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COUNTING ON EPIC: MATHEMATICAL POETRY AND HOMERIC EPIC IN ARCHIMEDES' *CATTLE PROBLEM*

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In 1773, the celebrated enlightenment thinker G.E. Lessing discovered in Wolfenbüttel's Herzog August Library a manuscript which contained a previously unknown Ancient Greek poem.[1] The manuscript identified the author as Archimedes (c.287-212 BCE), and the work became known as the *Cattle Problem* (henceforth *CP*). On the surface, its twenty-two couplets capitalise on Homer's depiction of the 'Cattle of the Sun' in Book 12 of the *Odyssey* and its numerical aspect. A description of the related proportions of black, white, brown and dappled herds of cattle, which are then configured geometrically on Sicily, creates a strikingly colourful image.[2] The author's decision to encode a number into the figure of the Cattle of the Sun styles the poem as a response to, and expansion of, Homer's scene. Reading through the work, though, it becomes clear that the mathematics is more complex than that of Homer's *Odyssey*.

Since the work's discovery, scholars have essayed solutions to the mathematical complexity that Archimedes weaves.[3] Not all have been successful. Only in 1965 was the problem 'solved' and written out in full (a number whose digits filled 42 sheets of paper).[4] The predominant focus on the mathematics stems from the text's position among historians of mathematics, keen to highlight how the *CP* attests to an ancient awareness of simultaneous equations, and their possible complexities and limitations.[5] Approaches that have eschewed the mathematics inevitably do so only to discuss authenticity, a thorny riddle as unsolvable as the equations.[6]

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1. This article started life as an M.Phil. thesis, submitted to Cambridge's Faculty of Classics in June 2013. I am indebted to the guidance of my supervisor Liba Taub, and the advice of my examiners Oliver Thomas and Richard Hunter. Others who deserve mention for sharing with me their time and thoughts are James Halladay, Alex Matthews, Francesca Middleton and Lucia Prauscello. Naturally, any errors are my own.

2. The specifics of the ratios of the cattle need not detain us here. I offer at the end an edition of the full text (Appendix I), a translation (Appendix II) and the traditional mathematical delineation of the ratios (Appendices III and IV).

3. According to Hermann (1831), 230, C.F. Gauss was reported to have worked on the problem, although Krumbeigel (1880), 123, doubts Gauss's involvement. The key advance towards a solution is found in Wurm (1830), 194f., later developed in Nesselmann (1842), 484, and finalised in the form we have in Amthor (1880), 154f. It was he who found a method for calculating the solution's large size, expressing only the first four significant digits of a number containing hundreds of thousands of digits.

4. That is to say, the number was fully expressed. See Williams, German and Zarnke (1965) and in a more manageable form, Nelson (1981).

5. Cf. e.g. Heath (1921), 14.

6. I will not discuss the question of authenticity at length, but I take it as quite possible that the epigram is genuine. For further discussions cf. Struve and Struve (1821); Nesselmann (1842), 481f.; Krumbeigel (1880), 125. The most recent and balanced approach can be found in Fraser

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'But what,' we might ask, 'is this poem actually about?' To my mind, the obsession with solving the mathematics and the question of authenticity has meant that the importance of the *CP*'s medium has been under-studied and under-valued. Discussions of the text have failed to unravel the *CP*'s deeper architecture, and to understand the cultural and literary context which engendered it. Most, if not all, readers have been left bewildered by the mathematical demands of Archimedes' prescribed proportions and configurations and read no deeper. The present article aims to correct this.

The confrontation of Homeric epic and mathematics is central to the work, yet its importance lies not in the complex calculations alone, but in how the mathematics is co-opted to manipulate a readership. It seems clear, given the time and effort modern scholars have put into solving Archimedes' ratios, that his recipient, Eratosthenes, would have been unable to solve the mathematical challenge.[7] Simultaneously, in attempting a solution, modern scholars have failed to resolve the literary tensions which the *CP*—as a poetic, epigrammatic production—constructs. A more productive approach is to accept the mathematical impossibility and then question how this might be incorporated within Archimedes' unique Homeric reception. Accepting and focusing on the work's fascinating hybridity, I intend to unpick its literary content and cultural significance.

In what follows, I suggest that the narrative of the *Odyssey*, far from offering a useful image with which to encode the mathematics, is at the heart of this composition, and in particular, that epic's concern with location. I tentatively highlight points of Archimedes' seemingly allusive language which are specifically illuminating considering the work's (self)-identification as being sent between Hellenistic scholar-poets. More important will be to see how the *CP* can be located in a number of intellectual spheres, and in particular how the internal workings of the poem can be read in multiple, yet still culturally significant, ways. In the second half, I contextualise the *CP*'s generic status, and how this might aid our reading. Indeed eventually I argue that Archimedes stages the conflict and cross-pollination of the epic and the epigrammatic genres within the poem. It will be seen that Archimedes' application and interweaving of mathematics and poetry reveal his peculiar cultural and poetic ideology. Furthermore, the emphasis on place, when combined with this reflection on the epic genre, speaks not just of a defence of epic, but very possibly of Sicily.

(1972), 407. I hope however that the discussion I offer here can at least be used to shed light on that debate.

7. It is still unclear how ancient mathematicians would begin to think about solving the problem, nor is it known if the creator of the mathematical problem knew the quantities beforehand, although another Archimedean work, the *Sand-Reckoner*, does develop a system for coping with large numbers. Cf. Vardi (1998), 318.

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1. Reading the Epigram

1.1 The Epigrammatic Odyssey—Beginning the Readerly Journey

How do we approach this text? The *CP* offers a number of different reading frameworks. The epistolary prose introduction—Πρόβλημα ὅπερ Ἀρχιμήδης …ἀπέστειλεν ἐν τῆι πρὸς Ἐρατοσθένην τὸν Κυρηναῖον ἐπιστολῆι ('A problem Archimedes…sent in a letter to Eratosthenes of Cyrene', *CP* pref.)—frames the recipient as Eratosthenes, and Archimedes as the sender.[8] Is this Archimedes' voice? It is at least an intentional communicative gesture to Eratosthenes on his part. Without this introduction we might look towards the generic history of epigram. For public inscriptions and literary epigrams, the address to a παροδίτης ('passer-by'), ὁδοιπόρος ('traveller') or ξένος/ξεῖνος ('stranger') is a competitive manoeuvre intended to catch the reader's eye, on busy public thoroughfares or on the scroll.[9] This aspect, as is often noted, is fruitfully exploited by poets of the Classical and Hellenistic period.[10] As Michael Tueller has shown, the implied 'materiality' affects how we understand the speaker and addressee in literary epigrams.[11] Depending on whether the epigram is sepulchral, dedicatory, or amatory, the dynamic between speaker and addressee differs. Archimedes' ξεῖνε ('stranger', *CP* 1) hints towards the genre, though it is unclear into which sub-genre the *CP* fits. Without additional context the reader may infer him/herself as the addressee, and the speaker the work.

Alternatively, one might recall the language of the *Odyssey*, and a passage often quoted in conjunction with the *CP*, in which Circe addresses Odysseus:

> Θρινακίην δ' ἐς νῆσον ἀφίξεαι· ἔνθα δὲ πολλαὶ
> βόσκοντ' Ἠελίοιο βόες καὶ ἴφια μῆλα,
> ἑπτὰ βοῶν ἀγέλαι, τόσα δ' οἰῶν πώεα καλά,
> πεντήκοντα δ' ἕκαστα.
>
> (*Od.* 12.127-30)

> Then you will come to the Thrinakian island: there many
> cows and stout sheep of Helios graze,
> seven herds of cows, and just as many fine flocks of sheep,
> and fifty in each.

8. Although it is far from epistolary in content; cf. Rosenmeyer (2002). A subsequent and no doubt purposefully ambiguous question then arises as to whether Eratosthenes is a foreigner (ξεῖνος) or a guest-friend (ξεῖνος).

9. This appears to be the default position, although, as Sourvinou-Inwood (1995), 279f., admits, it is often unstated. Cf. Tueller (2010), 59f.

10. The ideas of playfulness, generic awareness and supplementation have been a fruitful area of research in recent years. Cf. Bing (1995), 115-31; Bing (1998); Selden (1998), 307-19; Gutzwiller (2002); Fantuzzi and Hunter (2004), 291-306.

11. Tueller (2008), 66-94.

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An alert reader, if they know their Homer, may infer a similar dynamic here: Odysseus as the addressee, and Circe the speaker. Indeed, Odysseus as a ξεῖνος is a key theme in the *Odyssey,* and its use in the epigram is a possible exegetical sign-post.[12] Is this Odysseus quite literally (or is that textually?) in disguise? If the epigram echoes Circe's words, are they the truth or a seductive trap? Such Odyssean themes swim frustratingly beyond our grasp. Another possibility is the sympotic context. Whether or not epigrams were actually performed, the notional performance at an elite intellectual symposium informs their construction.[13] In reality, the multiple contexts exist simultaneously. An agonistic riddle at a symposium might be phrased as 'what Circe said to Odysseus' providing a performative context for the riddle-poser.[14] Equally, Archimedes is the riddle-poser, performing via the text the role of Circe to Eratosthenes' Odysseus. The core reading, however, comes from the reader himself, who in the absence of any Odysseus at which to aim Circean words, places himself as the Odyssean character. Indeed, knowing that Eratosthenes might have read the *CP*, the reader may wonder who is more successful playing Odysseus, and who at solving the problem. Noticeably, the multiple readings of this text create a multi-layered agonistic reflection. We compare ourselves to the archetypal addressees, Eratosthenes and Odysseus; are we as clever as they?

Intriguingly, the opening line and address points towards another generic form altogether:

> πληθὺν Ἡελίοιο βοῶν, ὦ ξεῖνε, μέτρησον
> φροντίδ' ἐπιστήσας, εἰ μετέχεις σοφίης.
>
> (*CP* 1f.)

> The multitude of the Cattle of the Sun calculate, O stranger,
> and set your mind to it, if you have a share in wisdom.

We have, in the initial hexameter line, an invocation (ὦ ξεῖνε), a command (μέτρησον), and a topic (πληθύν) modified by an extended description (Ἡελίοιο βοῶν). It structurally echoes the opening lines of many hexameter poems, including the *Iliad* and the *Odyssey*.[15]

> ἄνδρα μοι ἔννεπε, Μοῦσα, πολύτροπον, ὃς (…)
>
> (*Od.* 1.1)

> Tell me, o Muse, of the man of many ways, who (…)

12. Stewart (1976), 75f., and Murnaghan (1987), 91f., still offer the best discussions of disguise, recognition and guest-friendship in the *Odyssey*.

13. For inscriptions and re-performance cf. Day (1989), 16-20; Day (2007), 39-47; Day (2010), 14; Vestrheim (2010), 75-78; Tsagalis (2008b), 44-48. For the literary epigram and the symposium cf. Giangrande (1967).

14. Many such epigrams do in fact survive in the *Palatine Anthology* 9.457-80.

15. See also, for example, *Thebaid* Fr.1.

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μῆνιν ἄειδε, θεά, Πηληϊάδεω Ἀχιλῆος

(*Il.* 1.1)

Sing, o Goddess, of the anger of Achilles, son of Peleus

They too open with their subject, an invocation, a command, and often a polysyllabic adjective. Epic invocations are employed to request information from the poet's goddess or muse: they, and not the poet, have true knowledge and information.[16] Markedly, the *CP*'s 'epic invocation' is instead addressed to the reader and solver; will you be as successful as the omniscient Muses of epic in decoding the riddle? Is there irony for Eratosthenes, in the service of the Muses as head of the Alexandrian Mouseion, now the direct recipient of a Muse-like request for knowledge; will he live up to his title? By forming an opening which parallels the reader with the traditional Muse, Archimedes makes it quite clear what the intellectual stakes are here.

Equally, one should consider the role of Archaic elegy in the formation of the text about which Geoffrey Benson has recently written.[17] He notes the structuring principles, key terms (σοφία ['wisdom, 'skill', 'cleverness'], μέτρον ['measure', 'rule']), and address to a ξεῖνε which the work shares with elegy. Assuredly, elegy continues in the Hellenistic period, and sees some dramatic shifts. In particular, it is the form used for longer catalogue poetry. Thus the catalogue of calculation that the *CP* offers demands further reflection on its genre. Taken alongside the tradition of mathematical poems, it might be read as a long epigram (see below). Following Benson's line, though, the *CP*'s 'main motifs imitate Archaic elegy'. Certainly, wisdom and a sense of proportion appear in both, although the use of those terms in an emphatically mathematical context complicates the association; Archimedes enters into a dialogue with, but does not necessarily imitate, elegy.[18] So too, his suggestions concerning the wider implications of such terms in Archimedes' poem are not always convincing.[19] Nonetheless, I cannot help feel that in this case both epigram and elegy are in play, and the period attests amply to how both genres reinterpret and rework Homeric material. This question will return more pointedly in the final section, but for now, let us allow for both genres to operate within the text.

Whether the reader knows their Homer is a crucial point. The contexts of reading are related to a reader's literary exposure, and as often in the ancient

16. The clearest discussion of this is still Lenz (1980), 21-41.

17. Benson (2014). The issue of elegy was also highlighted by the anonymous reviewer. Benson's article came to my attention too late to remodel and incorporate fully his ideas herein. Needless to say, I encourage the reader to consult his work also.

18. See Benson (2014), 178-82.

19. Generally, his analysis of the structural similarities is strong. Antimachus, Hermesianax and Callimachus all employ elegy in catalogue form, and this may well have influenced Archimedes. His argument that something like the tradition of the Seven Sages exists behind the *CP* does not persuade.

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world, knowledge of Homer provides a measure of one's education. Moreover, the multiple contexts of speaker and addressee can be held up for comparison. We not only size up our own knowledge of Homer, we can read it as Archimedes attempting to measure up Eratosthenes' knowledge. Is the work aimed at sizing up the Cyrenean opposition? Has his time at the Alexandrian Mouseion made him, like the Muses, a font of knowledge? Such questions arise when considering it as a private correspondence, and for Archimedes, perhaps they only need to be asked. Also, the question is raised of how one encounters the poem. Do we imagine a physical inscription of the text, on contemporary Sicily attesting to the island's mythical pedigree, or on the 'literary' Thrinakia, addressed to the intrepid Odysseus (or Odysseus-like) figure? Or is this a variation on Circe's speech, a record of an oral performance (of a riddle), turned from hexameters to elegiacs? As we shall see, the text continues to be concerned with place, as well as embodying aspects of both epic and epigram. Leaving the work open to a multiplicity of readings, Archimedes constructs a riddle out of reading.

1.2 Continuing the Journey—A Textual Sign-Post and a Question of Geography

As our reading progresses, Archimedes plays with the idea of the reader as an Odysseus-like figure. After a gap of twenty-two lines, in which Archimedes elucidates the ratios of the herds of the Cattle of the Sun, he apostrophises the reader.

> ξεῖνε, σὺ δ' Ἠελίοιο βόες πόσαι ἀτρεκὲς εἰπών,
> χωρὶς μὲν ταύρων ζατρεφέων ἀριθμόν,
> χωρὶς δ' αὖ θήλειαι ὅσαι κατὰ †χροιὰν ἔκασται,
> οὐκ ἄϊδρίς κε λέγοι' οὐδ' ἀριθμῶν ἀδαής.
>
> (*CP* 27-30)

> If, o stranger, you accurately tell how many Cattle of the Sun there are,
> telling separately the number of well-fed bulls
> and separately again the number of each herd of cows according to colour,
> you would not be called unskilled or ignorant of numbers.

This sign-post is not for the unlettered. It is an allusive reference underscoring the work's scholarly nature and its ludic application of Homeric philology. The adjective describing the reader (ξεῖνε), ἄϊδρίς, is a *dis legomenon* in Homer, appearing once in the *Iliad* and the *Odyssey*. In the *Iliad*, Antenor describes Odysseus' feigned foolishness while on an embassy to Troy as ἄϊδρις, holding the speaker's staff 'seeming like a man who was ignorant of it' (*Iliad* 3.219). Yet in the *Odyssey* it suggests something quite different. After he has arrived on Aeaea and his crew have been transfigured into pigs, Hermes halts Odysseus and provides him with a protective potion before confronting Circe:

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> πῆι δὴ αὖτ', ὦ δύστηνε, δι' ἄκριας ἔρχεαι οἷος
> χώρου ἄϊδρις ἐών;
>
> (*Od.* 10.281f.)
>
> To where are you heading this time, poor man, alone along the hilltops, knowing nothing of the country?

This is not the sly Odysseus of the *Iliad*, but of the *Odyssey*, constantly wandering, and wondering to which land he has been blown, guided by the divine assistance of Athena.[20] Indeed, the related noun ἀϊδρείη is twice applied to Odysseus' men who 'with ignorance' entered Circe's palace: οἱ δ' ἅμα πάντες ἀϊδρείῃσιν ἔποντο ('they all at the same time entered with ignorance', 10.231 = 10.257). Superficially, this adjective seems diplomatic, a congratulatory compliment. What might the attentive reader infer about Archimedes' allusive description of them and another possible reference to Odysseus, again literally and textually, disguised before them?

The Odyssean passage is emphatically geographical: Odysseus has no knowledge of *where* he is. How does this square with the *CP*? Broadly, the reader's halted progress parallels Odysseus' movement along the hill-tops—δι' ἄκριας ἔρχεαι—intercepted by Hermes.[21] A problem that arises, however, is the transposition from Aeaea in the *Odyssey* to Thrinakia in the *CP*. A claim of oversight on Archimedes' part is a possibility, but this does not really explain why such a specific textual allusion would lead to a readerly 'dead-end'. Rather, I suggest, for the reader recognising both their adopted Odyssean role and the incongruity of the Homeric intertext, they best Odysseus by succeeding in orienting themselves with regards to Homeric geography, textually and figuratively. Thus we could reread Archimedes' line as 'you will not be called unskilled (as Odysseus was, *geographically speaking*)'.

Structured in geographic terms, the allusion asks readers if they can locate Odysseus. For Eratosthenes, questions of Odyssean geography are highly contentious. Broadly speaking, Homeric scholars had two positions on Odysseus' wanderings. Some, such as Strabo and Callimachus,[22] located the wanderings within the Mediterranean while others, including Apollodorus of Athens and Eratosthenes, pinpointed them beyond the Pillars of Hercules.[23] Sicily was identified as an especially likely candidate for the mythical island, and by the Hellenistic period, the association was common. This was no doubt

20. E.g. *Odyssey* 6.191, 7.193, 8.301.

21. On the literal and figurative movements of reading epigrams see Höschele (2007).

22. Fr. 9 R = Strabo 1.2.37 Radt. For Strabo's positive view of Homer see most recently Kim (2010), 47-84.

23. Fr. 8 R = Strabo 7.3.6-7 Radt. The particular naming and concretisation of this theory as ἐξωκεανισμός, however, comes only later with Crates of Mallos; cf. Crates frr. 44 and 77 Broggiato; Roller (2010), 120-23; Walbank (1979), 586f.

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bolstered by Thucydides' folk etymology: Θρινακίη, or as it was also known, Τρινακρία, a back-formation based on Sicily's three capes, τρεῖς-ἄκρας.[24] However, employing mythology to elucidate contemporary geography was found by some scholars to be methodologically dubious. Eratosthenes was a particularly vocal opponent. As a scientist and philosopher, as well as a literary critic and poet, he argued that Homer's *Odyssey* had no place in the burgeoning discipline of geography.[25]

Yet prior to my proposed 'geographical' intertext, Archimedes had already signalled for the reader his intellectual allegiances:

> πόσση ἄρ' ἐν πεδίοις Σικελῆς ποτε βόσκετο νήσου
> Θρινακίης τετραχῆι στίφεα δασσαμένη…
>
> (*CP* 3f.)

> As many as once grazed the plains of Sicilian
> Thrinakia's island, divided four-ways…

Archimedes' account of Sicily as Thrinakia signals no debate: the suggested geographical equivalence becomes fact. The association would pose no problem for the average reader, used to the mythical heritage of the island: cultural *terra firma*. For Eratosthenes however, the equation of Sicily with Thrinakia is an impossibility. From the beginning, Eratosthenes' acceptance of the mathematical challenge and the readerly journey would jar. The Odyssean allusion, then, advances Archimedes' strategy.

To decode Archimedes' allusion, the reader must take on the Odyssean role, journeying through a text and a myth firmly located on Thrinakia, a Thrinakia that is in fact Sicily. The allusion sets the reader, as I have argued, at the interstices of Homeric geography and Homeric philology. Yet Eratosthenes, who we might expect to notice this allusion, subscribes to a reading of Homer which does not allow Archimedes' (playful) geography and philology to intersect. The characterisation of the reader as οὐκ ἄϊδρις in a geographical sense gains piquancy when we imagine it aimed at Eratosthenes. Praise about knowing *where* one is is a pointed compliment for Eratosthenes the revolutionary geographer. Yet the setting of Archimedes' poem, and the Odyssean allusion which would constitute this praising, sets such a compliment on the precipice of ridicule. Eratosthenes may know where he is in this poem through textual allusions, but as a geographer, does he *really* know Homeric geography? Once again, Archimedes displays a sophisticated literary strategy, not only testing the reader's educated status, but offering a view of the literary challenge he sets up for Eratosthenes.

24. Gomme, Andrew & Dover (1970), 211.
25. Although he was not against Homer's poetry *per se*.

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1.3 Completing the Journey—The Significance of Success

The final lines of the *CP* again exhibit a conditional tone; a solution is not assured. Archimedes interweaves language reminiscent of Greek epinician poetry with that of epic, and employs an adjective with a curious philological history:

> ταῦτα συνεξευρὼν καὶ ἐνὶ πραπίδεσσιν ἀθροίσας
> καὶ πληθέων ἀποδούς, ξεῖνε, τὰ πάντα μέτρα
> ἔρχεο κυδιόων νικηφόρος ἴσθι τε πάντως
> κεκριμένος ταύτηι γ' ὄμπνιος ἐν σοφίηι.
>
> (*CP* 41-44)

> If, o stranger, having completely worked out in your mind these things,
> collating and giving an account of every dimension
> you may go, a victor, and carry yourself proud, knowing that wholly
> you have been judged '*ompnios*' in this species of wisdom.

Proceeding as one who is κυδιόων νικηφόρος, the 'foreign' reader proudly carries off his victory. This image is complex. In the riddling context, ἔρχεο is as much a sphinx-like 'you may pass'—having solved the riddle—as it is a secondary epigrammatic command to go forth, having contemplated an inscription. The initial conditionality of the challenge—εἰ μετέχεις σοφίης ('if you have a share in wisdom', *CP* 2)—is here resolved in a neat ring composition. Having completed these calculations, you have been judged wise; not only is it no longer a case of 'if', εἰ, but the successful solver is 'rich' in a species of wisdom (on which, see below). The νικηφόρος so reminiscent of Pindaric epinician should also make one read an agonistic context in κεκριμένος—'having been judged *in contest*'.[26] The novelty of this tone should not be overlooked. The riddle exchanged between the two scholars, a battle of learning and culture, offers a noticeably different view of competing individuals and *poleis* in the Greek world. Success is not gained through sporting prowess, but in giving an account of mathematical dimensions and aspects of Homeric poetry.

In addition, the participle κυδιόων has a noticeably epic context. It describes the exultant Agamemnon (*Il.* 2.579)—and, in the plural, the exulting gods (*Il.* 21.519)—with the intention of emphasising their proud behaviour. It also appears in two almost identical similes, comparing heroes, Paris and Hector, to horses which have bolted the stable and glorying in their splendour, enjoy their freedom (*Il.* 6.506-11 = 15.263-68). Each deployment colours our understanding. With Paris, the image of a horse that delights too much in his appearance reflects Paris' underlying nature, whereas Apollo, rousing Hector from his feeling of

26. Cf. Pindar *Isthm.* 1.22; *Nem.* 3.67; *Ol.* 2.5, 13.14.

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defeat, brings out in him the exulting confident defender of Troy. It is this onslaught, this final rallying against the Achaeans with Apollo's aid that leads to the death of Patroclus at Hector's hands, and thus seals his fate at Achilles'.[27] Of course, since in the *CP* only κυδιόων is present, any link must be tentative. Nonetheless, the work clearly demands epic familiarity. To read echoes of either narrative is to read a note of caution about believing in one's own abilities.

The final line contains an equally intriguing word, which I have left untranslated: ὄμπνιος. Instead of meaning simply 'well-fed' as the LSJ translates, it has a specific cultural and literary provenance. A *scholion* to Apollonius Rhodius offers the phrase στάχυν ὄμπνιον ('an *ompnios* ear of corn') which Jane Lightfoot's recent English edition rightly leaves untranslated.[28] Philetas of Cos, the fourth century poet and grammarian, defined it as corn that is εὔχολον καὶ τρόφιμον ('succulent and nourishing') in his *Ataktoi Glossai*, a glossography of rare literary and dialect words.[29] Subsequently, it becomes a word with a certain Hellenistic currency: Callimachus, Apollonius, Eratosthenes and Lycophron all employ it.[30] The semantic nexus appears to focus around the goddess Demeter in her role as provider of grain. Emanuele Dettori, however, cautions against applying the semantics of that phrase to ὄμπνιος alone.[31] How might ὄμπνιος function in the *CP*? Is Dettori correct to assert that it is unrelated to agricultural fecundity?[32] Or, if the overwhelmingly common sense of harvest and fecundity is absent, then what meaningful sense fits the context: 'large', 'huge' or 'flourishing'?[33] Perhaps there is an Odyssean pun in 'well-fed' reflecting the crew's sacrifice and eating of the cattle.[34]

In fact, the meaning is still unclear. This underscores how much we do not know about the developing uses and re-uses of antiquarian, technical and religious vocabulary within and without Hellenistic scholarship. While some of the language points towards an intricate and allusive *envoi*, its sense, for now, is irretrievable. It can be noted that the closing lines clearly respond to the challenge set out. Yet we should not forget that while the conclusion offers wisdom as the reward, the very chance of this occurring is doubtful, and to this point I shall return.

27. On both similes see most recently Graziosi and Haubold (2010), 226f.

28. Schol. in Ap. Rhod. 4.989i Wendel = fr. 16. Dettori. Lightfoot (2009), 79.

29. Cf. Dettori (2000), 21; Lightfoot (2009), 2.

30. Callim. frr. 1.9, 287 and 357 Pf.; Lycophr. 619 and 1263; Ap. Rh. 4.988. Eratosth. frr. XVIII-XIX Hiller = fr. 16 Powell. Eratosthenes' *Hermes* was a learned and recondite composition; the most recent and illuminating contributions are by Scanzo (2002) and Di Gregorio (2010). It is intriguing that the adjective appears at significant points in these two acquaintances' works.

31. Dettori (2000), 122f.

32. *Ibid,* 121.

33. LSJ *s.v.* ὄμπνιος.

34. Cf. LSJ *ibid*. Odysseus alone refrains from meat (*Odyssey* 12.391-400). This may suggest a playful meaning of ἐνὶ πραπίδεσσιν, where the Homeric πραπίδες means both 'intellect' and 'midriff' or broadly 'stomach'; a notable change from φροντίς (line 2). See LSJ *s.v.* πραπίδες. However, the allusion is by no means certain.

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2. Locating the Epigram

Having considered how Archimedes utilises the Odyssean narrative, I want to dig deeper into the ways he integrates, elides and confronts epic and epigrammatic forms. Through an analysis of some epigrammatic riddles and the ways in which their dense, allusive form reworks Homeric material, I suggest that the *CP* deserves to be read within the riddle genre. Equally, though, looking at the mathematical aspects, I subsequently argue that it must also be read within the framework of a peculiar sub-genre of epigram: the mathematical epigram. In both cases, I highlight the differing levels of assumed knowledge on the part of the reader, and what this can tell us about their, and the *CP*'s, context of production and reception. Most importantly, however, I take the epigram's opening word πληθὺν as a point from which to consider how the *CP* stages its own conflict of genre. Ultimately, I want to claim the *CP* as a unique document of cultural interaction, and suggest that Archimedes works well beyond, and actively strains, the boundaries of the genres in which we place his work. The *CP* is more than just a mathematical challenge, it is a self-aware piece of literature that poses many questions for its readers, and no-one more so than Eratosthenes.

2.1 Hidden Heroes: Learned and Popular References in Homeric Riddles

How purposeful are the allusions in the *CP*, and to what extent are they to be noticed by an astute reader? An epigram by Philetas of Cos underscores how Hellenistic riddle epigrams engage with Homeric material in intricate ways, employing both philology and a broader cultural knowledge.

> οὔ μέ τις ἐξ ὀρέων ἀποφώλιος ἀγριώτης
> αἰρήσει κλήθρην, αἰρόμενος μακέλην,
> ἀλλ' ἐπέων εἰδὼς κόσμον καὶ πολλὰ μογήσας,
> μύθων παντοίων οἶμον ἐπιστάμενος.
>
> (Philetas fr.12 Sbardella)

> No lumbering rustic from the mountains shall bear me,
> snatching up a hoe—me, an alder tree;
> but one who knows the marshalling of words, who toils,
> who knows the pathways of all sorts of speech.[35]

Peter Bing, rejecting variant views of the alder tree as a poet or a woman, suggested that it refers to a writing tablet.[36] More recently though, Jan Kwapisz highlights how the noun κλήθρη refers to the alder tree out of which Odysseus

35. Translation by Kwapisz (2013), 156.
36. Bing (1986), 224.

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constructs his raft on Calypso's island.[37] The noun only appears in *Odyssey* Book 5, and it is the key for decipherment.[38] If the pronoun μέ refers to the alder, then the 'alder-slayer' who knows 'the marshalling of words' and 'toils' is Odysseus, traits formulaically ascribed to him.

Similar to the *CP*, the character of Odysseus is revealed to us through a philological sign-post. How convincing is this reading? Philetas' epigram balances our broad cultural exposure to Odyssean material with a textual allusion. Retrospectively, we might congratulate ourselves for having noticed the unique κλήθρην. Might an ancient reader have deciphered the epigram simply from the references to a man who is good with speech, has struggled, yet knows the 'many ways'?[39] These are Odysseus' predominant traits. This is crucial when considering literary riddles. Within a riddle, the information proffered is never itself erroneous, rather it is obscurely expressed. With Philetas, as with Archimedes, their language describing Odysseus employs both philological specificities and in-grained cultural formularity. Not only does Archimedes repeatedly address a ξεῖνε—Odysseus being the archetypal ξεῖνος—but the very situation is uniquely Odyssean. The novelty of this type of riddling epigram, it seems to me, lies in our ability to observe the author at work covering up the identity of a figure in Greek culture, mentioning but not mentioning the great Homeric hero. For the astute reader, a philological allusion is a further sign of the poet's skill in pointing to, but not verbalising, the well-known subject.

The following riddle functions similarly, leaving its subject, a key Homeric figure, initially hidden from the reader

> ἄνδρ' ἐμὸν ἔκταν' ἑκυρός, ἑκυρὸν δ' ἔκτανεν ἀνήρ,
> καὶ δαὴρ ἑκυρὸν, καὶ ἑκυρὸς γενέτην.
>
> (*Anth. Pal.* 14.9)

> My father-in-law slew my husband, my husband slew my father-in-law,
> my brother-in-law slew my father-in-law, and my father-in-law my father.[40]

The epigram's features are not outwardly Homeric, nor are there any philological pointers; rather, a certain level of knowledge of Homer's epics is required. To solve this riddle and identify the figure as Andromache, one must know that her first husband Hector was killed by Achilles, who became her father-in-law when she married Neoptolemos, who had killed her first father-in-law Priam,

37. Kwapisz (2013), 156. Cf. Cerri (2005).
38. It is mentioned at *Od.* 5.64 and 239.
39. Bing (2009), 147-74, does in fact consider insightfully the difference between general and specific allusions.
40. Translations from the *Palatine Anthology* are adapted from Paton (1918).

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and that Andromache's brother-in-law Paris killed her father-in-law Achilles, who had killed her father Eetion. The epigram presents a set of propositions concerning certain members of an unknown person's family which are relatively straightforward. The repetitious language compounding the four interrelations, however, spawns complexity. With Philetas the identity of Odysseus is a textual matter, while this Homeric epigram weaves a knot of interconnection around Andromache out of the broader cultural currency of epic. Archimedes operates in like fashion. There is a certain superficial simplicity in offering up the ratios of herds of cattle. When considered thoroughly, though, it becomes obvious that things are more complicated. Both epigrams underscore how difficult it can be to untangle the mass of culture that is the Homeric tradition. The dénouement of the epigram on Andromache is successful because it offers the reader resolution; there are simple answers to knotty cultural interrelations.

Observable is a reflex of what Teresa Morgan calls 'joining the club'. Developing out of Classical and Hellenistic forms of education or *paideia*, degrees of acquaintance with Homer created both a shared identity, and a stratification of the educated classes.[41] As a context for the expression of this 'exclusivity', the symposium—and literary correspondences and circulation of epigrams enacting the social space of the symposium—re-affirmed and tested elite intellectuals' 'Greekness'. The agonistic intellectualism of the Andromache epigram seems clear; for Philetas this is probable, and in the case of the *CP*, the epistolary header is highly suggestive. Clearly, a philological note demands deeper knowledge than heroic genealogies. Nonetheless, these two aspects, erudite textualism and popular knowledge, are not mutually exclusive, and this, in fact, is part of the craft of the riddle.

In the *CP*, there is no enunciation of Odysseus. Yet his character and his narrative are never far from the reader's mind. The 'Club' has varying degrees of membership. Readers of the *CP*, picking up the Odyssean cues, could congratulate themselves. Those who notice the philological intertexts of ἄϊδρις and ὄμπνιος will feel 'intellectual', and may additionally reflect whether Eratosthenes too noticed these intertexts. Archimedes' epigram allows the reader to observe intellectual agonism 'in action', and the riddle is the genre *par excellence* to underscore this competitive interaction.

2.2 Culture by Numbers

Another intriguing epigrammatic sub-genre is the mathematical epigram. We find these mainly in the fourteenth book of the *Palatine Anthology*, along with oracles and riddles.[42] They encode mathematical questions in the shared Hellenic cultural 'database' of Greek myth, and some are specifically Homeric; one

41. Morgan (1998), 74f.; cf. Thompson (1994), 67f., and Cribiore (2001), 225f.

42. Although this compilation is undoubtedly Byzantine, it is now agreed that many of the epigrams, if not from the Hellenistic period, at least echo Hellenistic models. Cf. Cameron (1993), 268.

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discusses the capacity of a brazen Polyphemus (*AP* 14.132). Consider also the following on the Muses and Graces:

> αἱ Χάριτες μήλων καλάθους φέρον, ἐν δὲ ἑκάστηι
> ἶσον ἔην πλῆθος. Μοῦσαι σφίσιν ἀντεβόλησαν
> ἐννέα, καὶ μήλων σφέας ἠΐτεον· αἳ δ' ἄρ' ἔδωκαν
> ἶσον ἑκάστηι πλῆθος, ἔχον δ' ἴσα ἐννέα καὶ τρεῖς.
> εἰπὲ πόσον μὲν δῶκαν, ὅπως δ' ἴσα πᾶσαι ἔχεσκον.
>
> (*Anth. Pal*. 14.48)

> The Graces were carrying baskets of apples, and in each
> was the same amount. The nine Muses met them,
> and asked them for apples: to each they gave the same amount,
> and the nine and three had each the same number.
> Tell me how many they gave, and how they all had the same amount.

Such mythical characters encoding mathematics ensures that the epigram is accessible to those Greeks who were being (or were already) educated. Notably the number of Graces is not mentioned until line 4—'the nine [Muses] and three [Graces] had each the same amount'—and then only obliquely. Importantly, the epigram makes the number of the Graces and Muses not just coincidental, but asserts the intrinsic numerical nature of the goddesses. Yet, as Bonnie MacLachlan's work on the Graces shows, their number varies depending on the choices of each cult.[43] So too, Tomasz Mojsik underlines the differing numbers of Muses in the ancient tradition.[44] This assumption that there existed a 'correct' number of Muses collapses the multiplicity of the Greek tradition. Moreover, if we follow Aristarchus, Homer did not conceive of a specific number of Muses.[45] This literary epigram not only demands singularity out of plurality, it is markedly un-Homeric.

Another epigram, recorded as Homer's reply to Hesiod when asked how many Greeks took part in the Trojan War, highlights a similar 'classification':

> ἑπτὰ ἔσαν μαλεροῦ πυρὸς ἐσχάραι· ἐν δὲ ἑκάστηι
> πεντήκοντ' ὀβελοί, περὶ δὲ κρέα πεντήκοντα·
> τρὶς δὲ τριηκόσιοι περὶ ἓν κρέας ἦσαν Ἀχαιοί.
>
> (*Anth. Pal*. 14.147)

> There were seven hearths of fierce fire: and in each
> were fifty spits and fifty joints on them:
> about each joint were nine hundred Achaeans.

43. MacLachlan (1993), 51 n.23.
44. Mojsik (2011), 74f.
45. Cf. schol. *ad Od.* 24.1 Dindorf.

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Again, the reader's calculation has a 'literary' significance; it emphasises the great number of those at Troy. Equally, we see Greek culture, and Homer's *Iliad* in particular, concretized by means of numbers. Remarkable is the sheer extent to which it has delimited the Homeric tradition. Hesiod's presumed question here is that very same which the poet, prior to the *Iliad*'s Catalogue of Ships, claims as impossible to answer (*Il.* 2.484-90); instead he is able only to recall the leaders of men. This epigram collapses the Iliadic passage, 285 hexameters (*Il* 2.494-779), into three lines. Furthermore, whereas Homer reckons between 100,000 and 150,000 men, this epigram bests him by suggesting there were 315,000. Homer is stripped of poetic weight, and accuracy. These epigrams underscore just what is at stake when addressing the numerical aspects of shared cultural notions.

How, then, does Archimedes employ mathematics 'culturally', and does it confirm, or depart from, the orthodoxy? His exposition of the cattle dwarfs Homer's 350 cows and sheep. I suspect, however, that this is not an attempt to best the bard, but rather to emphasise Sicily's fertility. Archimedes' compatriot, Theocritus, as Marco Fantuzzi notes and Reviel Netz develops, plays on a similar theme in *Idyll* 16. That 'patriotic' *Idyll* addressed to Hieron II of Syracuse, looks towards the island's reinvigoration with ἀνάριθμοι/μήλων χιλιάδες ('countless thousands of sheep', Theoc. *Id.* 16.90f.). Netz pushes this numerical aspect, suggesting that Theocritus' emphasis on 'those who wished to slaughter its [Sicily's] cattle' refers to contemporary events, perhaps Marcellus' attacks and siege of the city.[46] Archimedes' language and his mathematics equally contrive a situation of innumerable livestock. Yet whereas Theocritus states the immeasurability, Archimedes offers the expectation of a solution, which the mathematical complexity duly thwarts; Sicily's cows are innumerable and Sicily unlimited in its resources, a promotion of wealth but pointedly also a challenging warning to its enemies.

How, then, might we establish the terms of the debate for the *CP*? Eva Sistakou's work on 'Homericizing' epigrams in the seventh book of the *Palatine Anthology* traces how the Trojan myths were 'fossilized' by Hellenistic poets.[47] Commenting on riddles, she suggests that *familiarity* with Homeric 'stereotyped patronymics' and specific literary data induced poets to codify texts with lexical puzzles.[48] A similar process occurs in the mathematical epigrams. Yet this approach can be developed. The effect of cultural material being employed in educational *curricula*, then recycled in the symposium, makes elite consumers active participants in the continual re-configuration of the Greek tradition. A profitable discussion is offered by Akira Yatsuhashi, who examines the cultural dynamics of knowledge in Hellenistic epigrams.[49]

46. Netz (2009), 168, where Fantuzzi's thought *per litteras* is noted. See also Gow (1952), 128.
47. Sistakou (2008), 50-54.
48. *Ibid*., 54 n.95.
49. Yatsuhashi (2010), 125-77.

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Advancing the view of the Alexandrian Library as a concerted expression of power, he suggests that erudite epigrams emblematise this store-house of cultural knowledge. Such a Foucauldian reading illuminates the discourses of knowledge in mathematical epigrams. Alongside considerations of the exposure to Homer the epigrams demand, from wider cultural figures to the *minutiae* of Greek philology, the act of defining something numerically is revealing. Just as ancient libraries physically categorise and codify the literary tradition, so too enumerations serve to simplify and limit that information. The peculiar way in which mathematical epigrams attempt to give a specific, manageable form to the amorphous mass of the proceeding tradition reveals the conditions of their construction. If there is indeed a patriotic vein to Archimedes' cattle and their innumerability, it is no surprise that this poem is aimed at the contemporary embodiment of the tyranny of the archive: Eratosthenes, polymath and head of the Mouseion at Alexandria.

2.3 Cows and Catalogues: Measuring up (to) Homer

I conclude with the opening of the *CP* and ask how Archimedes foregrounds such dynamics of knowledge. The opening word πληθύν both signifies a 'multitude' and gestures towards a salient intertext. This programmatic beginning crystallizes the theme of immeasurability and illuminates the dynamics of mathematical and poetic knowledge. Additionally, it raises questions about its poetic status and the complexities of thinking about epic in other genres. This intertext is the second invocation to the Muses prior to the catalogue of ships, a passage succinctly highlighting the poet's ability to cope with numbers. Its popularity as a stand-alone section of the *Iliad* in Greek society affords the opportunity to take πληθύν seriously and contemplate how this might affect our reading.[50]

> ἔσπετε νῦν μοι Μοῦσαι Ὀλύμπια δώματ' ἔχουσαι·
> ὑμεῖς γὰρ θεαί ἐστε πάρεστέ τε ἴστέ τε πάντα,
> ἡμεῖς δὲ κλέος οἷον ἀκούομεν οὐδέ τι ἴδμεν·
> οἵ τινες ἡγεμόνες Δαναῶν καὶ κοίρανοι ἦσαν·
> **πληθὺν** δ' οὐκ ἂν ἐγὼ μυθήσομαι οὐδ' ὀνομήνω,
> οὐδ' εἴ μοι δέκα μὲν γλῶσσαι, δέκα δὲ στόματ' εἶεν,
> φωνὴ δ' ἄρρηκτος, χάλκεον δέ μοι ἦτορ ἐνείη…
>
> (*Il.* 2.484-90)

> Tell me now, Muses who hold the Olympian halls,
> for you are goddesses and are present and know everything,
> while we only hear reports and know nothing:

50. Cribiore (1994); Cribiore (1996); Cribiore (2001), 194f.

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how many were the leaders and kings of the Danaans:
the multitude, though, I could not tell of, or recall,
not if I had ten tongues, and ten mouths,
nor if my voice was unbreakable, and my heart bronze…[51]

With the prospect of (re)counting all the men at Troy, in a scene often analysed,[52] the poet reaffirms his relationship to the Muses. The poet's inability to deal with a large number of people contrasts with the Muses' omniscience; he will have to settle for recalling only the leaders of men.

This 'purple passage' has been variously interpreted as the poet's lack of strength for the task, or his failure to remember a large quantity of information. The poet's hypothetical ten tongues and mouths are intriguing. In the face of a multitude, the poet underlines how the division of labour between mouths becomes a useless task. Reinforcing expression through the numerical multiplication of the organs of poetry—γλῶσσαι and στόματα—still falters against the undefined πληθύν; the poet's reliance on the Muses fails, and so he must be selective.[53] Certainly, the poet is not directly concerned with mathematics or numeracy here.[54] Rather, the specificity of the noun πληθύν,[55] and the passage's popularity, allows us to consider the *CP*'s echo as a condensation of themes latent in the *Iliad*. Whereas in the *Iliad* the invocation signals imminent divine elucidation of information, in Archimedes' epigram the reader himself must generate it. The 'database' of Greek cultural knowledge, in the *Iliad* the Muses, is located with the reader in the *CP*. Equally, the passage highlights how traditional poets fail when attempting to quantify πληθύν. Indeed, the distinction that the poet of the *Iliad* makes is between knowing about every man at Troy, and those narratives of the great heroes and kings. Omniscience remains the gods', but the poet can recall narratives of cultural importance. Archimedes offers readers Muse-like omniscience and the ability to affirm their intellectual Hellenicity, while emphasising the futility of obtaining a total knowledge of everything Greek. His unique combination of mathematics and poetics serves as a culturally loaded message about the limits of knowledge.

Important to contrast with πληθύν is the command μέτρησον—'measure'. This verb, μετρέω, and its cognates have been the focus of increasing attention in scholarship on poetry and post-classical reception of Homer in particular. It is now uncontroversial to see in the language of 'measure' powerful statements about visual and verbal aesthetics. The term highlights not just a manipulation of, but a control over, Greek culture and its Homeric aspects. The ability to

51. The translation is my own.

52. Cf. most recently Murray (1981), 90, and Graziosi and Haubold (2010), 2. This is no doubt an over-simplification of the passage. Further discussion can be found in Ford (1991), 57-89.

53. Purves (2010a), 8, makes a similar suggestion.

54. Or they are not concerned in a scientific way at least. For numbers in epic see the meticulous study of Rubincam (2003).

55. It appears only twelve times in the *Iliad*, four as verse initial.

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circumscribe, condense, and schematise Homeric narratives is constructed as a wondrous feat, and an expression of mastery and wisdom (σοφία) by those who claim to have done so.[56] Archimedes' opening line, flanked by these key terms, πληθύν and μέτρησον, proclaims his manifesto to Eratosthenes. The Homeric πληθύν, imbued with an epic sense of the 'multitude'—crucially immeasurable by the poet—contrasts with the very challenge laid down. His command here is more than a mathematical imperative to 'calculate', and in many ways it is not really about mathematics at all. In the *CP*, πληθύν synecdochically stands in for the epic material and tradition, and specifically its unquantifiability. The first distich signals conditional inclusivity and historical impossibility. Archimedes *offers* the reader the chance to succeed where the poet fails, employing the concrete tools of mathematics, yet the weight of the epic tradition suggests that this is not guaranteed. Indeed, for the celebrated poet and mathematician Eratosthenes, the gauntlet has certainly been thrown down.

Traditionally conceived as a marker opening a catalogue, πληθύν operates likewise in the *CP*. The reader's expectations are fulfilled by Archimedes' exposition of the ratios of the cattle, which functions as a 'catalogue of cattle'. Offering a catalogue in an epigram or elegy, however, might strain our concept of the generic form. At a total of twenty-two distichs, the work ranks as one of the longest extant epigrams.[57] The command μέτρησον also encourages the reader to take account of the work's size, not only in numerical terms, but the poetic expenditure required. Given the epic form of the opening hexameter and the epic subject matter of πληθύν, we expect to be measuring in the medium of hexameter. Those expectations are thwarted in the subsequent pentameter, which provides the conditionality of the problem. Combined with the command μέτρησον, it could be construed as 'measure *these lines of poetry* if you are wise enough'; is Archimedes subtly asking us to reflect on his generic play?

To my mind, Archimedes' elision of the epic and 'elegiac' finds its prototype in a fifth century reworking of Homer. The Carian poet, Pigres, recasts Homer in elegiac couplets, inserting, after the first Homeric hexameter at least, his own pentameter, producing μῆνιν ἄειδε, θεὰ, Πηληϊάδεω Ἀχιλῆος / Μοῦσα, σὺ γὰρ πάσης πείρατ' ἔχεις σοφίης ('Sing, o goddess, of the anger of Achilles, son of Peleus / Muse, you who possesses the limits of all wisdom', Pigres fr. 1 West).[58] Notably, Pigres' pentameter replies to the hexameter with a consideration of wisdom. The Muse who possesses the limits of all knowledge (πάσης πείρατ' ἔχεις σοφίης) can be seen as relating the Muse's knowledge to the Homeric narrative she instigates; she does have 'mastery' over Homeric material.

56. The most recent, illuminating and extensive discussion of this idea can be found in Squire (2011), 102-10 and 247-83.

57. We may compare it to the equally ambitious inscription found at Salamacis on the history of Halicarnassus, on which most recently see Gagné (2006).

58. West (1971), 93. Intriguing, though not to be covered here, is the echo of language from both the *Tabulae Iliacae*, especially the ἀδαής of *CP* 30 and the repeated use of δαείς in the inscriptions, as well as in the Eudoxus papyrus. For now, see Petrain (2014), 54-59, and Squire (2011), 102-10.

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In this light, that Archimedes offers the reader even a share in wisdom (μετέχεις σοφίης) concerning the epic πληθύν might appear to encroach on the Muse's domain. If composed in full, Pigres' reworking would have doubled the length of the epic poem. We may in fact question whether more than the initial couplet was ever composed, or if this was a pointed poetic experiment highlighting the limits of cross-generic composition. Certainly, the first pentameter halts in its tracks Pigres' project to best Homer: knowledge of the correct compositional and dramatic extent, and the limits thereof, is controlled by the Muse. We have seen already how Archimedes' mathematical enumeration pushes at the limits of the 'elegiac' generic boundary; was this inspired by Pigres' own generic flexing? Whatever their specific relationship, it is clear that in the *CP* μέτρησον not only foregrounds the short-footed metrical skip, but sets in high relief Archimedes' project, and his message to Eratosthenes. The polyvalent μέτρησον, and the opening couplet more broadly, forces the reader to reflect on Archimedes' attempt to encapsulate the Homeric Cattle of the Sun. In terms of condensing the epic subject-matter, in analogy to Pigres' elegiac *Iliad*, the insertion of pentameters, the transition from epic to elegiac, results in the textual extension of the traditionally shorter elegiac form. If the opening hexameter line alludes to the failure of poets to reckon totally epic material, then the length of the work signals Archimedes' own failure in compressing and containing epic. In fact, the blurred line between epigram and elegy reinforces this; the relatively recent advent of catalogue elegy represents a generic compromise between the concision of epigram and the expanse of epic.

We might briefly stop to re-consider the final lines of the poem. The condition on which the reader may go (ἔρχεο) is that he has worked out (συνεξευρών), gathered and given an account of (ἀποδούς) every measure (τὰ πάντα μέτρα) of the multitudes (πληθέων) of cattle. Pushing the synecdochic equivalence of πληθύν and epic material, Archimedes' final words can be read metapoetically. Interpreting μέτρα as 'verses of poetry', then 'give an account of every measure of the multitudes' can be re-read as 'give an account of every verse of the multitudes (i.e. the whole of epic)'. This reveals precisely why the conditions of the problem will never be satisfied. As I have argued, enumeration of cattle in this poem is paralleled with attempting to have a complete knowledge of Homer. There are too many cattle to count; there is too much Homer to know. Archimedes combats Eratosthenes' hyper-rational mathematical geography by devising this poem which precisely emphasises and embodies the disconnection between culture and any attempts to mathematically and objectively define it.

The architecture of this work, contrary to what the last century of scholarship would seem to suggest, aims to engage with its readers on literary, intellectual and cultural levels. Likewise, the multiple frameworks of reading, and the distance this provides, open up a view of Archimedes' agonistic poetics aimed at Eratosthenes. The *CP* works because it problematizes scientific and mathematical descriptions of cultural and literary artefacts, especially for Eratosthenes whose rationalising geography sees him strip Sicily of its Homeric past. Most importantly,

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the poem serves as a corrective to an Alexandrian *mal d'archive*, and Eratosthenic attempts to claim knowledge of the entire *cosmos* (he is repeatedly and emphatically a ξεῖνος, with no 'real' knowledge of Sicily). Archimedes beats Eratosthenes at his own game, versifying science in erudite and allusive poetry, offering a scientific expression of the Greek cultural idea of the Cattle of the Sun (not to mention the dimensions of Sicily itself), but with the expressed aim of underscoring the sheer fecundity and immeasurability of the Homeric tradition and Greek culture.

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Appendix I

Πρόβλημα ὅπερ Ἀρχιμήδης ἐν ἐπιγράμμασιν εὑρὼν τοῖς ἐν Ἀλεξανδρείαι περὶ ταῦτα πραγματευομένοις ζητεῖν ἀπέστειλεν ἐν τῆι πρὸς Ἐρατοσθένην τὸν Κυρηναῖον ἐπιστολῆι.

πληθὺν Ἠελίοιο βοῶν, ὦ ξεῖνε, μέτρησον
φροντίδ' ἐπιστήσας, εἰ μετέχεις σοφίης,
πόσση ἄρ' ἐν πεδίοις Σικελῆς ποτε βόσκετο νήσου
Θρινακίης τετραχῆι στίφεα δασσαμένη
χροιὴν ἀλλάσσοντα· τὸ μὲν λευκοῖο γάλακτος,
κυανέωι δ' ἕτερον χρώματι λαμπόμενον,
ἄλλο γε μὲν ξανθόν, τὸ δὲ ποικίλον· ἐν δὲ ἑκάστωι
στίφει ἔσαν ταῦροι πλήθεσι βριθόμενοι
συμμετρίης τοιῆσδε τετευχότες· ἀργότριχας μὲν
κυανέων ταύρων ἡμίσει ἠδὲ τρίτωι
καὶ ξανθοῖς σύμπασιν ἴσους, ὦ ξεῖνε, νόησον,
αὐτὰρ κυανέους τῶι τετράτωι τε μέρει
μικτοχρόων καὶ πέμπτωι, ἔτι ξανθοῖσί τε πᾶσιν.
τοὺς δ' ὑπολειπομένους ποικιλόχρωτας ἄθρει
ἀργεννῶν ταύρων ἕκτωι μέρει ἑβδομάτωι τε
καὶ ξανθοῖς αὐτοὺς πᾶσιν ἰσαζομένους.
θηλείαισι δὲ βουσὶ τάδ' ἔπλετο· λευκότριχες μὲν
ἦσαν συμπάσης κυανέης ἀγέλης
τῶι τριτάτωι τε μέρει καὶ τετράτωι ἀτρεκὲς ἶσαι·
αὐτὰρ κυάνεαι τῶι τετράτωι τε πάλιν
μικτοχρόων καὶ πέμπτωι ὁμοῦ μέρει ἰσάζοντο
σὺν ταύροις πάσαις εἰς νομὸν ἐρχομέναις.
ξανθοτρίχων δ' ἀγέλης πέμπτωι μέρει ἠδὲ καὶ ἕκτωι
ποικίλαι ἰσάριθμον πλῆθος ἔχον τετραχῆι.
ξανθαὶ δ' ἠριθμεῦντο μέρους τρίτου ἡμίσει ἶσαι
ἀργεννῆς ἀγέλης ἑβδομάτωι τε μέρει.
ξεῖνε, σὺ δ' Ἠελίοιο βόες πόσαι ἀτρεκὲς εἰπών,
χωρὶς μὲν ταύρων ζατρεφέων ἀριθμόν,
χωρὶς δ' αὖ θήλειαι ὅσαι κατὰ †χροιὰν ἔκασται,
οὐκ ἄϊδρίς κε λέγοι' οὐδ' ἀριθμῶν ἀδαής,
οὐ μήν πώ γε σοφοῖς ἐναρίθμιος. ἀλλ' ἴθι φράζευ
καὶ τάδε πάντα βοῶν Ἠελίοιο πάθη.

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ἀργότριχες ταῦροι μὲν ἐπεὶ μιξαίατο πληθὺν
κυανέοις, ἵσταντ' ἔμπεδον ἰσόμετροι
εἰς βάθος εἰς εὐρός τε, τὰ δ' αὖ περιμήκεα πάντη
πίμπλαντο πλίνθου Θρινακίης πεδία.
ξανθοὶ δ' αὖτ' εἰς ἓν καὶ ποικίλοι ἀθροισθέντες
ἵσταντ' ἀμβολάδην ἐξ ἑνὸς ἀρχόμενοι
σχῆμα τελειοῦντες τὸ τρικράσπεδον οὔτε προσόντων
ἀλλοχρόων ταύρων οὔτ' ἐπιλειπομένων.
ταῦτα συνεξευρὼν καὶ ἐνὶ πραπίδεσσιν ἀθροίσας
καὶ πληθέων ἀποδούς, ξεῖνε, τὰ πάντα μέτρα
ἔρχεο κυδιόων νικηφόρος ἴσθι τε πάντως
κεκριμένος ταύτηι γ' ὄμπνιος ἐν σοφίηι.[59]

Appendix II

A problem Archimedes devised in epigrams which he sent in a letter to Eratosthenes of Cyrene, to those in Alexandria attempting to work out such things.

The multitude of the Cattle of the Sun calculate, O stranger, and set your mind to it, if you have a share in wisdom, as many as once grazed the plains of Sicily's Thrinakian island, divided four-ways into groups of differing colours: one milky white, another shining with black hue, while yet another brown, the last, many-coloured. In each herd were bulls strong in number formed in the following proportions: the white-haired equal a half and third of the black bulls together with the brown bulls.

But consider, o stranger, that the black equals a quarter share and fifth of the many-coloured and the whole of the brown besides. Observe how the remaining dappled bulls equal a sixth and a seventh share of the white bulls and the whole of the brown. With the cows, it was the following: the white-haired were exactly equal to a third and a quarter share of the whole of the black herd: but the black cows again equalled a quarter of the dappled and a fifth share together, when with all the bulls they went to pasture. The many-coloured quartered have an equal number to a fifth and sixth of the brown-haired herd. The brown cows numbered equal to a half of a third share of the white herd, and a seventh share.

If, O stranger, you accurately tell how many Cattle of the Sun there are, telling separately the number of well-fed bulls and separately again the number of each cow herd according to colour, you would not be called unskilled or ignorant of numbers, yet nor would you be counted among the wise.

But come, consider all these conditions of the Cattle of the Sun. When the white-haired bulls mix their multitude with the black they stand firmly together, their length and breadth of equal measure, stretching far and wide the plains of Thrinakia were filled with their masses. Again, when the brown and dappled bulls were herded together they stood, beginning with one, increasing in number resulting in a three-bordered shape, neither any other coloured bulls among them, nor with any left out.

If, O stranger, having completely worked out in your mind these things, collating and giving an account of every dimension you may go, a victor, and carry yourself proud, knowing that wholly you have been judged 'well-fed' in this species of wisdom.[60]

59. This text of Archimedes is from Lloyd-Jones and Parsons (1983), 77f.
60. The translation is adapted from Thomas (1941), 202–05.

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Appendix III

$$White\ Bulls = \frac{5}{6}\ Black\ Bulls + Brown\ Bulls$$

$$Black\ Bulls = \frac{9}{20}\ Dappled\ Bulls + Brown\ Bulls$$

$$Dappled\ Bulls = \frac{13}{42}\ White\ Bulls + Brown\ Bulls$$

$$White\ cows = \frac{7}{12}(Black\ Bulls + Black\ Cows)$$

$$Black\ Cows = \frac{9}{20}(Dappled\ Bulls + Dappled\ Cows)$$

$$Dappled\ Cows = \frac{11}{30}(Brown\ Bulls + Brown\ Cows)$$

$$Brown\ Cows = \frac{13}{42}(White\ Bulls + White\ Cows)$$

Appendix IV

White Bulls + Black Bulls = A square number
Brown Bulls + Dappled Bulls = A triangular number

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