4

THE ARITHMETICAL POEMS IN *AP* 14

Archimedes' *Cattle Problem* is an early, extended and complex case of a poem seeking to interlace arithmetic and aesthetics, but it is not the only case. The focus of analysis in this chapter are the so-called arithmetical poems preserved in Book 14 of the *Palatine Anthology* (henceforth *AP*). They similarly challenge their readers to solve the outlined simultaneous equations, and this time, all the arithmetic is solvable. The poems constitute an odd collection: their authorship, date and purpose are all contested. *AP* 14.116–46 in the modern numbering are a collection of arithmetical poems, which are preceded by a collection of riddles (*AP* 14.14–47, 52–64, 101–11) and oracles (14.65–100, 112–15, 148–50). The arithmetical poems are attributed to one Metrodorus, whose identity is difficult to ascertain.[1] There seems to be no consensus as to whether Metrodorus should be thought the author or the compiler of the collection.[2] Poems 14.1–4, 6, 7, 11–13 and 48–51 are also arithmetical in nature, and there is evidence that some of them are part of the Metrodoran collection.[3]

An explanation of the purpose of *AP* 14 is given in a prefatory statement preceding the first poem: γυμνασίας χάριν καὶ ταῦτα τοῖς φιλοπόνοις προτίθημι, ἵνα γνῷς τί παλαίων παῖδες, τί δὲ νέων ('for the sake of mental exercise I also provide the following for the industrious, so that you might know what both the children of former times [did] and those of recent times').[4] It is unclear whether this preface goes back to Constantinus Cephalas, the Byzantine schoolmaster who compiled and edited together earlier epigram anthologies into a vast collection, which serves as the

1 On the connected issue of dating and the identity of Metrodorus see Buffière (1970) 36–7; Grillo (2019); Teichmann (2020) 87–8 and my own suggestions below.
2 Tannery (1895) II, xi–xiii; Buffière (1970) 36–7. See also Heath (1921) II, 442.
3 Although not *AP* 14.1 (see below), Buffière (1970) 45.
4 The Greek text follows Buffière (1970) 38, with my translation.

basis of the *codex Palatinus* (the modern day *AP*) and its some 3,700 poems.[5] In any case, the preface can be no later than the *codex*, formed in the middle of the tenth century CE, which contains *AP* in its current shape. The preface could equally apply to the oracles and riddles as well as the arithmetical poems, as examples of mental exercises. A contrast between the genres may then be implied in the contrast between children in the present and those of earlier generations. A reference to the arithmetical poems, though, is *prima facie* probable, given Plato's description in the *Laws* of calculating with real objects, that is, λογιστική. There the mixing and the dividing of tangible objects is a game employed by teachers in order to 'connect practices in elementary numbers to play' (εἰς παιδιὰν ἐναρμόττοντες τὰς τῶν ἀναγκαίων ἀριθμῶν χρήσεις, 819b–c).[6] The practice of λογιστική is a particularly apposite referent of the preface's comment, in other words, since it is the kind of mental training, on Plato's authority, that was engaged in by children.[7]

Given the place of λογιστική at the lower end of the educational ladder and the comments of the preface, scholarship has tended to approach the arithmetical poems within the context of the history of mathematics and of mathematical education.[8] As will become clear with discussion of specific poems, there is an awareness of the poetry's potential pedagogical function, and this chapter will show that the dialogue between number and poetry was one operating in an educational frame at least from the time of the Metrodoran collection. Equally, the literary influences on the arithmetical subjects of individual epigrams are various, and their form cannot be explained *only* as the result of a schoolroom context. The *CP* demonstrates that the intersection of arithmetic

5 See Cameron (1970) 346–50; Cameron (1993) 135–7. Cameron thinks that the preface, and therefore probably the book, goes back in some form to Cephalas. Maltomini (2008) 189–95 considers the book to have a mixed origin with some parts going back to Cephalas and others being introduced with the formation of *AP*.

6 For more on the connection of this passage of the *Laws* with logistic, see Taub (2017) 40–1.

7 Indeed, within Metrodorus' collection, youth and children are a recurrent focus (14.3, 116, 117, 123, 128, 143) – see also Section 3, below – as is play (*AP* 14.138.1 and 140.3).

8 Heath (1921) II, 441–3; Christianidis and Oaks (2013) 129–30; Taub (2017) 39–47; Christianidis and Megremi (2019). Grandolini (2006) works with the assumption that they derive from an educational context.

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and poetry occurred already in the Hellenistic period, anticipating the poems in the Metrodoran collection by at least three centuries (for the estimated dates of the poems and the collections see below). It supports the assertion that these later arithmetical poems need not be aimed solely at educating readers and that poems containing arithmetic could be refined literary products. Indeed, a recent flurry of interest in studies by Simonetta Grandolini, Jenny Teichmann and Jan Kwapisz has elucidated the literariness of the arithmetical poems.[9] These largely philological studies have examined the constitution of the poems and their *scholia* and highlighted the sophisticated – even allusive – imagery and language that they contain. Building on that trend, this chapter seeks to analyse the poems more fully – individually and as a collection – and to provide a clearer cultural context for their intertwining of arithmetic and aesthetics.

I proceed in four sections. In the first section, I offer an overview of the types of poems found in the Metrodoran collection and provide detailed study of select compositions. I pay close attention to the strategies for placing arithmetic information in poetry and the extent to which they rely on recognisable verse forms. That is, the first section outlines a literary archaeology for the arithmetical poems. I then consider a series of novel compositions by Ausonius and Optatian Porphyry in order to situate the poems' workings within the wider late antique literary landscape and to identify a shared practice of involving the reader in the construction of the poems' meaning and of setting numbers in a literary form as means of displaying one's cultural capital. My claim will be that they circulate in a context where arithmetical ability could be flaunted effectively by converting numbers into numbered aspects of the cultural and literary past. In Section 3, I turn to the arithmetical poems as a collection and propose that their arrangement and framing aims to present the poems as handed down the generations and central to the educational process. If the second section underscores the notably late antique nature of the arithmetical poems, then the third section shows that the editor of the collection figured the intertwining of literary and arithmetical learning as a highly

[9] Grandolini (2006); Teichmann (2020); Kwapisz (2020a).

conservative operation within the Graeco-Roman tradition. Section 4 concludes the chapter by looking to the later Byzantine incorporation of the collection into *AP* 14. Even at the 'end' of the tradition, it will be seen, there remains an awareness of the literary potential of arithmetic in verse.

4.1 An Archaeology of Arithmetical Poetry

This section examines the literary genres which the composers of arithmetical poems develop. My aim is to show how the arithmetical poets read these earlier works and genres as already containing the seeds of arithmetical operations in poetry and built on these models in versifying their own arithmetical challenges.

I begin with an epigram that not only poses a mathematical challenge: it is about a mathematician.

οὗτός τοι Διόφαντον ἔχει τάφος. ἆ μέγα θαῦμα·
  καὶ τάφος ἐκ τέχνης μέτρα βίοιο λέγει.
ἕκτην κουρίζειν βιότου θεὸς ὤπασε μοίρην·
  δωδεκάτην δ' ἐπιθεὶς μῆλα πόρεν χνοάειν·
τῇ δ' ἄρ' ἐφ' ἑβδομάτῃ τὸ γαμήλιον ἥψατο φέγγος,
  ἐκ δὲ γάμων πέμπτῳ παῖδ' ἐπένευσεν ἔτει.
αἰαῖ, τηλύγετον δειλὸν τέκος· ἥμισυ πατρὸς
  †τοῦδ' ἐκάη κρυερὸς† μέτρον ἑλὼν βιότου·
πένθος δ' αὖ πισύρεσσι παρηγορέων ἐνιαυτοῖς
  τῇδε πόσου σοφίῃ τέρμ' ἐπέρησε βίου.[10]

(*AP* 14.126)

This is the tomb of Diophantus. A! A great marvel; and the tomb speaks the measure of [his] life through [his] skill. The god granted a sixth share of his life to be a youth; he adds a further twelfth to furnish his cheeks with the first down; he lit the marriage torch a seventh later, and after the marriage he granted him a child in the fifth year. Alas, wretched late-born child: †he was burnt stone-cold† taking half the length of his father's life. Again, having consoled himself from grief for four years with the science of quantity he reached the end of his life. ($F = 2S$; $S - 4 = F(\frac{1}{6} + \frac{1}{12} + \frac{1}{7}) + 5$: F = the father's age; S = the son's age)

This is a neat composition employing a number of epigrammatic motifs. A deictic identifying the tomb in front of the reader is common in funerary epigrams, as is the emphasis on finality

[10] The Greek text follows Buffière (1970), although I follow other cautious editors in employing *cruces* in verse 8.

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(cf. τέρμ' . . . βίου) placed in the final position in the epigram. The exclamatory ὦ μέγα θαῦμα has an equally strong pedigree in the epigrammatic tradition.[11] The use of τηλύγετον brings an epic colour to the poem, although it is a term which is often considered to be ambiguous in meaning.[12] However, the description of Diophantus' son as τηλύγετον and the fact that something seizes the 'measure of his life' (μέτρον . . . βιότου, 14.126.8) recall the description of the Eleusinian Demophoon in the *Homeric Hymn to Demeter*. He is a 'late-born', τηλύγετος child of Metaneira (*Hymn. Hom. Cer.* 164) whom his sisters hope the disguised Demeter will raise in their house so that he might reach 'the measure of youth' (ἥβης μέτρον, *Hymn. Hom. Cer.* 166). Demeter attempts to deify the child in her care until Metaneira spies her and halts the attempt, after which, in some versions of the myth, the child dies.[13] This background is certainly not necessary to an appreciation of the poem, although being aware of the echo would elevate the status of Diophantus' child and make his death a matter of divine and epic significance, while at the same time marking a grim contrast between Demophoon, who is spared by Demeter, and Diophantus' child, who is not. But the hymn was also an important model for funerary epigrams and especially for young women, who are often likened to Persephone snatched in her prime.[14] The author of this arithmetical poem follows in that tradition but draws poetic language instead from the characterisation of the male child in the hymn.[15]

The poet also makes a play with language. He provides an etymological interpretation of Diophantus as 'conspicuous (cf. φαίνω) because of Zeus (cf. Διά, Διός, etc.)': θεός governs both ὤπασε and ἐπένευσεν, actions that are associated with Zeus, and the providing of a marriage 'light' or 'torch' could imply that the god is making Diophantus manifest in some respect. He may

[11] Cf. e.g. Meleager 26.3 *HE* = *AP* 5.160.3 and Leonidas 95.3 *HE* = *AP* 6.130.3.

[12] The LSJ *s.v.* τηλύγετος suggests 'son of one's old age', 'only son' and 'well-beloved', but also 'born far away'.

[13] See Richardson (1974) 242 and Foley (1994) 48–9.

[14] See e.g. Tsagalis (2008) 100–10.

[15] In contrast, for example, to two Imperial Greek verse inscriptions – *GVI* 1159 and 1595 – recently discussed in Hunter (2019) 145–8, where the male child is paralleled in various ways with the snatched Persephone.

also be offering a further pun on the fact that λογιστική traditionally dealt with the division of apples or sheep, both μῆλα in Greek; here the poet uses the same word with another meaning: 'cheek' (LSJ *s.v.* μῆλον II.2).

Thematically, this is not the first epigram to consider mathematicians in connection with their mathematics, but all others that are extant have a geometrical focus.[16] Unlike many Greek mathematicians, however, Diophantus' focus in his *Arithmetica* was on arithmetic and in particular on determinate and indeterminate linear and quadratic equations of the kind also employed by Archimedes in the *Cattle Problem*. In this poem, though, the author has provided a sufficient number of equations to be able to identify the unknowns. The poem thus embodies the intertwined nature of Diophantus' life and arithmetical interests, following a tradition that can already be seen, for example, in two epigrams on the scholars Philetas and Eratosthenes, where their deaths are closely connected to their intellectual activities.[17] The combination of epigrammatic style and Diophantine equations allows his life *and* learning to be exemplified in just five couplets, where the μέτρα and τέρμα of his life converge.[18]

In terms of the deeper literary history reflected in the epitaph on Diophantus, and others with a funerary subject matter (14.123, 128 and 143), the poet has exploited a connection that underlies countless compositions. Number and enumeration relating to age are, unsurprisingly, generically determined in funerary epigrams.

16 Eratosthenes of Cyrene composed an epigram to Ptolemy Philopator on his mechanical solution for the duplication of the cube (see Eutocius *In Archim. De sphaera et cylindro* 4.68.17–69.11 Mugler); one Perseus on his 'discovery' of spiral sections (Proclus *In Euc.* 111.23–112.2); an anonymous author (of indeterminate date) on Pythagoras' theorem (Diog. Laert. 8.12 = *AP* 7.119); and another on Euclid (Cougny III, 309).

17 Dionysius of Cyzicus' epitaph on Eratosthenes says that he did not die from some obscure disease, but 'Eratosthenes, you slept the sleep due to all at the peak of your studiousness' (εὐνήθης δ' ὕπνον ὀφειλόμενον | ἄκρα μεριμνήσας, Ἐρατόσθενες, 1.2–3 *HE* = *AP* 7.78.2–3). Similarly, an anonymous epitaph, in the voice of Philetas, announces that 'the lying word brought about my death, along with hard work at night after the sun went down' (λόγων ὁ ψευδόμενός με | ὤλεσε καὶ νυκτῶν φροντίδες ἑσπέριοι, Ath. 9.401e = T 22 Lightfoot). The lying word seems to have been some sort of logic puzzle, possible the Cretan liar paradox; study into the night is a typical representation of studious scholars; cf. Aratus according to Callimachus 56 *HE* = *AP* 9.507.

18 The measure of one's life in relation to numbers has a long history which goes back to Solon fr. 27 *IEG*.

For example, an epitaph on a fourth-century marble Attic lekythos describes the deceased Kerkope as 'numbering nine decades of years in old age' (γήραι ἀριθμ[ή]σασ' ἐννέα ἐτῶν δεκά<δ>ας, *CEG* 592.4). In a second-century BCE inscription from Smyrna the length of one Dionysius' life is a particular focus: 'You will find the length of my life by counting seven decades from the years and a small bit in addition' ἑπτά που ἐξ ἐτέων δεκάδας καὶ βαιὸν ἐπόν τι | εὑρήσεις ἀριθμέων μῆκος ἐμῆς βιοτῆς· (*SGO* 05/01/38 1–2). All the key terms used to enumerate the deceased's age can be seen in the epigram.[19] What is more, it both provides the deceased's age and figures the reader as enquiring after and calculating his lifespan: epigrammatic enumerations were as much an interest for the reader encountering a grave site as those commemorating a loved one.

Certainly, enumeration of objects occurred elsewhere in the epigrammatic tradition: victories were counted and dedications inventoried.[20] Yet the idea that sepulchral epigrams were particularly oriented to provide a reckoning was at least well-known enough in mid-first-century CE Rome for Philip of Thessalonica to develop it: 'everyone once counted Aristodice a proud mother since six times she had thrust away the pain of labours . . .' (ἠρίθμουν ποτὲ πάντες Ἀριστοδίκην κλυτόπαιδα | ἑξάκις ὠδίνων ἄχθος ἀπωσαμένην, 29.1–2 GP = *AP* 9.262.1–2). The interrelation of tombs and tallies can be seen most clearly in the Milan Posidippus.[21] The section of the collection (provisionally) entitled the ἐπιτύμβια (lit. 'things upon tombs') variously explores the notion of keeping count. The section may well open with the fantastic age of one hundred: ἡ ἑκατ[(42.1 AB), just as Onasagoratis is at 47 AB: 'at the age of one hundred, the people of Paphos deposited here the blessed offspring of On[asas] in the [fire-devoured] dust' (ἣν ἑκατονταέτιν Πάφιοι μακαριστὸν Ὀν[ασᾶ]

[19] For forms of ἔτος, see *CEG* 477.1, 480.2, 531.1, 538.3(?), 553.6, 584.3(?), 590.3, 592.4, 660.3, 747b.1, 757.2–3, 894.6 and 12; for δέκας see 477.1, 531.1, 554, 592, 660; for ἀριθμέω see 592. Individual numbers of years recur, too, but for reasons of space I point the reader to the appendix of *CEG*.

[20] For epigrams relating to victories cf. 795, 811 *CEG* and Simonides 27 Sider (= *AP* 13.14); for dedications cf. 747, 881 *CEG* and Theocritus Epigram 24 Gow (= *AP* 9.436).

[21] The author and editor are generally thought both to be Posidippus, see Acosta-Hughes et al. (2004) 4–5, although it would not affect my argument if this were not so.

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| θρέμμα πυ[ριβρώτ]ωι τῆιδ' ἐπέθεντο κόνει, 5–6).[22] Similarly, the woman praised in 45 AB 'was eighty years old, but still capable of weaving the [delicate] warp with her shrill shuttle' (ὀγδωκοντ [αέτις μέ]ν̣, ἔτι κρέξαι δὲ λιγε[ίαι] | κερκίδι λε[πταλέον] στήμονα δυναμ̣ε̣[νη, 3–4), as is Menestrate at 59.1–2 AB. Such successful aging is poignantly contrasted with the youths who do not survive: Hegedike who was only eighteen (ὀκ[τωκαιδε]κέτιν, 49.3 AB) and Myrtis who was ten (τὴν δεκέτιν Μυρτίδα, 54.2 AB). The deceased's lives are also measured by the children they produce: the anonymous mother at 45 AB 'saw the fifth crop of daughters' (θυγατέρων πέμπτον ἐπεῖδε θέρος, 6) and Menestrate (59.3 AB) and Aristippus (61.6 AB) are both blessed with numerous grandchildren. Onasagoratis is a wonder of fecundity, and the rhythmically dactylic third line of the epigram tots up her tots: 'the group is four times twenty; [she], in the hands of her eighty children . . .' (τετράκις εἴκοσι πλῆθος· ἐν ὀγδώκοντ' ᾄ̣[ρα] παίδω[ν] | χερσὶ, 47.3–4 AB). Already in the Hellenistic era there is a keen awareness that enumeration is a mode of accounting for life particularly suited to funerary epigram.

The numbered nature of time and its progression, as opposed to a lifespan, also finds a place in Posidippus. Poem 56 AB describes an unnamed Asiatic woman who gives birth five times (πέντε, 1), who 'died during the sixth labour' (ἕ]κτης δ' ἐξ ὠδῖνος ἀπώλεο, 3) and whose infant died 'on the seventh day' (ἐν ἑβδομάτωι . . . ἠελίωι 5). The question of causality hangs uneasily over the sequence and the extent to which it means anything: there is an unclear connection between the sixth labour and the infant's death on the seventh day. In different numerological contexts the number seven was connected with significant changes within the body and was known as an unproductive number.[23] Enumeration underscores a dread sense of the natural, arithmetical inevitability of things.

[22] The apparatus of the *editio minor* suggests ἡ Ἑκατ[ης πρόπολος or ἡ ἑκατ[ονταέτις *exempli gratia* Bastianini and Austin (2002) 64.

[23] For the general idea see Webster (1951), and on the fascinating and difficult Pseudo-Hippocratic treatise *On Sevens* (Περὶ ἑβδομάδων) see Mansfeld (1971) 1–31. Within arithmological thought, seven was considered not easy to work with and to signify the motherless and virginal Athena because it is neither a factor nor product of the numbers of the decad, i.e. 1–10. Cf. Speusippus fr. 28.30 Tarán, Philo *Leg. all.* 1.15 and Alexander of Aphrodisias on Aristotle *Met.* 985b26.

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The passage of time is a recurrent interest in the Metrodoran collection as well beyond the epitaph for Diophantus: how long it takes women (14.134 and 142) or bricklayers (14.136) to complete tasks and how much time has passed according to astrological phaenomena (14.140–1). The most basic form of time calculation also finds a place.

ὡρονόμων ὄχ᾽ ἄριστε, πόσον παρελήλυθεν ἠοῦς;
ὅσσον ἀποιχομένοιο δύο τρίτα, δὶς τόσα λείπει.

(*AP* 14.6)

Tell, o greatest of clocks, how much of the morning has passed? There remains twice so much as the two thirds that have passed by. ($L = \frac{4}{3}P$; $P + L = 12$ hours: L = time left; P = time past)

γνωμονικῶν Διόδωρε μέγα κλέος, εἰπέ μοι ὥρην,
ἡνίκ᾽ ἀπ᾽ ἀντολίης πόλον ἥλατο χρύσεα κύκλα
ἠελίου. Τοῦ δή τοι ὅσον τρία πέμπτα δρόμοιο,
τετράκι τόσσον ἔπειτα μεθ᾽ Ἑσπερίην ἅλα λείπει.

(*AP* 14.139)

Diodorus great fame of dial-makers, tell me the hour since which the golden wheels of the sun jumped to the pole from the east. So then there is left until the western sea four times so much as the three fifths of the course. ($L = \frac{12}{5}P$; $P + L = 12$ hours: L = time left; P = time past)

The tradition must be early since Posidippus composes an epigram that describes, and is represented as accompanying (see the deictic τοῦθ᾽, 52.1 AB), a sundial which the deceased father Timon has set up for his daughter Aste.[24] The closing makes the father's intention clear and touching: 'so that she might measure the beautiful sun through many a year' (σωρὸν ἐτέων μέτρει τὸν καλὸν ἠέλιον, 52.6 AB). Following those lives spanning a century mentioned earlier on in Posidippus' collection, the reader is asked here, together with the youthful addressee (cf. κούρη at 5), to reflect on the much shorter and perhaps more precious measures of a human life. A keen focus on not only the age of the deceased, but also the day and hour at which they died, is evidenced by numerous Latin inscriptions that detail specific *horae*.[25] A further Greek example focuses on life, instead of death.

[24] For further discussion see Puelma and Angiò (2005). [25] Ehrlich (2012).

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ἓξ ὧραι μόχθοις ἱκανώταται· αἱ δὲ μετ᾽ αὐτὰς
γράμμασι δεικνύμεναι ζῆθι λέγουσι βροτοῖς.

(*AP* 10.43)

Six hours are most sufficient for work: the subsequent hours showing through letters say to mortals 'Live!'

The epigram is preserved in the *Palatine Anthology*. There is a probable reference to the epigram on a sundial at Herculaneum (cf. *IG* 5862), which suggests that the epigram or something like it was known already by the mid-first century CE. It interweaves literary and numerical thinking by employing the same numerical-cum-literary reading practice explored in Chapter 2. The epigram explains that the seventh through tenth hours, when written in Greek numerals (ζ, η, θ, ι), can be interpreted as the imperative ζῆθι. The two poems in the collection above are building on the long tradition of epigrams on sundials toying with epigrammatic and time-keeping conventions, but they innovate by taking the accounting seriously.[26]

A further genre that employs enumeration is sympotic epigram, encapsulated by another Posidippean epigram representing the arithmetical *Realien* of the symposium.

τέσσαρες οἱ πίνοντες· ἐρωμένη ἔρχεθ᾽ ἑκάστῳ.
ὀκτὼ γινομένοις Χῖον ἓν οὐχ ἱκανόν.
παιδάριον, βαδίσας πρὸς Ἀρίστιον εἰπὲ τὸ πρῶτον
ἡμιδεὲς πέμψαι, χοῦς γὰρ ἄπεισι δύο
ἀσφαλέως, οἶμαι δ᾽ ὅτι καὶ πλέον. ἀλλὰ τρόχαζε,
ὥρας γὰρ πέμπτης πάντες ἀθροιζόμεθα.

(Posidippus 124 AB = *AP* 5.183)

Four are drinking at the party, and a girl is coming for each. That makes eight; one jar of Chian wine is not enough. Go, boy, to Aristius and tell him the first he sent was half-full: it is two gallons short certainly, I think more. Go quickly: we are all gathering at the fifth hour.

Posidippus presents the situation numerically: the amount of wine, the number of guests, the time of the party. Time, as I have already noted, was a theme turned to the advantage of arithmetical

[26] There is also a deeply astronomical aspect to this ratio-based approach to time-keeping. Aratus' discussion of the ecliptic (497–9, 509–10) – an essential phenomenon for measuring time with the *gnômôn* – is likewise given in the form of ratios.

exercises, and the same is true of the other factors. The amount of wine at a symposium was understood early on to be regulated by number. For Posidippus, the proportions of wine mixed with other ingredients elsewhere served as an image for his range of literary influences: ἕβδομον Ἡσιόδου, τὸν δ᾽ ὄγδοον εἶπον Ὁμήρου | τὸν δ᾽ ἔνατον Μουσῶν, Μνημοσύνης δέκατον ('The seventh [measure] of Hesiod, the eighth I say is of Homer, the ninth of the Muses and Mnemosyne the tenth', Posidippus 140.5–6 AB = *AP* 12.168.5–6). This undoubtedly had a programmatic function within his own collection, given that other poems draw on sympotic themes in introducing epigram collections.[27] Closer to the time of the arithmetical epigrams, Ausonius' *Riddle of the Number Three* (*Griphus tenarii numeri*; more on which below) underscores the orderliness that numbers gave to sympotic proceedings and the arithmetical extremes to which that might be taken: 'drink thrice, or three times three ... [or] nine times uneven three to complete the cube!' (*ter bibe uel totiens ternos ... imparibus nouies ternis contexere coebum*, Auson. *Griph.* 1 and 3).[28] If three is the numerical rule to follow, why stop at nine: 'three cubed' drinks also works! Beyond the world of poetry, arithmetic at the symposium does not escape the interest of Athenaeus. In Book 15 of his *Dinner Sophists* (Ath. 15.670f–671a), he discusses the division of apples and wreaths at symposia not only in language that suggests he has *mêlitês* and *phialitês* numbers in mind, but with specific reference to Plato's discussion of arithmetical games in education (*Laws* 819b–c) discussed at the beginning of this chapter. In addition to the influence of Posidippus' sympotic epigrams, that is, 'sympotic calculation' remained an interest for the intellectual figures at – and readers of – Athenaeus' literary dinner.

Sympotic calculations are found among the arithmetical poems. A notable development of Posidippus' calculation of guests is observable in the following epigram.

27 Gutzwiller (1998) 160–5.

28 The 'uneven' threes seem to mean only that it is an odd number, as in Verg. *Ecl.* 8.75; see Green (1991) 449.

δάκρυ παρὰ στάξαντες ἀμείβετε· οἵδε γὰρ ἡμεῖς,
  οὓς τόδε δῶμα πεσὸν ὤλεσεν Ἀντιόχου
δαιτυμόνας, οἷσίν <γε> θεὸς δαιτός τε τάφου τε
  τόνδ᾽ ἔπορεν χῶρον, τέσσαρες ἐκ Τεγέης
κείμεθα, Μεσσήνης δὲ δυώδεκα, ἐκ δέ τε πέντε
  Ἄργεος, ἐκ Σπάρτης δ᾽ ἥμισυ δαιτυμόνων,
αὐτός τ᾽ Ἀντίοχος· πέμπτου δέ τε πέμπτον ὄλοντο
  Κεκροπίδαι· σὺ δ᾽ Ὕλαν κλαῖε, Κόρινθε, μόνον.

(*AP* 14.137)

Let fall a tear as you pass by, for we are those guests of Antiochus whom his house slew when it fell, and the god gave us this place as both a banquet and a tomb. Four of us from Tegea lie here, twelve from Messene, five from Argos, and half of the banqueters were from Sparta, and Antiochus himself. A fifth of the fifth part of those who perished were from Athens, and you, Corinth, weep for Hylas alone. ($G = 4 + 12 + 5 + 1 + 1 + G(\frac{1}{2} + \frac{1}{25})$: G = total number of guests)

The epigram draws on a pre-existing dialogue between funerary and sympotic themes, making the connection explicit in verses 3–4 and by exploiting the bivalency of κείμεθα (5; cf. Simonides el. 102 Sider). In terms of content, the identity of Antiochus is unknown, but the scene is familiar. It recalls the story of Simonides' presence at a feast hosted by his patrons the Scopadae and his surviving the collapse of the banquet-hall when the Dioscouri appear and request his presence outside the building.[29] According to Cicero and Quintilian, that story was used to explain Simonides' 'invention' of mnemonics, since he was subsequently asked to remember who had been at the banquet and where they were sitting, although in all likelihood it is a biographical fiction.[30] This epigram rehearses the basic idea of the story, although in order to exemplify a different sort of mental dexterity. The epigram does not ask the reader to remember *who* was at the banquet, but to do the kind of sympotic summing seen in Posidippus' epigram and calculate *how many* dined and died at the dinner. Accounting for the dead is itself an aspect of Simonidean poetry, such as in his epitaph for all those who died at Thermopylae: 'once, four thousand from the Peloponnese fought against 3 million' (μυριάσιν ποτὲ τῇδε

[29] As early as Callimachus *Aetia* fr. 64.11–14; for all relevant sources and further aspects of the narrative see Simonides *PMG* 510 with useful clarifications in Molyneux (1971); the connection is noted by Buffière (1970) 199.

[30] Cic. *De or.* 2.351–3 and Quint. *Inst.* 11.2.11–16; see Slater (1972) and Lefkowitz (1981) 49–51.

τριηκοσίαις ἐμάχοντο | ἐκ Πελοποννάσου χιλιάδες τέτορες, 9 Sider = Hdt. 7.228). The overall effect is thus to present counting as an activity important for memory. The epigram presents enumeration as connected to the memorialisation of the war dead as seen in funerary inscriptions, but it also offers an explanation of that activity's origin by drawing on the recognisably Simonidean narrative that provided the origin of mnemonics. It employs the sympotic context to reposition the aetiology of commemoration, as well as its recognising and identifying of the fatalities, closer to the practice of arithmetic.

Beyond the *Palatine Anthology*, there survives another arithmetic poem with a sympotic setting, and it is to be found in Diophantus' *Arithmetica*. There are six books of the *Arithmetica* extant in Greek and a further four in Arabic; the order is thought to be the first three Greek books, then the four in Arabic, followed by the final three Greek books.[31] At the end of the fifth Greek book there is an epigram that versifies an arithmetic problem.

ὀκταδράχμους καὶ πενταδράχμους χοέας τις ἔμιξε
  τοῖς ὁμοπλοῖσι ποιεῖν χρήστ' ἐπιταττόμενος·
καὶ τιμὴν ἀπέδωκεν ὑπὲρ πάντων τετράγωνον,
  τὰς ἐπιταχθείσας δεξάμενον μονάδας
καὶ ποιοῦντα πάλιν ἕτερόν σε φέρειν τετράγωνον
  κτησάμενον πλευρὰν σύνθεμα τῶν χοέων·
ὥστε διάστειλον τοὺς ὀκταδράχμους, πόσοι ἦσαν,
  καὶ πάλι τοὺς ἑτέρους, παῖ, λέγε πενταδράχμους.[32]

(Diophantus *Arithmetica* V.30 Tannery)

Someone mixed eight-drachma and five-drachma measures of wine having been ordered by their fellow sailors to make it good. The price he paid for it all is a square number which when the units are ordered side by side will give back to you another square number, which possesses a side [i.e. a root] that is the sum of the measures. So discern the eight-drachma measures and speak about the other five-drachma ones, child, how many they are.

It is not the work of Diophantus himself: the *Arithmetica* otherwise exhibits little in the way of literary flourishes besides the introductory address to Dionysius, an orientation for the reader not

31 That is: I–III (Greek), 4–7 (Arabic), IV–VI (Greek). However, Book IV is not necessarily Book 8 of the original, and V is not necessarily 9 etc., since it appears that material is missing between the end of the Arabic text and the restart of the Greek. See Rashed and Houzel (2013) 6–8 for further discussion of the text and its history.

32 The text follows Tannery (1895) I, 384, a reading which he justified in Tannery (1891).

uncommon in mathematical treatises.[33] I think it is safest to consider it a later composition interpolated into the text which reworks the prose arithmetical problem into verse, and for my present purposes a poetic response to his arithmetic inserted into the *Arithmetica* only adds to the picture of Diophantus' poetic reception.[34] It is clear from the *scholia* to the *Palatine Anthology* that Diophantus was an important source for resolving the poems in Book 14.[35] So too, whether it was composed specifically for its place in the *Arithmetica* or taken from elsewhere, the interpolation of this epigram likewise shows an arithmetical poem being read together with Diophantine mathematics.

The epigram draws on a range of sympotic themes. The reference to the wine-mixer being ordered by his fellow sailors (ὁμοπλοῖσι, 2), if this is the correct reading,[36] leans on a well-trodden equation of symposiasts as sailing together in a ship.[37] The central problem is working backwards from the mixing of two wine measures (χόες) that were bought for different prices. The mixing of wine is a common theme in sympotic epigram, as Posidippus attests; mention of the units consumed also occurs (cf. Hedylus 3.2 *HE* = Ath. 11.486b2 and 6.2 *HE* = Ath. 11.473a5). Likewise, the commercial aspect of buying the wine recalls shopping-list epigrams recounting transactions (Asclepiades 25.9 *HE* = *AP* 5.181: λογιούμεθα, 'we will reckon'; 26.3 *HE* = *AP* 5.185.3: ἀριθμήσει δέ σοι αὐτός, 'he [the fishmonger] will count them himself'). A further important sympotic resonance is the speaker's concluding address to a παῖς to carry out the calculation. The request brings to mind sympotic addresses to

33 Cf. e.g. Archimedes' *On Spiral Lines* or Apollonius of Perga's *Conics*.

34 Allard (1980) II, 47–8, having provided a detailed palaeographical and philological analysis, concludes that while it is not by Diophantus, it is the work of someone well acquainted with Diophantus' method and that the textual tradition points to it existing already in the common archetype of the surviving MSS, the earliest of which comes from the thirteenth century. These are good grounds for thinking that it is a sophisticated and ancient poetic response to Diophantus' arithmetic.

35 Tannery (1895) II, 43–72 preserves the *scholia* with the epigrams as testimonia to the Diophantine tradition of arithmetic.

36 Tannery (1891) 378 proposes the corruption to the difficult ὀβελοῖς of the manuscripts from ὁμοπλοῖσι as a slip arising from confusion between β and μ in an archetype.

37 See Archilochus fr. 4, Choerilus fr. 9, Bernabé and Timaeus 566 F 149 = Ath. 2.37b–d, together with Slater (1976); Corner (2010); Gagné (2016) 223–4; Franks (2018) chapter 2.

a youth functioning as wine-pourer, for example Anacreon's command 'come now, bring to us the bowl, o youth' (ἄγε δή, φέρ' ἡμίν, ὦ παῖ | κελέβην, fr. 33 Gentili). Given the nature of the request, though, the epigram is also characterising the symposium as a site of intellectual competition and education. Challenges were set to test one's cultural prowess: in the game of *skolia* symposiasts could each be required to contribute a verse to a song;[38] they could probe each other's knowledge of, say, Homer;[39] or they could be interrogated about which fish is best in which season.[40] Equally, the symposium in Archaic and Classical Greek society was where younger elite males were expected to absorb Greek culture as well as to learn how to behave, and that idea lasted well after education became more formalised outside of the dining room.[41] In this respect, the speaker offers a sympotic challenge to a younger participant as a test of his educational progress in arithmetic. The epigram stages a youth being put on the spot and asked to calculate the number of wine measures in total just before they would be serving up the wine to the attendants: even complex arithmetic is part of one's sympotic acculturation.

As well as integrating numbers into various generic forms, there are poems in the collection that take a playful approach to the content of tradition. The single couplet of *AP* 14.12 looks back to a figure more well known from Herodotus' *Histories*: 'Croesus the king dedicated six bowls weighing six minae, each one heavier than the next by one drachma' (ἓξ μνῶν ἓξ φιάλας Κροῖσος βασιλεὺς ἀνέθηκεν | δραχμῇ τὴν ἑτέρην μείζονα τῆς ἑτέρης: the first bowl weighs 97.5 drachmas). Herodotus had surveyed Croesus' dedications to Apollo at Delphi, which included two large bowls – one of gold, one of silver – weighing many talents and minae (Hdt. 1.51.1–2). He gives both the geometric form of solid gold ingots and their total – 'he made the longer sides six palm-lengths, the

[38] On the nature of the *skolion*, see Dicaearchus frr. 88 and 89 Wehrli and the discussion of Collins (2004) 84–98.

[39] In Aristophanes' *Banqueters*, for example, a father takes the opportunity at the symposium to check his son's knowledge of Homer by asking him the meaning of the *hapax* κόρυμβος (fr. 233 KA; cf. *Il*. 9.241).

[40] Cf. Clearchus fr. 63.1.28–31 Wehrli. See Kwapisz (2014) 211 for the wider context of the fragment.

[41] See Griffith (2015) 45–7 with references and bibliography.

shorter sides three palm-lengths and the height one palm. Their number was one hundred and seventeen' (ἐπὶ μὲν τὰ μακρότερα ποιέων ἑξαπάλαστα, ἐπὶ δὲ τὰ βραχύτερα τριπάλαστα, ὕψος δὲ παλαστιαῖα, ἀριθμὸν δὲ ἑπτακαίδεκα καὶ ἑκατόν, Hdt. 1.50.2) – and their weight in talents – 'four of them were refined gold, each weighing two and a half talents, the others ingots were of white gold, with a weight of two talents' (ἀπέφθου χρυσοῦ τέσσερα, τρίτον ἡμιτάλαντον ἕκαστον ἕλκοντα, τὰ δὲ ἄλλα ἡμιπλίνθια λευκοῦ χρυσοῦ, σταθμὸν διτάλαντα, Hdt. 1.50.2). Moreover, he also provides a little calculation of his own when accounting for the solid gold lion which weighed ten talents that Croesus dedicated but which was burnt in a fire at Delphi: 'and now it lies in the treasury of the Corinthians, but weighs only six and a half talents, for the fire melted away three and a half talents' (καὶ νῦν κεῖται ἐν τῷ Κορινθίων θησαυρῷ, ἕλκων σταθμὸν ἕβδομον ἡμιτάλαντον· ἀπετάκη γὰρ αὐτοῦ τέταρτον ἡμιτάλαντον, Hdt. 1.50.3). Herodotus had already demonstrated that one needs arithmetical acumen to count up Croesus' gifts, and this poem develops that numerically exacting survey to offer a more challenging account of Croesus' 'ever growing' (cf. τὴν ἑτέρην μείζονα τῆς ἑτέρης) riches.

Two further poems revolve around the number of Muses, who divide apples among themselves. In one, the Graces share apples with the Muses (*AP* 14.48). It asserts the intrinsic numerical nature of the goddesses even though, as Bonnie MacLachlan's study on the Graces and Tomasz Mojsik's on the Muses have shown, their number varies depending on the ancient tradition and on the choices of each cult.[42] In the other, the setting and language bring to mind two parallel literary themes, with Eros complaining to his mother Aphrodite that the Muses have stolen his apples (Πιερίδες μοι μῆλα διήρπασαν, *AP* 14.6.3). Although late in the tradition, this recalls the use of apples in contexts of declaring one's love and more specifically of the apple of discord that ultimately precipitated the Trojan War, which according to Colluthus Aphrodite wanted for her Erotes (*De rapt*. 67). Two others in the collection have apples apportioned not by the Muses

[42] MacLachlan (1993) 51 n.23; Mojsik (2011) 74–97.

or Graces, but by the Bacchants Agave, Ino, Autonoe and Semele (14.117–18). There is humour in replacing their famous *sparagmos* of Pentheus with a different, less lethal kind of 'dividing up', and this replacement is thematised through the similar-sounding μῆλα ('apples') and μέλη ('limbs'). The fact that Semele is included in both poems – while dead during the events of Euripides' *Bacchae* (cf. 1–63) – places this particular apportioning prior to the fatal events that conclude the play: even before Dionysus' arrival, that is, Theban women knew well how to divide things between themselves.

As the *Cattle Problem* so clearly demonstrates, composing arithmetic in verse went hand in hand with searching the literary past for a suitable image or images through which to express the manipulation of numbers. The arithmetical poems in *AP* 14, it should now be clear, enact the same sort of excavation of traditional genres and content, in order to furnish their poems with the sensible bodies – the 'stuff' – of logistic that must be calculated. To put it another way, this section has shown that producing arithmetical poetry involved a specifically numerical reception and (re)reading of the earlier tradition.

4.2 The Cultural Capital of Calculation

The preceding section has demonstrated that, at the level of individual poem, the result of packaging arithmetical content in poetic form is a trend of reading pre-existing genres and motifs as containing the seeds of arithmetic. That is, the intent to cultivate mathematical dexterity through poetry pushed authors of the poems to reinterpret and reuse traditional literary forms and to reify their numerical aspects. Late antique poetry is now a burgeoning area of scholarship, with numerous studies seeking to reappraise its poetry as creative reactions to changing literary and cultural contexts and not as belated and derivative show pieces palely imitating earlier models.[43] This section thus aims to provide a wider intellectual context for the arithmetical poems and how

[43] The bibliography on this subject is ever-growing, but in terms of orientation and the larger view of the period I have found the following particularly useful: Roberts (1989); Pelttari (2014); Elsner and Hernández Lobato (2017).

they might have functioned within a late antique literary culture. I look to the Latin poetry of Late Antiquity and its reflections on number in poetry; the analysis is offered as comparative material informing a reading of the Greek arithmetical poems: I am not claiming that they were composed with knowledge of the following Latin works. In terms of the level of mathematics, too, there is nothing comparable, but the poems should nevertheless be understood as constructing a recognisably late antique mode of engagement for their readers as well as being representative of a wider trend of incorporating arithmetic within displays of poetic novelty and learning. Arithmetic finds a place within poetry, I propose, as an additional means for gauging the cultural capital of both educated elite composers and readers.

First, however, it is worth locating the arithmetical poems' context of production. Their common thread is the numericalisation both of pre-existing literary forms and of figures or objects from the literary past. This is a strategy of fitting calculations into verse that arose, *inter alia*, with Archimedes' *Cattle Problem*. The difference, though, is both the lack of surrounding cultural historical context, as there is in the case of the *Cattle Problem* and its exchange between two famous intellectuals, and the lack of a broader poetic project into which the poems fit, as there is, for example, in the passages from Lycophron's *Alexandra* or Hesiod's *Melampodia* discussed in Chapter 3. A parallel for the arithmetical poems' reworking of earlier genres and topics as well as their self-contained nature can be identified in the wider educational curriculum. The preserved rhetorical handbooks or *progymnasmata* detail the literary education of the imperial student, providing a series of different exercises in the art of speaking and writing; these included how to deploy anecdotes, recount mythical narratives and fables, offer arguments for and against a proposition and deliver encomia and invective. One of the later exercises to be completed is prosopopoeia, the personification of an object or a person from history or myth.[44] The student would have to compose a response in verse or prose to such questions as 'what

[44] In the earliest extant example, the *progymnasmata* of Theon, he makes no distinction between ethopoeia as the characterisation of people and prosopopoeia as the personification of things. This distinction does not affect my argument.

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words would Cyrus say as he attacks the Massagetae?' (τίνας ἂν εἴποι λόγους Κῦρος ἐλαύνων ἐπὶ Μασσαγέτας, Aelius Theon 115.17–18 Spengel) or 'what words would Andromache say to Hector?' (τίνας ἂν εἴποι λόγους Ἀνδρομάχη ἐπὶ Ἕκτορι, Hermogenes 15.7 Spengel). The exercises not only asked students to dwell on the material of the inherited literary tradition, they asked them to recompose it, to produce compositions matching the style and metre of the original but with new things to say. This educational background is part of the impetus for the return to Homeric subject matter and the Homeric voice or, say, to rhetorical performances in the style of the Attic orators, while at the same time offering something novel.[45] Yet many short verse compositions survive in the *Palatine Anthology*, exemplifying what such exercises might produce, and they may have once formed a collection (for example, *AP* 9.457–80). In their reliance on the forms and models of the past as well as in the revivification of mythical or historical figures, the arithmetical poems echo the strategies of these *progymnasmata*. Their rehearsing and reconfiguring of the literary past not only produces mythical 'what would X say to Y' scenarios, it reaches across disciplines to incorporate aspects of mathematical education too.

The parallel of the *progymnasmata* proposes a post-Hellenistic context of production for the arithmetical poems. In terms of their context of reading and of reception, I think that it makes most sense to view them as a late antique development. To exemplify what is particular to engagements with the reader in the poetry of Late Antiquity, I want to consider two Latin works that underscore the importance of arithmetic for conceptualising the form and interpretability of a poem. Ausonius' preface to his *Cento nuptialis* (*Wedding Cento*) is a key passage of late antique literary theory, and it rests on an explicitly arithmetical comparison. A cento is a poem stitched together from lines of existing poetry, and in this case the poem is a bricolage of Vergilian half-lines reassembled in order to describe a night of nuptial consummation. In introducing the poem to his correspondent Paulus, he outlines the practice of

45 For the 'revival' of oratory see Anderson (1993) chapter 3 and Schmitz (1999b); for the reanimation of Homer see broadly Zeitlin (2001) and Greensmith (2020) chapter 1 for Quintus of Smyrna's *Posthomerica* in particular.

composing centos.[46] His explanation exemplifies the composing of centos with the Greek game called στομάχιον ('Belly-teaser'), a tangram in which a square cut into fourteen polygons can be rearranged to create many other figures (such as a ship or a gladiator).[47] It was also explicitly theorised by Archimedes, who dedicated a treatise to the topic, a single fragment of which has been recovered from a palimpsest.[48] Whatever the precise focus of Archimedes' treatise, it undoubtedly influenced the later use of the image for underscoring the possibilities of combination.[49] Given the close relationship I argued for in Chapter 3 between mathematics and Homeric epic in a work by Archimedes, Ausonius' choice of the στομάχιον to describe his own use of epic may have been informed by a now lost literary or cultural implication of the calculations mentioned in the treatise.[50] As Fabio Acerbi has shown, moreover, combinatorics was certainly a matter of theory by the time of Hipparchus (second half of the second century BCE), who criticised the Stoic thinking of Chrysippus and his calculation of the possible claims that could be made given ten 'assertables' connected by a conjunction such as 'and'.[51] For my purposes, it is sufficient to note that combinatorics was applied in the domain of language and the construction of sentences from the Hellenistic period. Ausonius' example of the στομάχιον, while not requiring the application of arithmetic, attests to an arithmetic understanding of compositional possibilities and of the construction of new meanings out of canonical forms.

[46] For an extended discussion of the preface and its importance see McGill (2005) chapters 1–21; Pelttari (2014) 104–7, and for the textual issues in the passage see Green (1991) 521–2.

[47] Aside from Archimedes – see below – Lucretius uses the image to explain how colours come about from colourless elements (2.772–87) and the Latin grammarians Caesius Bassus (*CGL* 6.270.30) and Aelius Festus Aphthonius (*CGL* 6.100.4) to refer to metrical combinations. See too Ennodius (*c.* 340 Vogel).

[48] On the reconstruction of the text see Netz et al. (2004), Netz in Netz et al. (2011) 285–7, with a cautionary and sensible evaluation of the evidence by Morelli (2009).

[49] Both Caesius Bassus and Aphthonius – p. 181 n.47 above – refer to the original, divided square as a *loculus Archimedius*.

[50] For what it is worth, the puzzling name στομάχιον could have had the secondary interpretation (or indeed primary meaning which was subsequently corrupted) of στόμα Χῖον ('Chian mouth'), referring to Homer's mouth. A game of almost infinite variety would resonate with his place as the fountainhead of Greek culture and his single mouth's ability – despite demurring – to list the entire multitude at Troy.

[51] Acerbi (2003).

An additional example that again functions with the idea of compositional combination will set in high relief the role of arithmetic in conceiving of a poem's interpretability. The early fourth-century poet Publilius Optatianus Porfyrius – commonly known as Optatian – is a late antique poet who is now gaining his fair share of scholarly interest. He was a composer of *carmina cancellata* ('latticed poems'), poems in grid-like patterns that preserve hidden sentences and verses at their edges and in variegated patterns across the gridded page.[52] For example, poem 16 presents 38 hexameters comprising a panegyric to Constantine with an acrostic that likewise extols Constantine as ruler and inheritor of Augustus' mantle. Three further mesostichs also run vertically from the top to the bottom of the grid starting from the tenth, nineteenth and twenty-eighth letter of each verse. They produce a string of letters that, when converted into Greek, announce instead Christ's bestowing of power on Constantine.

Rather different from these *carmina cancellata* is poem 25.

ardua componunt felices carmina Musae
dissona conectunt diuersis uincula metris
scrupea pangentes torquentes pectora uatis
undique confusis constabunt singula uerbis.[53]

(Optatian 25)

The productive Muses compose laborious poems,
they connect discordant chains from diverse metres;
composing difficulties, twisting the poet's heart,
they fit individually whichever way the words are combined.

The poem develops a Hellenistic model of composition first attempted by Castorion of Soli (*SH* 310 = Ath. 10.454f), in which the feet of his *Hymn to Pan* can be arranged in any order, and where the content of the words also advertises the fact. With Optatian's poem, the reader is freer since the words rather than the feet can be reorganised. Thus, these four verses of five words each can be combined in a truly staggering array of combinations.[54]

[52] The edition of Polara (1973) remains fundamental, although see Squire and Wienand (2017) 28–51 for a new typesetting of the figure poems.
[53] The text follows Polara (1973).
[54] See Levitan (1985) 250–1; Squire (2017) 88–90. Pelttari (2014) 77–8 outlines the rules restricting the combination of words, which nevertheless allows for many combinations.

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The poem sets an arithmetic challenge to the reader: in just how many ways can the words be rejigged (*confusis … uerbis*, 4)? There were attempts – possibly dating back to the fourth century CE – to calculate the poem's potential permutations, and the question is equally alive in modern scholarship (just over 39 billion variations, according to one commentator).[55] Optatian's four-line poem is a textual Rubik's cube that outdoes Leonides' isopsephic epigram by concealing not a numerical account, but an innumerable amount of further poetry. Poem 25 also outdoes the *Cento nuptialis*: it is the poetic instantiation of the στομάχιον game, since it provides the 'square' of words that – unlike the *Cento* – can be rearranged any way the reader likes. Fascinating, in this respect, is that in some manuscripts the combinatory challenge has led the copyist to try out the permutations, scaling the poem up as far as 84 verses.[56] A later reader has attempted to answer the implicit question exhaustively. This evidences the imbrication of numerical and literary appreciation that confronts readers of the poem; the copyist – and indeed the scholiast – makes a claim about the numerical extent of the poem's reconfigurability.

Ausonius and Optatian's explorations of poetic form establish that arithmetic had a role in conceptualising the possibilities and the limits of literary innovation. Their importance for understanding the arithmetical poems lies in the connection between the arithmetic and the deep involvement of the reader in the construction of meaning. Ausonius explains this through a mathematical image, and the readers of Optatian's poem 25 clearly aimed to calculate the number of meanings possible. The arithmetical poems are neither as self-conscious nor as theoretical in their comments. Nevertheless, they demand the work of the reader to make sense of the poem and get beyond the surface of the expressed ratios, just as a reader must work to configure the many meanings of Optatian's chequerboard *carmina cancellata* and to appreciate the Vergilian undercurrent of Ausonius' *Cento*. In a seminal study of Hellenistic epigram, Peter Bing argued that

55 For the date of the *scholia* see Pipitone (2012) 28–30, 91–3. For the number of combinations: 1,792, Levitan (1985) 251 n.17; 3,136, Flores and Polara (1969) 116–20; 39,016,857,600, Pelttari (2014) 78.

56 Flores and Polara (1969) 116–22.

they were often written in such a way as to require the reader to supply further information about context, addressee or imagined location not made explicit, an effect which he called 'the game of supplementation' (*Ergänzungsspiel*).[57] Given that many arithmetical poems are influenced by Hellenistic epigram, this readerly demand may be part of the genre's adaptation to arithmetical content. A similar process is at work: in both cases the reader must take the epigram's contents and out of that construct a plausible scenario beyond what the poem describes on the surface. While number and epigrammatic poetry thus have a long interrelation, the notably late antique development of the arithmetical epigrams is the extent to which the experiment with form is taken. The presence of numbers on epitaphs has become a full series of calculations that require computing, just as Optatian's poem outdoes earlier 'reconfigurable' poems in its possible permutations.[58] The arithmetical poems belong to Late Antiquity, simply put, in their increased reliance on the role of the reader in uniting the individual components of a text into a meaningful whole.

A further operative aspect of poetry in Late Antiquity is the construction of innovative poetry and the display of virtuosic skill using the material building blocks of the literary tradition: Vergilian lines are cut and pasted to form Ausonius' *Cento*, while Optatian's poems draw on numerous canonical works which disintegrate and reform in front of the reader's eyes.[59] The arithmetical poems, by contrast, do not work at the level of the material text but with the constituent objects described within it. However, as I noted in the previous section, these topics themselves draw heavily on the heritage of various literary forms. The matter of the tradition itself becomes the objects with which the poets demand the reader grapples and engages. Fortunately, the poetry of Late Antiquity also

[57] Bing (1995).

[58] In addition to the example of Castorion (above), see the Midas epigram quoted by Socrates in the *Phaedrus* (264c–d; with variant reading at *Cert*. 15 and in *GVI* 1171a and b), Simonides' poem (el. 92 Sider = *AP* 13.30) possibly in reference to Timocreon and Timocreon's reply (*AP* 13.31). For Nicodemus of Heraclea's rearrangeable poems, see Page (1981) 541–5.

[59] For Optatian's affinities with and allusion to earlier Latin literature see González Iglesias (2000) and Schierl and Scheidegger-Lämmle (2017).

furnishes an example of where tradition and its constituent objects and tropes are treated numerically. A poem that is almost entirely composed out of numbers and enumeration is Ausonius' *Riddle of the Number Three*. The poem rings the changes on things existing in threes or nines, under the influence of three cups at the symposium. There has been much discussion about the possible 'answer' to the riddle, although I am most persuaded by the proposal that, since the Greek γρῖφος means riddle but also a woven fishing-basket or net (LSJ *s.v.* γρῖφος A.1; cf. Ath. 10.457c–458a), the title *Griphus* indexes 'the dense texture of its literary allusions'.[60] Ausonius is steeped in the numbered-ness of tradition. His prose preface contains multiple references to no less than four canonical Latin authors.[61] The *Griphus*' composition is figured as the result of drinking, following the style of Horace's poem (3.19) 'in which, on account of midnight, the new moon and Muraena's augurship the inspired bard calls for three times three cups' (*in qua propter mediam noctem et nouam lunam et Murenae auguratum ternos ter cyathos attonitus petit uates*, *Praef. ad Griph.* 16–17). Two further references to Horace, in significant third positions (*Satires* 1.3 and *Odes* 3.1), make for a three-pronged allusion to the Augustan lyricist, supported also by an opening reference to Catullus *c.* 1, which plays with the idea of a three-book collection (see Chapter 2, Section 3).

While the preface establishes that talking in threes is a habit inherited from canonical authors, the verses aim to affirm the three-ness of various cultural institutions. As in the arithmetical poem on the Muses and Graces, Dunstan Lowe has noted that Ausonius in the *Griphus* asserts the numerical nature of the Muses as nine (22), despite elsewhere thinking of them as either three or eight (*Epist*. 13.64), and that he numbers the Sibyls at three, although that number is nowhere else attested.[62] Ausonius' strategy amounts to an attempt to collect and order cultural data from

60 Lowe (2012) 344.
61 Lines 2–4 ~ Ter. *Eun*. 1024; 5–6 ~ Cat. *c*. 1.1; 16 ~ Cic. 2 *Verr*. 1.66; 17–18 ~ Hor. *Odes* 3.19.9–15; 28 ~ Hor. *Sat*. 1.3.29–30; 38 ~ Hor. *Odes* 3.1.1.
62 Lowe (2012) 342–3. Varro's list of ten Sibyls seems to have been the standard (cf. Lactant. *Div. inst.* 1.7–12).

the past and to regulate it so as to make it manageable. Indeed, Ausonius' regulatory mode is a key part of the preface. He sent the letter to Symmachus with the expectation that the enclosed poem may be either approved or destroyed (*Praef. ad Griph.* 11–13), but this is paired with the concern that his original composition has been 'mutilated for a long time by secret yet popular readings' (*diu secreta quidem, sed uulgi lectione laceratus*, *Praef. ad Griph.* 10–11). Regulation is part of the impetus for preserving the text; literary and cultural artefacts are associated with specific numbers, which Ausonius must protect against the distortions of time and populism: indeed his list of threes does not extend to anything related to the *profanum uulgus* ('unitiated crowds').[63] He is aiming, not exhaustively but symbolically, to impress the idea of literature and culture's numerical nature within elite circles and their shared late antique *paideia*. The *Griphus* too is an argument for the cultural capital of numbers.

Reading the *Griphus* in this way makes Ausonius' allusiveness in the preface particularly piquant. He characterises the original composition of the *Griphus* as nothing more than 'a frivolous piece worth less than Sicilian baskets' and 'a trifling booklet' (*haec friuola gerris Siculis uaniora … nugator libellus*, *Praef. ad Griph.* 9–10). Yet his claims to mere playfulness belie his referentiality. The second phrase refers back to the Catullan allusion at the start of the preface and Catullus' opening poem responding to a three-volume history (*c.* 1.6). The first phrase refers to *gerrae*, another form of wickerwork that had a metaphorical meaning of nonsense, but it is also modified by *Siculus*, which makes it a product of the three-cornered Sicily.[64] Ausonius intimates that the composition is certainly playful and may be nothing more than an experiment; but his allusiveness suggests that even in trifling works, reading a little deeper uncovers a whole world of numbers and numberedness.

Of course, the arithmetical poems are more challenging than the *Griphus* in that its answer – if that is the right word – is not hidden to the reader. Nonetheless, further works do reveal Ausonius'

[63] A Horatian tag, cf. *Odes* 3.1, and a clear allusion to Callimachus 2 *HE* = *AP* 12.43 and his aesthetics of social exclusion.
[64] Sonny (1898).

cultural capital of numbers in action.[65] *Epistle* 14 addressed to Theon – an otherwise unknown friend – records a gift of thirty oysters and, noting the lack of literary accompaniment, reworks an old letter in return, the poem that follows the prose introduction. The poem is divided into four metrical schemes: hexameter (1–18), iambic (19–23),[66] hendecasyllable (24–35) and asclepiads (36–56). The hexameters introduce the theme of the oysters and list a series of single verses (*monosticha*, 4) characterising the number: for example 'as many as the Geryones, if they were multiplied by ten' (*Geryones quot errant, decies si multiplicentur*, *Epist*. 14b.6). In the following iambics, Ausonius characterises the number arithmetically, for example 'three times ten, I think, or five times six' (*ter denas puto quinquiesue senas*, 24). The hendecasyllables describe the sourcing and cooking of the oysters. The focus is on lexical dexterity and 'a general luxuriance of expression'.[67] In the concluding asclepiads, he notes the excessive length of his writing and commands his pen to stop writing (or the composition be erased), in case the parchment costs more than the oysters. The concluding reflection that the papyrus may cost more than the (presumably free) thirty oysters invokes the relationship – by now recognisable from Part I – between poetic content and the extent required to express it. The humour here is that Ausonius may have overdone his attempt to supply a composition in lieu of one from Theon. This virtuosic piece displays the mythological, mathematical and lexical skills required to be a learned writer. Significant for my purposes is the arithmetical section's introduction.

quod si figuras fabulis adumbratas
numerumque doctis inuolutum ambagibus
ignorat alto mens obesa uiscere,
numerare saltim more uulgi ut noueris,
in se retortas explicabo summulas.[68]

(Ausonius *Epistles* 14b.19–23)

[65] In addition to *Epistle* 14, arithmetic combined with literary reference is displayed at *Epist*. 10.5–25 and 15.5–14.
[66] *Pace* Green (1991) 632, who gives the hendecasyllables as 35–46 and the asclepiads as 47–56.
[67] Green (1991) 634.
[68] Latin text after Green (1991).

But if in some way a mind fattened to its innermost depths does not know forms shadowed by stories and number wrapped in learned riddles, I will unfold the factorised sums so that you might know how to count in the common way at least.

These lines mark the transition between the literary and arithmetical characterisation of thirty and mark out the stakes attached to the different types of learning. Unlocking the number through literature requires a knowledge of narratives and an ability to decipher obscurities or riddles, whereas arithmetical calculation alone belongs to the *uulgus*. Theon is mocked for his size elsewhere (*Epist.* 16.31), but the imagery in these lines makes a more general point about mental exercise: a mind wrapped in fat (out of disuse) will not be able to deal with the already obscure and wrapped-up descriptions of numbers. It is the expression of numbers through poetry that makes the exercise intellectual and not accessible to the masses, that is, what makes it elite.

Ausonius' use of *ambages* – an obscurity or enigma – to characterise his descriptions of the number thirty through literary references provides one explanation for the designation of the *Griphus* and its three-counting as a riddle. More importantly, however, Ausonius' distinction provides a parallel for the nature of the arithmetical epigrams. It is my contention that their form is a result of the same sense of the cultural capital of numbers. Their exercising of the reader's knowledge of, and control over, the numerical aspects of the cultural and literary past is part and parcel of the wider habit of deploying learning competitively. Around a third of the arithmetical epigrams directly invoke mythological topics, while others take on topics such as the constellations (e.g. *AP* 14.124). But it is not solely about content. As I have demonstrated, almost all wrap their arithmetic in the *ambages* of a pre-existing poetic form. The possibility of solving the series of simultaneous equations encoded in the arithmetical poems offers readers the opportunity to cash in their own cultural capital, and it is a capital derived from knowing literary tropes, traditions and clichés as much as it is knowing enumerable 'objects' or 'stuff' of the mythical past. More than an awareness of the numbered nature of the cultural and literary past, though, the poems provide real and serious arithmetic problems to be solved that go beyond Ausonius'

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display of factorisation: they are both an arithmetical and literary exercise. Ausonius' poem explicitly notes, furthermore, that in erudite exchanges, arithmetic retains its currency best when expressed in obscure and circumlocutory language, framed in stories (cf. *fabulis*). By versifying numerical aspects of antiquity, the poems not only provide a literary and arithmetic challenge for the reader simultaneously, they supply it in a form that also increases the distinction of the author (and solver) within an elite group.

The arithmetical poems are a quintessentially late antique product in that sense, since their insertion of arithmetic into poetry demands the reader's participation in the construction of meaning, displays the authors' education and skill in transforming the literary tradition and results in an innovative and experimental poetic form. Accounting for the potential educational context, moreover, does not mitigate this claim. Rather, if they are the product of rhetorical training, then they evidence a practice taking seriously Ausonius' emphasis on the value of computing in poetry, not to mention providing *exempla* for the combination of literate and arithmetical learning. Ultimately, though, attempting to distinguish definitively between the function of the poems as either educational *exempla* or virtuosic show pieces is unhelpful; the two are not mutually exclusive and the poems beyond the Metrodoran collection show that they circulated in multiple contexts. The wider significance of the cultural capital of calculating for which I have argued in this section, then, is that it modifies the literary historical trajectory of numbers in poetry. Whereas the poems of Archimedes and Leonides have often been imagined to be esoteric, peculiar experiments of form that survive only out of curiosity, the view from Late Antiquity is rather different. The arithmetical poems make clear that composing calculations was not only the preserve of mathematicians grappling with the inherent difficulty of incorporating their disciplinary content into verse, but an expectation for educated late antique authors as well as readers.

4.3 Arithmetic Anthologised

At some point after the appearance of the arithmetical poems, they were brought into a collection by the shadowy figure Metrodorus.

In this section, I want to trace out the poems' reception and interpretation as they were anthologised by Metrodorus. I illuminate the dialogue between poems encouraged by their editorial organisation and selection within the Metrodoran collection. I then identify an overarching theme that comments on the nature of the collection and the purpose of the compositions. Following the conclusion of the previous section, I argue that the nature of the Metrodoran collection foregrounds the same sophisticated balance of arithmetic novelty expressed through traditional poetic forms that was operative in individual poems.

First, though, it is necessary to set out the evidence for Metrodorus' collection. The organisation of the poems within Book 14 may date back to Constantinus Cephalas in the early tenth century CE and is no later than the formation of the *codex Palatinus* in the middle of that century, the basis for the modern *AP*.[69] His collection is reconstructed on the basis of a comment in the *scholia* to Book 14 in the *codex Palatinus*. At poem *AP* 14.116 the scholiast introduces the following poems as 'the arithmetic epigrams of Metrodorus' (Μητροδώρου ἐπιγράμματα ἀριθμητικά), and this probably extends all the way to 14.146.[70] The collection is accompanied by an intermittent marginal numbering that in all likelihood represents the poems' order in the Metrodoran collection: *AP* 14.116 is designated β (2), 117 as γ (3), etc. This coherence is supported by the wording of arithmetical solutions given in a number of *scholia* which implies that the poems are drawn from a single collection.[71] Outside of this section, poems have been found with a marginal numbering that is missing in the core sequence: *AP* 14.6 and 14.7 are 19 (ιθʹ) and 28 (κηʹ) respectively. They are thus also added to the Metrodorus collection, as are *AP* 14.2–5 and 14.48–51, which are thematically and stylistically of

69 See p. 163 n.5 above.

70 I will discuss 14.147 below. The final three poems of *AP* 14 are oracles and seem to have no connection with the arithmetic poems but rather look to have been displaced from the oracle section or added later. Since the *scholia* cross-reference different arithmetical poems, it has reasonably been thought that they accompanied a previous collection. Tueller (2021), which considers the interrelation between the *scholia* and the poems in Metrodorus' collection, appeared too late for me to fully address here. He understands the *scholia* also to be Metrodoran; I would say that this has yet to be proved and that the *scholia* could well have been added in the course of the collection's transmission.

71 See Teichmann (2020) 102 n.76 and 103 n.85.

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a piece with the securely Metrodoran compositions. *AP* 14.1 is not thought to be from the Metrodoran collection.

The arithmetical epigrams share with the wider literary context an immersive participation in the production of significance on the part of the reader. The 'game of supplementation', however, could also operate across a poetic collection, in which the arrangement invites the reader to make connections between poems as they navigate through the work. An early example of this editorial ordering is the Milan papyrus of Posidippus, the individual poems of which echo and cap each other, both within and across its thematic sections.[72] Posidippus' ἐπιτύμβια is again particularly important here, since the theme of accounting operates across the section, contrasting different forms of enumerating and valuing life. Admittedly, the Metrodoran collection and its bounds cannot be identified with the same precision as Posidippus', recovered from a mummy cartonnage (more or less) intact, but its integration into Book 14 is sufficiently contained to allow for analysis and cautious conclusions.

Preliminarily, poems in the Metrodoran collection evince an order suggestive of editorial placement, with similar poems set in thematic dialogue and close proximity, creating a cohesive anthology playing variations on a theme.[73] The epigram on Diophantus appears within a sequence of epigrams counting up life and death (*AP* 14.124–7) and other funerary-themed epigrams ask instead for the inheritance to be calculated from its respective proportions (14.123, 128 and 143). Poems were also connected on the lexical and stylistic level. For example, 14.125 is a funerary epigram for Philinna that asks for the number of her children to be calculated. Philinna is a common enough name to encounter in an epigram, but it is noteworthy that it appears in two earlier epigrams in the collection.[74] Philinna is the name of one of the maidens who divide up the walnuts in 14.116 and 14.120. The shape of the

[72] The bibliography on this topic is now quite large. For an introduction to the various interrelations in the papyrus, see the contributions of Bing, Kuttner, Sider, Stewart and Sens in Gutzwiller (2005).

[73] See Tarán (1979).

[74] Cf. *AP* 9.434.3 (an epitaph on Theocritus) and Apollonides 11 GP = *AP* 9.422.3; probably later than this epigram is Paul the Silentiary 5.258.1 and Agathias 5.280.1.

collection parallels a reader's progress with the mathematically themed events in an imagined Philinna's life: as a youth she plays with her age-mates and later is buried by her remaining family. Given the epigrams on dividing up walnuts and apples (14.116–20), the description of her offspring as the 'fruit of her womb' (καρπὸν . . . λαγόνων, *AP* 14.125.2) frames the calculation as following the same rubric as those that began the collection: the topic is new, but the arithmetical process will be the same as before. In a similar vein, 14.120 begins as a poem on dividing walnuts following 14.116, but by the end of the poem it has resumed a focus on the Graces and the Muses, echoing 14.3. Likewise, the dual focus of 14.124 on astronomy and the lifespan of an unnamed man echoes the language of the Diophantus epigram. The child of the unnamed man is also 'late-born' (τηλύγετον, *AP* 14.124.6), he sees his child (and wife) perish (7–8), and then he attains the end of life (βίου . . . τέρμα περήσεις, 9; cf. 14.126.10 above). Represented as a prediction, though, its future tenses invert the funerary finality with which Diophantus' life is laid out. There is little to determine which poem has priority. Important rather is the shared language echoing across the collection. It points to an editorial arrangement that expects readers to move through the collection, make connections and read the compositions in a similar manner to other literary anthologies, in addition to possibly extracting a poem for educative or socially competitive purposes.

One further theme in the collection that has (to the best of my knowledge) received no attention is the focus on family relations. It is not just the inheritance for children, the number of offspring or family members that must be calculated. Three extant poems have a more marked sense of familial connection.

ἁ Κύπρις τὸν Ἔρωτα κατηφιόωντα προσηύδα·
τίπτε τοι, ὦ τέκος, ἄλγος ἐπέχραεν; ὃς δ' ἀπάμειπτο·

(*AP* 14.3.1–2)

Cyprus addressed downcast Eros: 'what grievance touches upon you?' He answered . . .

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τίπτε με τῶν καρύων ἕνεκεν πληγῇσι πιέζεις,
ὦ μῆτερ; τάδε πάντα καλαὶ διεμοιρήσαντο
παρθένοι.

(*AP* 14.116.1–3)

Why, mother, do you distress me with blows on account of the walnuts? All these the beautiful maidens divided up.

ποῦ σοι μῆλα βέβηκεν, ἐμὸν τέκος; ἕκτα μὲν Ἰνὼ
  δοιὰ καὶ ὀγδοάτην μοῖραν ἔχει Σεμέλη·

(*AP* 14.117.1–2)

Where have the apples gone, my child? Ino has twice a sixth share and Semele an eighth.

The mother asks an initial question which prompts the delineation, and then the child outlines the proportions but does not offer the calculation. Embedded alongside the intertwining of arithmetical and literary and generic allusion is a frame that presents the arithmetical challenge as one exchanged between mother and child, in which the child requires help with resolving the ratios. Since this occurs in both hexameter and elegiac compositions it is reasonable to think that there is an underlying explanation for the shared frame (whether they are the product of multiple authors, or the concerted variation of a single author).

An anonymous poem preserved in an appendix to the *Planudean Anthology* helps to shed light on this framing and its connection to arithmetical problems.

ἡμίονος καὶ ὄνος φορέουσαι σῖτον ἔβαινον·
αὐτὰρ ὄνος στενάχιζεν ἐπ᾽ ἄχθεϊ φόρτου ἑοῖς·
τὴν δὲ βαρυστενάχουσαν ἰδοῦσ᾽ ἐρέεινεν ἐκείνη·
μῆτερ, τί κλαίουσ᾽ ὀλοφύρεαι, ἠύτε κούρη;
εἰ μέτρον ἓν μοι δοίης, διπλάσιον σέθεν ἦρα·
εἰ δὲ ἓν ἀντιλάβοις, πάντως ἰσότητα φυλάξεις.
εἰπὲ τὸ μέτρον, ἄριστε γεωμετρίης ἐπίιστορ.

(Cougny III, 563 = Jacobs, Appendix 26)

A mule and an ass plodded along carrying food; but the ass groaned at the weight of her cargo. Seeing her groaning deeply she asked: ‘Mother, why do you cry and lament like a girl? If you were to give me one measure, I would carry twice as much as you; if you were to take one from me, you would preserve equity entirely.’ Tell me the measure, o greatest one skilled in geometry! (D + 1 = 2 (M – 1); D – 1 = M + 1: D = daughter’s cargo; M = mother’s cargo)

The poem is recorded as being addressed to Euclid and, although he is not mentioned, this is supported by the final words of the poem: Euclid would be a likely candidate for the title of best geometer in the ancient mind. While the poem is ostensibly a conversation between a mule and an ass, a further operative frame emerges in verse four, which forms a hinge between the set-up and the arithmetic. It heightens the language of lament from the previous two lines and employs the simile used by Achilles to address the petulant Patroclus in the *Iliad* (16.7), in order to imply a parental association between the mule and ass. The arithmetic, however, is confined to verses 5–6, where there is no language to distinguish it as particularly poetic or to locate it within the framework of a mother-and-child relationship, to say nothing of implicating it as the words of a talking mule. Those two verses are reminiscent of two poems from Book 14.[75]

δός μοι δέκα μνᾶς, καὶ τριπλοῦς σοῦ γίνομαι.
κἀγὼ λαβὼν σοῦ τὰς ἴσας σοῦ πενταπλοῦς.

(*AP* 14.145)

Give me ten minas and I am three-times you; and if I [the other speaker] get the same amount from you, I am five-times you. ($A + 10 = 3(B - 10)$; $B + 10 = 5(A - 10)$; A = speaker one; B = speaker two)

The fact that this sort of arithmetical challenge circulated freely suggests that the poet of the verses addressed to Euclid has surrounded a core arithmetic challenge with lines that imbue (or at least seek to imbue) the arithmetic with a literary quality and contextualise it as an exchange between mother and child.[76] It is external, supporting evidence for an author embedding within the poems their context of use as well as for an author setting arithmetic within the frame of a maternal exchange.

These three arithmetical poems are placed as the second (*AP* 14.116), third (14.117) and fifth poems (14.3) of the Metrodoran

[75] One of which is a modified version of the other. In *AP* 14.146 τριπλοῦς is replaced with διπλοῦς and πενταπλοῦς by τετραπλοῦς. Cf. *AP* 14.51.

[76] Arithmetical problems in this form are dealt with by Diophantus at I.15. That *AP* 14.145–6 represent a somewhat more free-floating form of calculation may be inferred by the fact that there are no *scholia* elucidating the problems, which accompany the majority of poems from the Metrodoran collection. The similar type represented by *AP* 14.51 was known to Olympiodorus 4.8.43–9, but as the inscriptions on statues.

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collection. The fifth poem in Metrodorus' collection thus pointedly varies the theme of the first two: *AP* 14.116 described walnuts divided by a group of maidens in hexameter, *AP* 14.117 addressed the division of apples, but this time by Corinthian women in elegiacs, and then *AP* 14.3 combines the use of hexameter with a return to the topic of apples. Accordingly, three of the five opening poems of the original Metrodoran collection frame the exchange of arithmetical problems as a maternal matter, the third even doing so archetypally in the use of gods, as well as of the eternal child, Eros. The fact that the maternal framing is intentional is supported by the identity of the author or editor Metrodorus. Francesco Grillo has recently shown that it is difficult to identify the Metrodorus mentioned in *AP*; through a combination of scholarly mistakes and wishful thinking a range of figures have been suggested, but none can be proposed with any degree of certainty.[77] Buffière raised the possibility that the name may be a pseudonym, although he is not explicit why 'for an author of problems in verse, it would not be unwelcome'.[78] I assume him to have had in mind a *Μετρόδωρος, which characterise the collection as a gift (δῶρον) of measures (μέτρα). That meaning may have been intended on the aural level, but the spelling Μητρόδωρος speaks against it. Nevertheless, Μητρόδωρος already makes sense as a pseudonym playing an etymological name game: just like the arithmetical education framed in the opening poems, the collection itself is a 'mother's gift' (μητρο-, δῶρον).

The focus on the maternal, to my mind, encapsulates the unique nature of the arithmetical poems for which I have been arguing. On a pragmatic reading, since mothers would have been expected to care for infants, the framework of mother–child interactions mirrors the probable reality of early education, and it may imply the pedagogical function of the poems. According to Plato in the *Laws*, λογιστική is part of their early education, while in the second book of the *Republic* (377c) he charges mothers with teaching children through (the approved) myths. Arithmetic

77 Grillo (2019).
78 '[P]our un auteur de problèmes en vers, il ne serait pas mal venu': Buffière (1970) 37.

cloaked in mythical dress would seem to be a particular maternal form of early education. Yet their function only partially explains the maternal framing; many of the poems do not frame their problem as an exchange between two people. As I argued in the preceding section, the repertoire of the elite as perceived by Ausonius included displays of arithmetic (preferably in verse) but also a proficient grip on the numerical nature of the late antique literary and cultural inheritance, and the reader brings these to bear in approaching, solving and appreciating the arithmetical epigrams. Ausonius' conservative cultural outlook is metaphorised in the maternal framing of the arithmetical poems. The connection between mother and child not only provides a continually valid context in which to place the poems, it also implies an unbroken lineage transmitting the traditions of antiquity to the subsequent generations. Indeed, individual poems in the collection pay close attention to the literary past, looking for legitimation within pre-existing literary forms for their use of arithmetic in verse. That it is a maternal as opposed to a paternal relationship arguably further emphasises the conserving of the tradition unchanged.[79] In each case, moreover, either the child is expected to answer, or they provide only the series of equations before the poem concludes, without the maternal voice resuming. As the reader identifies the proportions embedded in the verses, they take on the role of the child, aiming both to solve arithmetic problems and to discern and construct the underlying meaning of the poem from its constituents.

Thus, the pseudonym Metrodorus figures the cultural exchange across generations in the ambiguity of the μητρο- stem, since it could index either a subjective genitive (the gift the mother gives) or an object genitive (the gift the mother receives). As educational poems they would be given from parents to children, but equally that education can be repaid and reproduced, as demonstrated by *AP* 14.3, in which Eros gives apples (read perhaps: new compositions) to Aphrodite as a gift. The thematic shape of the

[79] As Leitao (2012) chapter 6 has well demonstrated, male pregnancy was an operative image for conceiving of literary production and authorship. The collection's avoidance of the male frame in favour of the focus on motherhood dwells on intellectual transmission as opposed to the creation of novel ideas.

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Metrodoran collection, in short, associates the interpreting and deciphering of the arithmetic problems with the core pattern of generational cultural transmission and preservation at large. Although the poems are innovative in their reworking of the literary past and integration of arithmetic, the collection presents them as deeply traditional.

4.4 Arithmetical Poetry beyond Late Antiquity

The precise date of the Metrodoran collection is difficult to ascertain, although I have suggested that the compositions' investment in the past and the involvement they demand from the reader make most sense within a late antique literary context and that this conservative literary approach is also indexed by the form of the collection. In the concluding section of this chapter I want to emphasise that the appreciation of these poems and their editorial engagement does not end with the late antique collection of Metrodorus. Rather, it can be observed in the final stages of the *Palatine Anthology*'s formation. It, too, exhibits a conscious arrangement of the poems aware of their literary and arithmetical significance.

On the broadest level, it is clear that the arithmetic poems were purposefully set in a book alongside both riddles and oracles. While it might be thought that arithmetical poems fit uneasily with riddles and oracles, there is a deep literary logic to the combination. Consider again Herodotus' first oracle: it exhibits generic aspects of riddles and of arithmetic. On the one hand, the Pythia's claim to know the number of the sands – οἶδα δ᾽ ἐγὼ ψάμμου τ᾽ ἀριθμόν (Hdt. 1.47) – ascribes to her numerical abilities, whereas the further *adynaton* of hearing the dumb (κωφοῦ συνίημι) and the subsequent mixing of expected categories (tortoise and lamb: κραταιρίνοιο χελώνης | . . . ἅμ᾽ ἀρνείοισι κρέεσσιν) is reminiscent of the paradoxes that riddles offer to their audiences to (re)solve. Numbers are also part of the riddle genre, which can be seen in those collected in Book 14.[80] The similarity of these poems is aided by the shared

[80] Cf. *AP* 14.14, 20, 59, 64, 101, 105, 106. The connection is seen already with the riddle of the sphinx; see Taub (2017) 25–6.

metrical form: oracles are invariably in hexameter, while many riddles and arithmetic problems are as well.[81] An earlier parallel for the mixing of riddles and arithmetic poetry in *AP* 14 can be found in the collection of Latin riddles by Symphosius, which exhibits the influence of Ausonius' *Griphus* in its prefatory material and the many three-line poems.[82] The author of that collection evidently saw a link between Ausonius' reflection on the numerical aspects of culture and the nature of his riddles. As well as a formal dialogue between oracles, riddles and arithmetic problems, there is also a shared intellectual challenge in that they all require reader interpretation. With riddles and oracles, this usually requires lateral thinking with regards to the description of an object and the unravelling of the poem's use of, *inter alia*, metonymy and double meaning, whereas the arithmetical poems require the objects to be treated 'laterally' as numbers or ratios.[83] What binds these generic forms is the involvement of the reader in the construction of meaning and exercising of their intellectual grasp of Graeco-Roman culture. In this sense, they all fall under the category of 'how children in the past learnt', as described by the book's introductory lemma.

In addition to being combined with riddles and oracles, arithmetical poems also take pride of place as the first four compositions in the book. The transmission history of the opening poems of *AP* 14 and its relation to the opening of Metrodorus' collection require discussion, since scholarship on this point contains much supposition. The opening poem of *AP* 14 appears to be attributed to one Socrates by the scholiast, since it is preceded by the lemma Σωκράτους, but the scholiast says nothing more about him. Paul Tannery, in his edition of the works of Diophantus, which included the arithmetical poems, identified the Socrates as an epigrammatist mentioned by Diogenes Laertius (2.47), but again nothing more is known about this figure.[84] Whether the two figures are

[81] Hexameter riddles: *AP* 14.19, 22, 24, 25, 37, 40, 64, 101, 111; hexameter arithmetic epigrams: *AP* 14.1, 2, 3, 4, 6, 8, 48, 49, 116, 118, 120, 124, 127, 129, 130, 135, 136, 139, 140, 145, 146.

[82] For the extent of the connection see Leary (2014) 4–6.

[83] For a discussion of what constitutes a riddle see Luz (2013), with further bibliography. The same strategies apply to the deciphering of oracles.

[84] Tannery (1895) II, xi–xii.

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the same person is a moot point. What there is certainly no external evidence for is that *AP* 14.1 is the first poem of a collection by this Socrates, as Tannery suggests, nor that his collection shared poems with Metrodorus'.[85] Tannery's reasoning is as follows. The marginal account that accompanies the core arithmetical poems is lacking for those that open *AP* 14. Therefore, those poems must have been shared by Socrates' collection and the copyist must have not wanted to add the further Metrodoran numbering and instead stuck with Socrates' ordering. The Socratean numbering relies on reading the ordinal designation at the beginning of *AP* 14 (α at 14.1, β at 14.2, γ at 14.3) as coterminous with the order in Socrates' collection. Tannery's proposal was developed by Félix Buffière, who identified *AP* 14.2 as Metrodorus' inaugural poem (followed by *AP* 14.116–18), with *AP* 14.3 occupying the fifth place in the collection and *AP* 14.4, like 14.1, belonging to Socrates' collection only.[86]

However, in addition to there simply being no evidence for this collection, nor of an independent Socratean numbering, the marginal numbering of *AP* 14.6 (κη΄ = 28) and 14.7 (ιθ΄ = 19) show that the arithmetical poems outside the preserved core were still identified by their number in the Metrodoran collection. The argument that the prime position of 14.1, and the second position of 14.2 (etc.), reflects the position *also* in a Socratean collection cannot be proved or disproved given that the numbering in each case is the same. The arithmetical *scholia* certainly help to determine inclusion in Metrodorus' collection, but this is not a watertight rule.[87] Nor, importantly, is the inverse – that those without *scholia* are from the Socratean collection – a necessary consequence. The existence of a Socratean collection ultimately relies solely on the lemma Σωκράτους immediately following the preface to the book: a particularly precarious castle of sand.[88]

85 Thus, I cannot follow the argument of Grillo (2021) – which came to my attention too late to fully incorporate here – that this Socrates composed *AP* 14.1 and that it shows him to have Pythagorising Middle Platonic affiliations.

86 Buffière (1970) 35–6. His reasoning rests on there being no accompanying arithmetical *scholia*.

87 Certainly, *AP* 14.145–6 do not have *scholia*, but as I have demonstrated they certainly belong to the tradition of arithmetical poems.

88 The lemma Σωκράτους is preceded by a dicolon. It has been argued that the position of the lemma indicates that more than the opening poem belongs to a collection by one

When the spectre of the Socratean collection is removed, it can be said that the first poem offers no clear signs of belonging to Metrodorus' collection, but neither does it exhibit anything alien to the collection. Nonetheless, it is my working assumption that it is not part of the Metrodoran collection. *AP* 14.2–4, however, bear all the hallmarks of being from Metrodorus' collection, since they are closely related in form and theme and 14.2–3 are even accompanied by arithmetical *scholia*. Before considering the introductory poem of *AP* 14 and its programmatic aspects, then, I want to consider *AP* 14.2–4 and suggest that they have been moved from the Metrodoran collection to the beginning of the book in order also to have a programmatic function. In other words, I am arguing that the later compiler is reading these poems and actively arranging them into a poetic-cum-arithmetical programme.

First is *AP* 14.2.

Παλλὰς ἐγὼ χρυσῆ σφυρήλατος· αὐτὰρ ὁ χρυσὸς
 αἰζηῶν πέλεται δῶρον ἀοιδοπόλων.
ἥμισυ μὲν χρυσοῖο Χαρίσιος, ὀγδοάτην δὲ
 Θέσπις καὶ δεκάτην μοῖραν ἔδωκε Σόλων·
αὐτὰρ ἐεικοστὴν Θεμίσων· τὰ δὲ λοιπὰ τάλαντα
 ἐννέα καὶ τέχνη δῶρον Ἀριστοδίκου.

(*AP* 14.2)

I am Pallas beaten out in gold; but the gold comes as a gift from strong poets. Charisius gave a half, Thespis gave an eighth share and Solon a tenth share, but Themison a twentieth. The remaining nine talents and the skill is the gift of Aristodicus. ($T = 9 + T(\frac{1}{2} + \frac{1}{8} + \frac{1}{10} + \frac{1}{20})$; T = total number of talents)

The speaking statue explains the ratios of gold given for the construction of the statue which was (presumably) made by

Socrates; see Tannery (1894); Tannery (1895) II, xii; Buffière (1970) 34–5. At any rate, given that *AP* 14.2 has its own lemma εἰς ἄγαλμα Παλλάδος ('on a statue of Athena'), I think only *AP* 14.1 could be attributed to a Socrates. Here I differ from Kwapisz (2020a) 462, who takes the dicolon and lemma to cover a larger section than just the opening epigram. The habit of positioning a lemma introduced by a dicolon at the end of the preceding line in order to introduce a subsequent epigram is evidenced elsewhere in the MS, such as before *AP* 14.117 and 118. The paratextual notes in the MS beside *AP* 14.117 and 118 may be from a later hand than the opening lemma (although I find it hard to distinguish), but this does not necessarily imply that the use of the dicolon itself differs in the case of later additions. I have an unsubstantiated suspicion that the presence of Σωκράτους could be an identification of the preface's debt to the Platonic idea of education which involved λογιστική that I noted in the introduction to the chapter. It is a thought which has now been developed by Kwapisz (2020a) 480–1.

Aristodicus. As Jan Kwapisz has brilliantly elucidated, the epigram can be read programmatically, since the contributors are designated as poets and Solon and Thespis are even recognisable figures. Since this was most probably Metrodorus' opening poem, it self-referentially indexes the collection as formed by the contribution of numerous poets and at the same time represents that act of (editorial) combination as an arithmetical operation.[89] The entire material form of the statue is a gift from numerous poets, and in opening Metrodorus' collection it would likewise have signalled the collection as a gift. If my argument about the maternal framing of the collection is correct, then Athena as a female goddess who is renowned for her wisdom and knowledge of many crafts makes this a collection that has hypostasised female intellectual prowess as its frontispiece, so to speak. As a virgin goddess she is not a mother of children; her progeny is rather the mathematical abilities transmitted in the collection. In any case, in moving the poem out of the Metrodoran collection to the opening of the book, the editor of *AP* 14 retains the epigram's programmatic force and its use of numerical combination to imbue literary significance.

In the case of *AP* 14.3 there is also recontextualisation at work from the Metrodoran collection into the wider book, but it occurs in tandem with *AP* 14.4. It is not assigned to the Metrodoran collection, because it lacks accompanying *scholia*, but is placed in the supposed Socratean collection by Buffière.[90]

ἁ Κύπρις τὸν Ἔρωτα κατηφιόωντα προσηύδα·
τίπτε τοι, ὦ τέκος, ἄλγος ἐπέχραεν; ὃς δ' ἀπάμειπτο·
Πιερίδες μοι μῆλα διήρπασαν ἄλλυδις ἄλλη
αἰνύμεναι κόλποιο, τὰ δὴ φέρον ἐξ Ἑλικῶνος.
Κλειὼ μὲν μήλων πέμπτον λάβε, δωδέκατον δὲ
Εὐτέρπη· ἀτὰρ ὀγδοάτην λάχε δῖα Θάλεια·
Μελπομένη δ' εἰκοστὸν ἀπαίνυτο, Τερψιχόρη δὲ
τέτρατον· ἑβδομάτην δ' Ἐρατὼ μετεκίαθε μοίρην·
ἡ δὲ τριηκόντων με Πολύμνια νόσφισε μήλων,
Οὐρανίη δ' ἑκατόν τε καὶ εἴκοσι· Καλλιόπη δὲ
βριθομένη μήλοισι τριηκοσίοισι βέβηκε.

[89] Kwapisz (2020a) 462–4. [90] Buffière (1970) 36.

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σοὶ δ' ἄρα κουφοτέρῃσιν ἐγὼ σὺν χερσὶν ἱκάνω
πεντήκοντα φέρων τάδε λείψανα μῆλα θεάων.

(*AP* 14.3)

Cypris addressed downcast Eros: 'what grievance touches upon you?' He answered: 'The Pierides [Muses] snatched from me the apples I was bringing from Helicon, each one for the other, seizing them from my garment-fold. Clio took a fifth of the apples and Euterpe a twelfth; still, godly Thalea took an eighth as her lot. Melpomene took away a twentieth and Terpsichore a fourth. Erato following next took the seventh share. Polyhymnia deprived me of thirty apples, Urania one hundred and twenty. Calliope went off weighed down with three hundred apples and so I come to you with my hands lighter, carrying these fifty apples left over by the goddesses.' ($A = 500 + A(1/5 + 1/12 + 1/8 + 1/20 + 1/4 + 1/7)$; A = total number of apples)

Αὐγείην ἐρέεινε μέγα σθένος Ἀλκεΐδαο
πληθὺν βουκολίων διζήμενος· ὃς δ' ἀπάμειπτο·
ἀμφὶ μὲν Ἀλφειοῖο ῥοάς, φίλος, ἥμισυ τῶνδε·
μοίρῃ δ' ὀγδοάτῃ ὄχθον Κρόνου ἀμφινέμονται·
δωδεκάτῃ δ' ἀπάνευθε Ταραξίπποιο παρ' ἱρόν·
ἀμφὶ δ' ἄρ' Ἦλιδα δῖαν ἐεικοστὴ νεμέθονται·
αὐτὰρ ἐν Ἀρκαδίῃ γε τριηκοστὴν προλέλοιπα·
λοιπὰς δ' αὖ λεύσσεις ἀγέλας τόδε πεντήκοντα.

(*AP* 14.4)

The great strength of Heracles questioned Augeus, inquiring about the multitude of the herds of cows. He replied: 'Friend, around the streams of Alpheus are half of them; the eighth share pasture about the hill of Cronos; a twelfth far from the shrine of Taraxippus; a twentieth graze in divine Elis; but I left a thirtieth in Arcadia. Here you see the remaining herds are this fifty.' ($H = 50 + H(1/2 + 1/8 + 1/12 + 1/20 + 1/30)$; H = herds)

The poems bear strong similarities. They are framed as a dialogue and conclude with an amount of fifty left for the addressee. As I noted above, the application of λογιστική involved *mêlitês* numbers (μηλίτας . . . ἀριθμούς). This could be interpreted as referring to either apples or herds. By setting these two poems side by side, the compiler knowingly alludes to and rings the changes on the debate about what *mêlitês* numbers in poetry might look like.[91]

Moreover, the two poems resonate on the metapoetic level when read at the opening of Book 14. In Meleager's *Garland*, the

91 That the meaning was ambiguous is shown by the *scholium* to *Charmides*, which sees the need to clarify that the so-called μηλίτας . . . ἀριθμούς ('*mēlites* numbers') refer to 'those having to do with flocks' (τοὺς δ' ἐπὶ ποίμνης, *Schol. Charm.* 165e).

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epigrams that he weaves into a collection are described in his introductory poem mostly by comparisons to flowers, but also by comparison to fruits such as 'intoxicating grapes' (μαινάδα βότρυν, 1.25 *HE* = *AP* 4.25; of Hegesippus), 'sweet apple' (γλυκύμηλον, 27; of Diotimus) and 'wild pear' (ἀχράδα, 1.30; of Simias). Likewise in Philip's *Garland*, modelled on Meleager's, he states that he has formed the collection for the reader by 'plucking the flowers [for you] from Helicon, having cut the first-growing buds of famous-wooded Pieria' (ἄνθεά σοι δρέψας Ἑλικώνια καὶ κλυτοδένδρου | Πιερίης κείρας πρωτοφύτους κάλυκας, 1.1–2 GP = *AP* 4.2.1–2). The apples that Eros takes from Helicon – and which survive the division of the Pierian Muses – stand in for the arithmetical problems that the editor has sourced and that the poem introduces.[92] A similar reading works for *AP* 14.4, too.[93] Multiple epigrammatic variations composed on Myron's cow were subsequently conceptualised as a 'herd of poems' in need of rounding up.[94] A further epigram by Artemidorus imagines a collection of bucolic poetry in a similar manner: βουκολικαὶ Μοῖσαι σποράδες ποκά, νῦν δ' ἅμα πᾶσαι | ἐντὶ μιᾶς μάνδρας, ἐντὶ μιᾶς ἀγέλας ('Once the Bucolic Muses were scattered, but now they are all together in one fold, in one herd', 1 *FGE*).[95] The poem can be read as a competing programmatic introduction to an arithmetical poetry collection that instead conceptualises the poems as a herd, by drawing on a pre-existing

92 Although similar poems conclude with a portion remaining to the speaker or main subject (*AP* 14.116–20), this is the only poem in which the apples are selected by Eros and left behind by the Muses. Since, on my count, there are forty-three arithmetical poems in Book 14 (excluding *AP* 14.1), it is possible that the remaining fifty apples with which the poem concludes refer to a collection of *circa* fifty poems. The deictic τάδε, although spoken to Aphrodite, might also function to introduce the following poems within the context of a poetry book collection. Deictics in book epigrams implying textual format occur already in the Hellenistic period; see e.g. Sens (2015) 43 n.8. For the poems in a collection indexing their own place within it and the reader's progress through it, cf. Höschele (2007). The Muses' arithmetical intervention would metaphorically produce the collection of arithmetical poems.

93 As Kwapisz (2020a) 464–72 has thoroughly demonstrated, moreover, this poem also allusively engages which similar passages in the *Iliad*, Theocritus *Idyll* 25 and Quintus of Smyrna's *Posthomerica*.

94 See *AP* 9.713–42, 793–8. For a detailed discussion of the epigrams on Myron's cow see Gutzwiller (1998) 245–50 and Squire (2010b), esp. 616–24.

95 This imagery was also understood in the Byzantine period; a Byzantine epigram on Theocritus' bucolic corpus uses much the same metaphor; see Gow (1952) II, 550.

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motif for editorial activity and on a Homeric motif deeply connected to counting. The position of both poems in juxtaposition at the opening of the book is a (further) programmatic placement by the later compiler.[96]

Furthermore, *AP* 14.4 displays an approach to arithmetic in poetry observable in Archimedes' *Cattle Problem.* As I demonstrated in Chapter 3, Archimedes is a keen reader of Homer's poetics of enumeration, since he combines Homer's reflection on whether he has the capacity to recall the entire πληθύς at Troy with the imagery preceding the Invocation and Catalogue that likens accounting for the troops to the counting and controlling of herds. Regardless of whether in the second verse the poet is cognizant of, and refers back to, Archimedes' πληθύν Ἠελίοιο βοῶν, ὦ ξεῖνε, μέτρησον ('the multitude of the Cattle of the Sun calculate, O stranger', 1), the verse-initial πληθύν with the genitive βουκολίων undoubtedly shows their awareness of Homer's archetypal exploration of handling numbers in poetry. Not insignificantly, then, the programmatic allusion to the Invocation prior to the Catalogue of Ships also informs the final arithmetical poem of the book. As I have noted, the poet's invocation in *Iliad* 2 was adapted into a pointedly numerical challenge in the *Contest of Homer and Hesiod*. Remarkably, those same verses are appended immediately after the Metrodoran section.

ἕπτ' ἔσαν μαλεροῦ πυρὸς ἐσχάραι, ἐν δὲ ἑκάστῃ
πεντήκοντ' ὀβελοί, περὶ δὲ κρέα πεντήκοντα·
τρὶς δὲ τριηκόσιοι περὶ ἓν κρέας ἦσαν Ἀχαιοί.

(*AP* 14.147)

There were seven hearths of fierce fire, in each fifty spits and about each [fire] fifty cuts of meat; there were three times three hundred Achaeans around each cut. ($7 \times 50 \times 900 = 315{,}000$)

This poem is contextualised in the manuscripts with the following comments: Ὅμηρος Ἡσιόδῳ ἐρωτήσαντι πόσον τὸ τῶν Ἑλλήνων πλῆθος τὸ κατὰ τῆς Ἰλίου στρατεῦσαν ('Homer, to Hesiod after he asked how great was the number of Greeks that campaigned against Ilium'). The emphasis on the πλῆθος and the suggestion

[96] One means of organising an anthology was to order the poems alphabetically; orthographically, both *AP* 14.3 and 14.4 have a claim to have opened a sequence of poems.

of the question-and-answer format of Homer and Hesiod's exchanges make it plausible that the verses were drawn directly from the *Contest*.[97] So too, they make the cultural value of the arithmetic poems clear in that they give their combination of numerical calculation and poetry the greatest possible pedigree. Important for my argument, however, is its concluding position following the arithmetic epigrams; the lines take on new meaning when placed in Book 14. Again, the reworking plays on the two possibilities raised in the Invocation to the Muses, namely the recalling and naming of the πληθύς and the counting of it. It takes advantage of multiplication's ability to avoid the linear relationship between poetic content and poetic extension and reduces the much-prized 285 hexameters of the Catalogue of Ships to three verses. What is more, it looks back to the 'πληθύς of poems' programmatically introduced in *AP* 14.4 with a further allusion to Homer's counting in poetry. In terms of the arrangement of the collection in *AP* 14, placing lines that collapse the Catalogue of Ships into three verses at the end of a catalogue of arithmetical poems provides fitting metatextual closure: lines that end the need for a catalogue through calculation signal the end of a catalogue of calculations.[98]

Thus, there are signs that the compiler of Book 14 appreciated the significance of arithmetical poems as products of a simultaneously arithmetical and literary education and sought to reflect that in their arrangement of the book. This approach is nowhere more evident than in the opening poem of the book, which I take to be attributed to one Socrates and which is most probably not from the Metrodoran collection.

[97] For a thorough explanation why these are likely to be the original verses from the *Contest*, cf. Kwapisz (2020b).

[98] Given that *AP* 14.4 (and indeed 14.1) are equally self-conscious regarding their combination of arithmetic and poetry, it may be that they were intended to bookend a collection of arithmetic poetry together with *AP* 14.147. Indeed, were it not for the three oracles that follow the *contest* poem, this proposition would apply to the arrangement of Book 14. Their heterogeneity in date and historicity – 14.148 is for Julian, 14.150 is for the mythical Aegeus – and incompleteness (cf. 14.149) does not show the same cohesiveness as the oracles preserved in the core of Book 14, the majority of which are attributed to the Pythia and might well have come from a prior collection. It is highly plausible that some previous version of Book 14 concluded with *AP* 14.147, with three further poems being placed at the end of the collection at a later point, and that this might – but need not – have coincided with the addition of the oracles and riddles.

ὄλβιε Πυθαγόρη, Μουσέων Ἑλικώνιον ἔρνος,
εἰπέ μοι εἰρομένῳ, ὁπόσοι σοφίης κατ᾽ ἀγῶνα
σοῖσι δόμοισιν ἔασιν ἀεθλεύοντες ἄριστα.
τοιγὰρ ἐγὼν εἴποιμι, Πολύκρατες· ἡμίσεες μὲν
ἀμφὶ καλὰ σπεύδουσι μαθήματα· τέτρατοι αὖτε
ἀθανάτου φύσεως πεπονήαται· ἑβδομάτοις δὲ
σιγὴ πᾶσα μέμηλε καὶ ἄφθιτοι ἔνδοθι μῦθοι·
τρεῖς δὲ γυναῖκες ἔασι, Θεανὼ δ᾽ ἔξοχος ἄλλων.
τόσσους Πιερίδων ὑποφήτορας αὐτὸς ἀγινῶ.

(*AP* 14.1)

'Fortunate Pythagoras, Heliconian offspring of the Muses, tell me this thing I ask: how many in your house are competing in the contest of wisdom excellently?'

'Well then, I will tell you, Polycrates: half pay serious attention concerning fine teachings; a quarter again have laboured over immortal nature; and a seventh practise complete silence and internal unchanging discourses. There are also three women, Theano pre-eminent above the others. These are how many interpreters of the Muses I lead.' ($G - W = G(\frac{1}{2} + \frac{1}{4} + \frac{1}{7})$: G = group; W = women = 3)

Polycrates was the tyrant of Samos, and Pythagoras one of its most famous inhabitants. They were contemporaries – Pythagoras left Samos because of Polycrates' rule – and this poem imagines a dialogue between them. The opening verse's address to Pythagoras as an offspring of the Muses connects a foundational figure of mathematics and numerology to poetry, which the Muses inspire. The term ἔρνος – literally, a 'sprout' or 'offshoot' of a plant – subordinates Pythagoras to the Muses. The collection which intertwines poetry and arithmetic contains in its opening gambit the claim that mathematical interests are dependent on, and develop out of, the traditional cultural practices which the Muses represent (that is, poetry, but also music, history and astronomy). In terms of form, the dialogue also makes clear the question-and-answer format that is implicit in many of the subsequent poems, in that they are to be posed by one person to another. Most notable about the poem, however, is its meta-pedagogical stance. As commentators have observed, the groupings in the poem seem to reflect the division of Pythagoreans found in some sources into the ἀκουστικοί, who meditate in silence, the μαθηματικοί, studying sciences, and the φυσικοί, contemplating the nature of the

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universe.[99] Pythagoras enumerates those in his circle, and the different forms of enquiry that they make, in a poem that introduces a collection which contains arithmetical poetry (as well as riddles and oracles) gathered together for educational purposes.[100] The mix of numerical and poetic learning is thematised as well in that μαθήματα could refer to 'lessons' or 'knowledge' broadly conceived but also had the specific sense of 'mathematical sciences' (LSJ *s.v.* μάθημα A.3). These 'Pythagorean' students within the poem have a range of interests that encompass the cultural and the mathematical, but they are nevertheless all interpreters of the plural Muses (Πιερίδων). These students reflect the aim of the collection. The effect of reading through it is that one is initiated into the house of Pythagoras, a teacher of mathematics homegrown on Helicon, and that one is endowed not just with mathematical knowledge, but is in commune with all the Muses.

The Byzantine compiler's ordering shows that they too appreciated *AP* 14.1's self-reflexive comment on the dialogue between poetic and arithmetical learning; their positioning of the work at once emblematises and instigates the educational process of dealing with mathematics alongside the Muses. In other words, although probably placed in that location well after Graeco-Roman antiquity as commonly conceived, the poem nevertheless was seen to comment on and justify the significance of arithmetic poetry. Far from these poems being thought of as marginal literary experiments, the Byzantine compiler actively engaged with the significance of arithmetic in poetry. Similarly, I have argued in this chapter that the arithmetic poems themselves encapsulate

99 Burkert (1972) 191–2, with n.6, suggests that this particular division is one of a number of artificial or secondary distinctions between the ἀκουστικοί and μαθηματικοί. Yet he also shows that there were many such divisions in circulation. Grillo (2021) notes that the division as described in the poem is only paralleled by the Middle Platonist Calvenus Taurus (*fl.* 145 CE), and so he dates the poem and the so-called Socratean collection to the second century. This rare division of Pythagorean groups need not be taken as serious and need not have Taurus in mind. I prefer to take the poem as appealing with a certain whimsy to a more general idea of the Pythagorean sect divided into groups with varying degrees of knowledge and with Pythagoras himself counting up his followers.

100 Their total of 28, moreover, has particular Pythagorean resonance in being both a triangular number (the sum of the numbers 1–7) and a perfect number (the sum of its divisors; i.e. 1 + 2 + 4 + 7 + 14 = 28). The numbers that emerge from such poems, that is, are not always arbitrary. For further discussion and bibliography see Kwapisz (2020b) 476.

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a broader conversation between poetry and arithmetic in Late Antiquity. Individually and as a (Metrodoran) collection, the poems demonstrate how well arithmetic could not only be versified, but also presented and framed in a way that provides an additional means of enhancing poetry as an object of cultural value and social exchange. Whether it was arithmetical skill or cultural prestige, there was something to be gained by producing and appreciating the arithmetical aesthetics of these poems. The collection testifies that over the course of a millennium the practice of composing calculations in verse really did count for something.