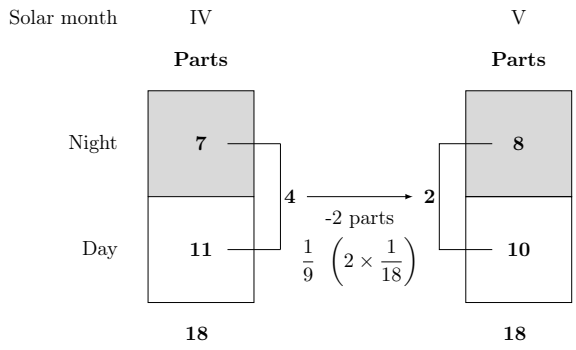


Fig. 2. *1 En.* 72:18a – variation in the duration of the night and day, month IV to V

When calculating the length of the day in relation to the night in the first month of the year, the Ethiopic text equates the fraction of 'a ninth' with the adverbial syntagma 'double amount' (I.10a): 'the day is double amount (*kā ʿəbata*) longer than the night – a ninth' (*tās ʿəta ʾəda*).

It is difficult to understand what this short clause means. The daytime on this day is ten 'parts', while the night – eight (I.10b), hence it is impossible for the day to be twice as long

14 VanderKam interprets '2 parts' as the difference between the day/night ratio of 11:7 (72:16b, month IV) at the beginning of the month and 10:8 (72:18b, month V) at its end ("1 Enoch 72–82," 425). He evidently confuses the notation of the duration of the day and night in two different months, IV and V. Then he explains 'two parts' (72:18a, month V) with the time that elapsed from the solstice in month III (72:14b), when the daytime was 12 parts, to month V (72:18b), when it is 10 parts. The explanation is again incorrect, and the error results from a lack of distinction between section *a* in 72:8–32, which measures the difference between the day and night (the 1/9 fraction or 2 'parts'), and section *b*, which gives the duration of the day and night in relation to the previous month (1 'part').

15 The same explanation is valid for II.12a: for month I (10:8, 2 'parts' of difference) and month II (11:7, 4 'parts' of difference), the factor of change is 2/18, which is 1/9. VanderKam interprets section *b* (12b) in light of section *a* (12a) and claims that 'the difference had been two units (10:8), now at the end of this month it is four (11–7)' ("1 Enoch 72–82," 424). Since such a statement goes against the value of '2 parts' given in 12a, he adds 'additional' in brackets: 'two (additional) parts'. Such an interpretation is incorrect: the Ethiopic text in section *a* (here 12a) does not accumulate the difference between the length of the day and night but notes the constant factor of change in the duration of the day in relation to the night between month I (10:8) and month II (11:7). The two notations belong to two different months, contrary to VanderKam's opinion.

as the night, as one could infer from the normal understanding of the adverbial *kāʿəbata*.[16] The latter meaning of this lexeme is attested in two other places in chapter 72, when on solstices the day is indeed double the night and vice versa: III.14b, summer solstice: 'The daytime is double (*kāʿəbata*) the night' (12:6); IX.26a, winter solstice: 'On that day the night is longer and is double (*kāʿəbata*) the daytime (12:6).'

In his Lexicon, Dillmann renders the adverbial *kāʿəbata* with the usual 'doubly, twice, double amount', but to its use in 72:10a, he assigns a separate category of meaning – *duae partes*, 'two parts', not attested elsewhere in *Gəʿəz*.[17] This understanding relies on the immediate context, in which the difference between the daytime (10 'parts') and the nighttime (8 'parts') is two 'parts' (= 1/9) according to the normal terminology used in chapter 72. This is, however, not what the adverb *kāʿəbata* means here, and the integer of two (*duae*) is not equivalent to the fraction of 1/9, which appears in the same clause as a corrective value in relation to the difference between the length of the day and night.[18] Additionally, if, following Dillmann, the Ethiopic *kāʿəbata* should mean 'two parts', then its use in v. 10a, instead of the usual *kəlʾeʾəda* – 'two parts' (e.g. II.12; V.18a), is hardly justified.

Considering distinctive characteristics that numbers can have, a different explanation is more adequate here. The adverbial unit of time, *kāʿəbata*, interpreted as 'double portion, double amount',[19] is an alternative technical name for the same unit fraction, 1/9 – the latter being divisible by 2: 1/9 ÷ 1/18 = 2; consequently, it is composed of the double amount of 1/18, viz. 2/18. This means that the fraction of 1/9 combines two smaller fractions. Since the proposed meaning refers to the characteristic of 1/9, it is not in line with Dillmann's interpretation and certainly must not be translated as 'two parts'. As in the two other cases discussed above, the fraction 1/9 is the factor of the monthly change in the duration of the day in relation to the night. While on the day of the vernal equinox (XII.32), the daytime is equal to the nighttime (6:6), in the first month of the year (I.10a) that proportion

16 For this reason, Charles considers *kāʿəbata* to be an interpolation (*The Ethiopic Version of the Book of Enoch*, 133, n. 13).

17 A. Dillmann, *Lexicon linguae aethiopicae cum indice latino* (Leipzig: Weigel 1865; reprint New York: Frederick Ungar 1955) col. 867; cf. W. Leslau, *Comparative Dictionary of Geʿez (Classical Ethiopic): Geʿez-English/English-Geʿez with an Index of the Semitic Roots* (Wiesbaden: Harrassowitz 2006) 271: 'doubly, twofold, twice, double portion". While VanderKam's logical inference is certainly correct, the adverbial *kāʿəbata* does not mean 'two units' ("1 Enoch 72–82," 424).

18 Charles interprets the fraction 1/9 as the ninth part of the whole day (*The Ethiopic Version of the Book of Enoch*, 133, n. 15). By 'the whole day', he evidently means the 24h period, which is incorrect. He then goes on to affirm that since the interval of the monthly change of the day and night is 1/18, the entire difference each month is 2/18 or 1/9 of the day. This statement seems to mean that he is summing up 1/18 of the monthly increase in the daytime and 1/18 of the monthly decrease in the nighttime to find 1/9. If this is what he meant, then he is undoubtedly correct.

19 Through the intermediary of Greek, the Ethiopic noun may go back to the Aramaic noun כפל – 'double' or perhaps to the nominalised adjective כפיל; cf. the translation of the proper name מכפלה in Targum Neofiti Gen 23:9, 17, 19; 49:30, by the Aramaic כפיל; cf. M. Sokoloff, *A Dictionary of Jewish Palestinian Aramaic of the Byzantine Period*, 2 ed. (Dictionaries of Talmud, Midrash, and Targum 2; Ramat Gan – Baltimore, MD: Bar Ilan University Press – Johns Hopkins University Press 2002) 266. For the noun כפל, cf., e.g. 1QGenAp XII, 29; yet the term is not attested in any astronomical context in 1QGenAp and at Qumran.

changes by the monthly factor of change – 1/9 (= 2/18). Since this is the first month after the equinox, the factor of change equals the difference between the day and night (I.10b), unlike in II.12b.

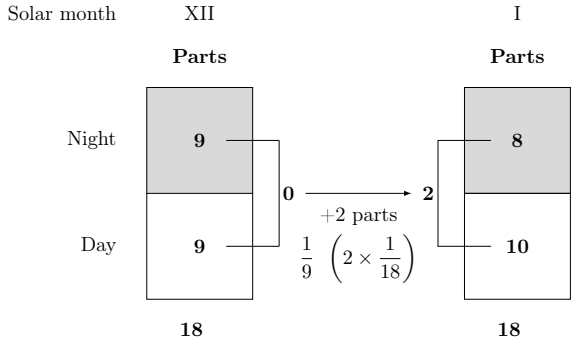


Fig. 3. *1 En.* 72:10a – variation in the duration of the night and day, month XII to I

Explaining the 'double amount' as 1/9 may allow us to find a distant echo of this notation in Syriac astronomical tradition based on Greek texts. Since the Ethiopic version of the Astronomical Book was translated from Greek, it is worth noting, following Dillmann, that in the Ethiopic translation of the LXX, the noun *kā ʿəbat* translates the adjective διπλοῦς – 'dual, double' or 'twice as much, double amount' (Exod 16:5, 22; 22:3, etc.). In his *Treatise on the Astrolabe*, Severus Sebokht, a seventh-century Syriac astronomer and Bishop of Kinnesrīn, transliterated the Greek term διπλοῦς as *dypnʾ* and used it to describe two types of astrolabes: 'The astrolabe may be bipartite (*dypnʾ* διπλοῦς)[20] when one inscribed degree represents two of them, or even tripartite (τριπλοῦς) when an inscribed degree represents three.'[21] Knowing that the degrees in the astrolabe are fractions of 360°, the meaning of the 'bipartite' degree seems to overlap with the 'double' character of 1/9 in our text.[22]

20 The Syriac *dypnʾ* – 'double' is a neologism in Syriac, created from the Greek διπλοῦς; cf. M. Sokoloff, *A Syriac Lexicon: A Translation from the Latin, Correction, Expansion, and Update of C. Brockelmann's Lexicon Syriacum* (Winona Lake, IN – Piscataway, NJ: Eisenbrauns – Gorgias 2009) 298: 'each degree indicated on an astrolabe represents two.'

21 For the Syriac text, see F. Nau, *Le Traité sur l'astrolabe de Sévère Sabokht écrit au VIIe siècle d'après des sources grecques* (Paris: Leroux 1899) I, 23; English translation in S. Sebokht, "Description of the Astrolabe," *The Astrolabes of the World* (ed. R.T. Gunther) (Oxford: Oxford University Press 1932) I, 83; in note 3, Margoliouth notes that Philopon calls these astrolabes διμοιρίαιοι and τριμοιρίαιοι. Sebokht' treatise is a Syriac version of a Greek text on the plane astrolabe, written probably by Ammonius of Alexandria, cf. E. Villey, "Ammonius d'Alexandrie et le Traité sur l'astrolabe de Sévère Sebokht," *Studia graeco-arabica* 5 (2015) 105–128.

22 The division of the astrolabe into three parts reminds the reader of the Babylonian 'Three Stars Each' astrolabes, where in three concentric circles representing three paths of Ea, Anu, and Enlil, the writing in the outermost circle (Ea) is double of the second circle's writing (Anu) and triple of the third, innermost one (Enlil), cf. Horowitz, *The Three Stars Each*, 18, Table 1.

Table 3. Numerical notations in *1 En.* 72:8–32

Verse	Notation	Translation	Fractions of the nychthemeron
Section *a*			
10a	*kāʿəbata*	double amount	(1/9 ÷ 2 = 2/18)
10a	*tāsʿəta ʾəda*	a ninth/one-ninth	1/9 (= 2/18)
12a	*kəlʾeʾəda*	two parts	2/18
14a, 26a	*kāʿəbata*	double	2 x 6 (= 12 = 12/18)
18a	*kəlʾeta kəfla*	two parts	2/18 (= 1/9)
28a	*tāsʿəta ʾəda*	a ninth/one-ninth	1/9
16a	*kəfla ʾaḥada*	one part	1/18
28a	*kəfla ʾaḥada*	one part	1/18
Section *b*			
14b	*sədəsa kəfla*	six parts	6/18
12b; 16b; 24; 28b	*sabʿāta kəfla*	seven parts	7/18
10b; 18b; 22c; 30b	*samanta kəfla*	eight parts	8/18
20b; 20b; 32a; 32a	*tasʿāta kəfla*	nine parts	9/18
10b; 18b; 22c; 30b	*ʿāśarta kəfla*	ten parts	10/18
12b; 16b; 24; 28b	*ʿāśarta waʾaḥada kəfla*	eleven parts	11/18
14b	*kəfla ʿāśarta wakəlʾeta*	twelve parts	12/18

Taking into consideration the equations between the two 'parts' and the fraction one-ninth, as discussed above, it is reasonable to conclude that the length of the day and night in chapter 72 adds up not only to 18 'parts' but also to the integer of one.[23] The same principle of counting the length of nighttime separately from that of daytime is found in 4Q208 and 4Q209, which compute the length of lunar visibility periods during the night and day with recourse to the fraction of a half of a seventh (0.5/7), that is one fourteenth (1/14), as the constant value of the daily change. Thus, for example, on day 26 of the lunar month, the period from sunset to moonrise is 5.5/6, and moonrise to sunrise is 1.5/7, which yields the integer of one as the entire length of the night. The two periods measured in the same way during the day are: sunrise to moonset = 6/7, and moonset to sunset = 1/7, which equals 1.[24]

However, the Aramaic text (4Q208–4Q209) does not present a calculation of the length of the night in relation to that of the day, as exemplified by the cases discussed here (section *a*). The difference is caused by time units related to the presence or absence of the moon

23 Cf. Table 2.

24 4Q209 7 II, 9–11, see H. Drawnel, *The Aramaic Astronomical Book (4Q208–4Q211) from Qumran: Text, Translation, and Commentary* (Oxford: Oxford University Press 2011) 161 (text), 163 (Table 2.32); cf. *ibidem*, 239.

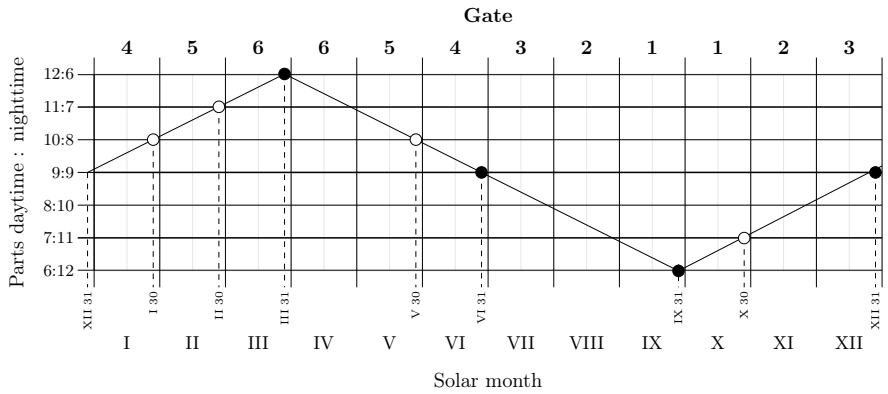
in the sky during the night or/and during the day. Both texts, however, deal with the length of the nychthemeron, and in both cases, the calculation is based on a time unit cited according to the rule of arithmetical progression. Although in section *b* of *1 En.* 72:8–32, the numerical values are not written in a manner corresponding to the fractional notations in classical Ethiopic, they remain fractions of the length of the nychthemeron, as evidenced by their comparison with the regular fractional notation 1/9 in section *a*.

The second conclusion is that the Aramaic author uses two, not one, factors of change in discussing the duration of the nychthemeron. The first is 'one part', or rather 1/18, which is used consistently in *1 En.* 72:8–32 and always marks the monthly increase or decrease in the length of the day and night in section *b* in the structure of each month. This is not explicitly mentioned in section *b*, but must be inferred from the entire process of time measurement. The second factor, used in section *a* – only in I.10a, II.12a, V.18a, X.28a – is the fraction one-ninth (1/9) that indicates the constant monthly progression or diminution of the day–night relationship.

The unit 'one part' (1/18), found twice in section *a*, measures the changing length of the day (IV.16b [11 'parts']) or the night (X.28b [11 'parts']) in relation to the length of the day or night in the preceding month (III.14b [12 'parts'] and IX.26b [12 'parts'] correspondingly). Hence, its use in these two cases in section *a* corresponds to section *b* in which the change in the length of the day and night is established with recourse to one 'part' as the constant factor of change. The author of chapter 72 perhaps intended to explicitly mention what is implicit in section *b*: the factor of monthly change in the length of the day and night is 'one part' (1/18).

In Babylonian schematic astronomy, discussed in § 2 of this study, the first factor (1/18) corresponds to 20 shekels[25]; using the same type of schematic astronomy as the background for the second factor, the fraction of 1/9 corresponds the value of 40 shekels, the numerical value inherent in the monthly change of the day–night relationship in Babylonian schematic astronomy, discussed in Table 6. For the correspondence between 1/9 and 40 shekels, it is instructive to study one example from Table 6: on day 15 in month I, the day is 3 1/3 minas (200 shekels) and the night is 2 2/3 minas (160 shekels); the difference is 40 shekels. The same factor of monthly change appears on each 15th day in the schematic year. The same factor of 40 shekels is also calculated on each 30th day of the month, beginning with month I. While the factor of 20 shekels constitutes the basis for the changing duration of the day and night in EAE XIV Table C, and especially in BM 17175 + 17284, the second one of 40 shekels, present in EAE XIV Table C, governs the relationship between the length of the day and night, just as in the case of the fraction 1/9 in the Enochic measurements.

25 See § 2 in this study.



Legend:
○ Fraction $\frac{1}{9}$ factor (I.10a, II.12a, V.18a, X.28a).
● Summer solstice (III.14a); autumnal equinox (VI.20a); winter solstice (IX.26a); vernal equinox (XII.32b).

Fig. 4. *1 En.* 72 – daytime – nighttime ratio

Table 4. *1 En.* 72:8–32 – Fraction 1/9 or 2 'parts' – factor of monthly change between the length of the day and night (section *a* in the literary structure)[26]

Month and number of days	Daytime	Difference (parts)	Monthly change: 1/9 = 2 parts (=2/18)	Nighttime	Four cardinal days
XII 31	9 (9/18)	[0]	[+ 1/9 = 2 parts (=2/18)]	9 (9/18)	Vernal equinox
I 30	10 (10/18)	[2]	**+ Double amount** (2/18) = **one-ninth** (1/9)	8 (8/18)	
II 30	11 (11/18)	[4]	**+ 2 parts** (2/18 = 1/9)	7 (7/18)	
III –	12 (12/18)	[6]	[– 1/9 = 2 parts (=2/18)]	6 (6/18)	Summer solstice
IV 30	11 (11/18)	[4]	[– 1/9 = 2 parts (=2/18)]	7 (7/18)	
V 30	10 (10/18)	[2]	**– 2 parts** (2/18 = 1/9)	8 (8/18)	
VI 31	**9 (9/18)**	[0]	[+1/9 = 2 parts (=2/18)]	**9 (9/18)**	Autumnal equinox
VII 30	8 (8/18)	[2]	[+1/9 = 2 parts (=2/18)]	10 (10/18)	
VII 30	7 (7/18)	[4]	[+1/9 = 2 parts (=2/18)]	11 (11/18)	
IX 31	**6 (6/18)**	[6]	[– 1/9 = 2 parts (=2/18)]	**12 (12/18)**	Winter solstice
X 30	7 (7/18)	[4]	**– one-ninth** (= 1/9 = 2/18)	11 (11/18)	
XI 30	8 (8/18)	[2]	[– 1/9 = 2 parts (=2/18)]	10 (10/18)	

26 Text in square brackets (factor 1/9 in columns 'difference' and 'monthly change') does not appear in the Ethiopic text. It is given here only to illustrate the regular process of time measurement with the help of the fraction 1/9.

2. The Origin of the Division of the Nychthemeron into Eighteen 'Parts'

Reflecting on the division of the day into 18 'parts', the 19th century German scholar Andreas G. Hoffmann arrives at the conclusion that one 'part' – 1/18 of 18 'parts' – must equal 1 and 1/3 part of 24 hours, which does not concord with the 'natural course of things'.[27] He evidently meant the lack of correspondence between the division of the nychthemeron into 24 units of time and that found in chapter 72 of *1 Enoch*. Although he placed a low value on the chronological information drawn from chapter 72, his observation about the correspondence between one 'part' and 1 and 1/3 hour – 80 minutes in our modern counting – is correct. The question arises whether the time unit of 1/18 corresponding to 80 minutes did exist in the time measurements attested in Babylonian schematic astronomy.

With recourse to the weight of mina and its fractions used as time units, Table C of EAE XIV notes the changing length of the day and night on the 15th day and the 30th day of each month of the schematic 360-day year, beginning with the month of Nisannu. The combined length of the day and night is always six minas, while the interval of change in the length of the day and night is 10 shekels of the water-clock per half month of 15 days, viz. 20 shekels per month.[28]

When creating his version of the schematic year composed of 12 months, the Aramaic scribe, responsible for chapter 72, must have been well acquainted with the calculations found in Babylonian schematic astronomy, an example of which is Table C of EAE XIV. He found his two factors of monthly change, as well as the length of the nychthemeron, by the simple arithmetical process of dividing the length of the nychthemeron (360 shekels) by the factor of monthly change, i.e. 20 shekels, to arrive at 18 units as the total duration of the nychthemeron. Consequently, the monthly change factor of 20 shekels occurs 18 times within the combined duration of the day and night and each numerical entry in Table C can be transformed into parts, for each one is divisible by 20. Hence, the whole Table C can be written in the format found in chapter 72 of *1 Enoch*, in which each 'part' multiplied by 20 will produce the numerical value found in Table C. It is not a coincidence that both one part in the Enochic text and 20 shekels correspond to 80 minutes of our time. The division of the factor of 20 shekels by the length of the nychthemeron, 360 shekels, produces the value of one-eighteenth, exactly as in chapter 72 of *1 Enoch*, where one 'part' was interpreted as a fraction and where two 'parts' (2/18) correspond to one-ninth.

The same Table C evinces the factor of monthly change applied to the relationship between the day and night – it always equals 40 shekels, which entails double the monthly change factor; when applying the same method cited in the case of 20 shekels,[29] 40 shekels correspond to 2 'parts' or 1/9 of the length of the nychthemeron.

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27 A.G. Hoffmann, *Das Buch Henoch in vollständiger Übersetzung mit fortlaufendem Commentar, ausführlicher Einleitung und erläuternden Excursen* (Jena: Croeker 1833) II, 596, n., 'mit dem natürlichen Laufe der Dinge'.

28 For details, see Drawnel, "Early Babylonian Astronomy," § 2.

29 See Table 5.

It cannot be stated with certainty that the Aramaic author based his calculation on the information found in EAE XIV Table C, which operates with 10 shekels as the biweekly factor of change, or in tablet BM 17175 + 17284, from which the monthly interval of 20 shekels can be deduced. To divide the nychthemeron into 18 'parts', the author would need to know that Babylonian schematic astronomy operated with 360 shekels (or 360 UŠ) as the combined length of the day and night. The second principle the author would have to know is the regular interval of change, which, departing from EAE XIV Table C, could be easily adapted from 10 to 20 shekels or obtained from tablet BM 17175 + 17284. Yet, without access to cuneiform schematic astronomy as found in these two texts, the creation of a nychthemeron divided into 18 'parts' with a 1/9 factor of monthly change between the length of the day and night could hardly be possible. Moreover, the literary structure of *1 En.* 72:8–32, the literary form of the short formulaic sentences with numerical entries, and the solstice formulae adapted to 30-day months testify not only to thematic but also to literary points of contact with the early form of Babylonian schematic astronomy as it appears in EAE XIV Table C.[30]

Table 5. From six minas to 18 units

Early Babylonian astronomy	**Period measured**	***1 En.* 72:8–32 (2a and 2b)**
6 minas = 360 shekels	Length of the nychthemeron	18 parts (18/18)
10 shekels (40 min)	Interval of biweekly change	—
20 shekels (80 min)	Interval of monthly change: duration of daytime and nighttime	1 part (1/18) (80 min)
40 shekels (160 min)	Interval of monthly change: duration of daytime in relation to nighttime	1/9 or 2 parts (160 min)
Division of the duration of the nychthemeron by 20 and 40 shekels		
360 ÷ 18 = 20	Length of the nychthemeron	18 parts
20 shekels = 1	Interval of monthly change: duration of daytime and nighttime	1 part
20 ÷ 18/1 = 360	Interval of monthly change: duration of daytime and nighttime	1/18 (fraction)
40 ÷ 9/1 =) 18/2 = 360)	Interval of monthly change: duration of daytime in relation to nighttime	1/9 or 2 parts

Table 6 illustrates the function of two monthly change factors in Table C of EAE XIV and their corresponding values in 'parts'. It also demonstrates that the numerical values found in chapter 72 correspond to those found in Table C on the 15th day of each month, rather than on the 30th day, the latter being 10 shekels larger. The text of *1 Enoch* 72 does not specify a day of the month on which the measurement of the duration of the nychthemeron takes place. That it occurs on the last day of the month has to be inferred from

30 For the interpretation of the literary characteristics of *1 En.* 72:8–32 in relation to EAE XIV Table C, see Drawnel, "The Literary Structure and Schematic Clauses," §§ 1–3.

the context.[31] The same table shows the monthly change factor between the duration of the day and night both in Babylonian schematic astronomy, where it is regularly used, and *1 En.* 72:8–32, where it appears randomly.[32]

Table 6. Two factors of monthly change in EAE XIV Table C, Day 15 and *1 En.* 72:8–32

1 Nychthemeron = 360 shekels					
Day of the month	**Daytime shekels (parts)**	**Shekels**	**Shekels (parts)**	**Nighttime**	**Combined – shekels (= parts)**
I 15	200 (10)	**40**	**+ 40 (2 parts)**	160 (8)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**			**– 20 (–1 part)**	
II 15	220 (11)	**80**	**+ 40 (2 parts)**	140 (7)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**			**– 20 (–1 part)**	
III 15	240 (12)	**120**	**– 40 (2 parts)**	120 (6)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
IV 15	220 (11)	**80**	**– 40 (2 parts)**	140 (7)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
V 15	200 (10)	**40**	**– 40 (2 parts)**	160 (8)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
VI 15	180 (9)	**0**	**+ 40 (2 parts)**	180 (9)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
VII 15	160 (8)	**40**	**+ 40 (2 parts)**	200 (10)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
VIII 15	140 (7)	**80**	**+ 40 (2 parts)**	220 (11)	360 (= 18)
Monthly change factor	**– 20 (–1 part)**			**+ 20 (+1 part)**	
IX 15	120 (6)	**120**	**– 40 (2 parts)**	240 (12)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**			**– 20 (–1 part)**	
X 15	140 (7)	**80**	**– 40 (2 parts)**	220 (11)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**			**– 20 (–1 part)**	
XI 15	160 (8)	**40**	**– 40 (2 parts)**	200 (10)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**			**– 20 (–1 part)**	
XII 15	180 (9)	**0**	**+ 40 (2 parts)**	180 (9)	360 (= 18)
Monthly change factor	**+ 20 (+1 part)**		–	**– 20 (–1 part)**	

20 shekels = 1 part (1/18) of the nychtemeron;

40 shekels = 2 parts (2/18 = 1/9) daytime–nighttime change.

31 For more information on this topic, see Drawnel, "The Literary Structure and Schematic Clauses," § 1.2. Note that the linear zigzag function based on 'parts' in the Enochic text does not take into account day 31, wherever it occurs. Hence, it follows the 360-day year, just as EAE XIV Table C.

32 See Table 4.

Although it was the Aramaic scribe who created a system in which the nychthemeron is divided into 18 units, such a division is inherent in Table C, describing the length of the day and night with the fraction of six minas. Hence, our author did not create a new system independently of the Sumero-Akkadian time measurements, but he rewrote it, parting from the monthly change factor he found in his source and transforming it into 18 'parts'. His comparison of the fraction 1/9 with one 'part' in section *a* (part 2a in the literary structure of the month) in *1 En.* 72:28a proves that he was aware that each unit in section *b* was a fraction of the entire length of the nychthemeron.[33] The application of the 1/9 fraction in section *a* to the duration of the monthly factor of change between the duration of the day and night further demonstrated the author's awareness of the way the whole calculation worked, not only in the text of *1 En.* 72:8–32 but also in the source he used to create the 364-day year. Table 7 contains the same notations taken from *1 En.* 72 and EAE XIV Table C and presented in Table 6, translated into fractions of the combined length of the day and night, where the mina/shekels values divided by the factor of 20 shekels yield fractions of the total length of the nychthemeron (6 minas).[34] Moreover, it shows how the Aramaic scribe, responsible for chapter 72 of *1 Enoch*, interpreted the mina/shekel values on day 15 of each month.

Table 7. The fractions of the duration of the day and night in *1 En.* 72:8–32 and EAE XIV Table C, day 15

***1 En.* 72:8–32**			**EAE XIV Table C**		
Day of the month	**Fraction of daytime**	**Fraction of nighttime**	**Fraction of daytime**	**Fraction of nighttime**	**Day of the month**
I 30	10/18	8/18	10/18	8/18	I 15
II 30	11/18	7/18	11/18	7/18	II 15
III –	**12/18**	**6/18**	**12/18**	**6/18**	**III 15**
IV 30	11/18	7/18	11/18	7/18	IV 15
V 30	10/18	8/18	10/18	8/18	V 15
VI 31	**9/18**	**9/18**	**9/18**	**9/18**	**VI 15**
VII 30	8/18	10/18	8/18	10/18	VII 15
VIII 30	7/18	11/18	7/18	11/18	VIII 15
IX 31	**6/18**	**12/18**	**6/18**	**12/18**	**IX 15**
X 30	7/18	11/18	7/18	11/18	X 15
XI 30	8/18	10/18	8/18	10/18	XI 15
XII 31	**9/18**	**9/18**	**9/18**	**9/18**	**XII 15**

33 See § 1 in this study.

34 A similar transformation of the sexagesimal notations of UŠ units in EAE XIV Table A into West Semitic fractions took place in 4Q208 and 4Q209, cf. H. Drawnel, "Moon Computation in the *Aramaic Astronomical Book*," *RevQ* 23 (2007) 3–41; Drawnel, *The Aramaic Astronomical Book (4Q208–4Q211) from Qumran*, 301–310, 341–352 and Table 3.12.

Conclusion

This research proposed a new explanation of the numerical data in chapter 72 of *1 Enoch*. Early Babylonian astronomy, with its schematic division into day and night, has been shown to provide a proper astronomical background, helpful in grasping division of the nychthemeron into 18 units in *1 En.* 72:8–32. In his description of the schematic year, the author of chapter 72 marked the solstices and equinoxes in months III, VI, IX, and XII, just as in the early form of Babylonian schematic astronomy. He measured the monthly change in the length of the day and night with recourse to the factor of regular change, which amounted to 1/18 of the duration of the nychthemeron. He also established another monthly change factor in the length of the day/night in relation to the night/day, namely the fraction 1/9, i.e. double the value of 1/18. He did not invent a new way of calculating the duration of the day and night throughout the year. Still, he modelled it on Babylonian schematic astronomy, which attested to the two monthly change factors. The relationship of the duration of the day and night in *1 En.* 72:8–32 and in EAE XIV Table C, which operates with the 360-day year, demonstrates that the four additional days in the Enochic chapter modify the original pattern and are not considered in the monthly calculation of the nychthemeron.

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