Ludic Proof: Greek Mathematics and the Alexandrian Aesthetic. By REVIEL NETZ. Cambridge and New York: Cambridge University Press, 2009. Pp. xv + 272. Cloth, $99.00. ISBN 978–0–521–89894–2.

Ludic Proof, Netz's (N.) third book-length study in Greek mathematics, both complements and departs from his earlier work. N.'s first book analyzed the style of Greek mathematical treatises in a general, abstract way, covering the full temporal range of Greek scientific mathematical writing (5th c. BC – 6th c. AD). [[1]] The second, more culturally and historically directed, treated the renovation of mathematics in the Middle Ages. [[2]] The current project focuses on one period of Greek mathematical writing (3rd – 2nd c. BC) and aims to analyze the scientific style of writing within the context of contemporary (Hellenistic) literary (poetic) style.

N.'s premise, to ground Greek mathematical writings "not in the generalized polemical characteristics of Greek culture, but rather in a more precise interface between the aesthetics of poetry and of mathematics, operative in Alexandrian civilization" (p. x), reflects current trends across the discipline in investigating the role of aesthetic, social and political ideology in the formation and reception of texts. [[3]] Although the socio-political settings for poetry and science differ, science, like literature, responds to its socio-cultural heritage and is "the creature of its own age" (p. 241). In four packed chapters, N. analyzes Greek mathematical works with a deep sensitivity for style, and he situates them within the broader intellectual landscape of the early Hellenistic world. Needless to say, there is much math in the book, but N. is methodical and cautious. His careful analysis, bolstered by exegetic diagrams, makes the material accessible even to the mathematically challenged. Moreover, Greek is used sparingly, and is translated when it is. Herewith, my only major complaint: full Greek texts of significant passages would be salutary. Although the text is often "thick," much resembling the mathematics that serves as the core of the study, pertinacious readers will be rewarded by a deeper understanding of an important set of Hellenistic texts.

N. makes the simple assumption that "people do the things they enjoy doing" (p. x) and that literary style reflects this enjoyment. His animated style proves the point. Hellenistic mathematics is a verbal, textual activity, produced by educated, non-professional elites for an audience of genteel amateurs, most of them also consumers of Hellenistic poetry. Such readers find no charms in prosaic compositions of mensuration and other mundanely practical topics. Consequently, mathematical texts are stylistically playful, subtle and sophisticated.

In his analysis of Archimedes' *Spiral Lines* (3–14), for example, N. shows that Archimedes incorporates intrigue, suspense, surprise, variety and sharp transitions, with increasing opaqueness that deliberately obfuscates the mathematics and disorients the reader. In the end, Archimedes draws together contradictory propositions into an elegant multi-dimensional, surprising narrative, manipulating both arithmetic and geometry, straddling the physical and abstract, to the reader's amazement. In *Spiral Lines*, an exegesis of complex multi-dimensional geometric concepts, Archimedes spins a text of coiling layers of propositions and proofs that narratively parallels the very mathematics under study. Content and style are interdependent and complementary. *Spiral Lines*, in fact, is presented as a verbal spiral. N., ever cautious, does not make so blunt an observation, but like Archimedes and other Hellenistic mathematicians, he allows modern readers to fit together the puzzle pieces for themselves. Mathematics becomes an activity shared by author and reader.

In the first chapter, "The Carnival of Calculation," N. offers a close reading of several mathematical works on large numbers whose results are open-ended: e.g., Archimedes' *Stomachion*, a tangram game; Aristarchus' *On the Sizes and Distances of the Sun and Moon*; Eratosthenes' *Sieve*, an algorithm to find prime numbers; and Archimedes' *Sand Reckoner*, a numerical system to express very large numbers. The authors employ a complex, mosaic structure, "via complex, thick structure of calculation, to unwieldy numbers" (p. 20), which provides N. with his "carnival of calculation." Content and style are integrated according to four main themes: (1) bounding the unbounded (a prominent aim in early Greek cosmologic and geographic initiatives); (2) demonstrating the opaque, cognitive texture of calculation (evoking the abstruseness and erudition of contemporary literature); (3) engaging in non-utilitarian calculation (just as Hellenistic literature may focus on apolitical themes); and (4) the Hellenistic fascination with size, both the extremely small and the extremely large. Several treatises, through series of complex calculations, lead up to "fantastically rich numbers…, contributing to a sense of dazzlement, of the carnivalesque" (p. 58), a direct reflection of contemporary political and military culture: the Ptolemaic *pompe*, the colossus, huge warships (p. 60). The act of calculation does not simplify or solve, but shows the complexity of the problem.

The second chapter, "The Telling of Mathematics," centers on the narrative technique of suspense and surprise as employed by mathematical writers. N. shows that, despite the ostensibly impersonal nature of Greek science, authorial voice is successfully modu-

lated. Many mathematical works are cast as letters, whose writer–narrator–characters interact directly with addressees, usually prominent historical figures explicitly invoked in the prologues. Science, no less than history or drama, can be highly personal, as recent scholarship has shown. [[4]] N. raises cogent questions about readership and the expectations of those readers (40–3, 75–80). Authors, writing as much for themselves as for those with shared interests, present challenging mathematical riddles, offering no pedagogic intervention to explain the flow of the text. To do so would cheat the reader of the delight of discovery. Where is the fun in reading a text that gives away the answers? The puzzle is meant to tantalize and to be solved.

In the third chapter, "Hybrids and Mosaics," N. explores variety in Hellenistic Greek mathematics. Authors juxtapose (seemingly) unrelated threads in compositional variation. On the surface, most treatises seem incongruous. But critical reading shows that authors balance the abstract with the concrete, geometry with arithmetic, mathematical approaches with mechanical, and they even present multiple proofs of the same proposition to create a richer reading experience. In two separate treatises, for instance, Archimedes offers three discrete proofs for the basic measurement of the parabola, while Eratosthenes emphasizes the multiplicity of his abstract and mechanical approaches to duplicating the cube. *Variatio* is likewise reflected in the very topics studied in Hellenistic geometry—the description, mensuration and understanding of complex planar and spherical shapes, such as Nicomedes' cissoids and conchoids. Further, mathematical nomenclature is drawn from visual but mundane vocabulary (shells, locks). N. discusses parallels from contemporary medical terminology (pp. 157–9), providing another example of the unexpected juxtaposition of the sublime (scientific) with the mundane. N.'s discussion could be further advanced with evidence from geography and other scientific fields. Eratosthenes reduces the landmasses to easily recognizable geometrical shapes (rhomboids, triangles), and metaphors drawn from daily life are deliberately and vividly applied to maps by Strabo and his predecessors. [[5]]

N. begins to connect science to literature by linking Hellenistic mathematics with earlier literature. Archimedes' *Sand Reckoner* plays on an ancient poetic trope that dates back to Homer (p. 165). Eratosthenes appeals to mythology in *Doubling the Cube*, and Homer, no longer the divinely authoritative source, serves as a foil in his *Geography*. Nicander's *Theriaca* is composed in hexameters. Archimedes'

Cattle Problem suggests a literary setting (*Odyssey* 12) and may even respond to contemporary Sicilian politics (pp. 168–9).

The fourth chapter, "The Poetic Interface," is probably of greatest interest to *CJ's* audience. Here, N. investigates how poetic conventions complement and parallel scientific style, and how poets weave science into literature. It is perhaps no surprise that N. branches beyond mathematics but restricts himself to passages whose scientific content is unambiguous: e.g., Apollonius of Rhodes' *Argonautica*, with its interface between "modern" and mythic geography, ethnography and medicine; Callimachus' geographically relevant *Hymn to Delos* and astronomically charged *Lock of Berenice*; and Aratus' *Phaenomena,* whose hexameters straddle astronomy, astrology and meteorology. N.'s analysis of theme and purpose is satisfying. For example, he shows that *The Lock of Berenice* demonstrates the features of mathematical style lucidly explored in the first three chapters: duality of meaning, bounding the unbounded, and the impossibility (unsolvability) of the task. Callimachus also effectively retains the scientific context of Conon's original astronomical discovery (or, rather, declaration) while blurring the precise geometrical reference in utilizing a mathematically charged phrase: *en grammaisin*, to do something based on a diagrammatic representation in geometry (p. 179; see also 195). One might like to have seen even more analysis of scientifically charged vocabulary as used by the poets (technical terminology in Apollonius; medical vocabulary in Theocritus?). Likewise useful would have been further social contextualization of science in literature, along the lines of N.'s observation that Leto's new-fangled upright position for giving birth, perhaps, derives from Herophilus' theories in obstetrics (p. 194).

Ludic Proof is a welcome addition and valuable complement to the growing body of scholarship in Greek science, especially those works that investigate the nexus between science and literature, including Cuomo on practical mathematics and Romm on geography. [[6]] N. successfully contextualizes scientific activity within the Hellenistic intellectual landscape and personalizes these authors, men of lively intellect who approached mathematics with éclat and vivacity, spinning page-turning tales of suspense and mystery. Undoubtedly (or at least hopefully) this study will inspire some among the mathophobic to read these gems of Hellenistic mathematics with a fresh eye.

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[[1]] *The Shaping of Deduction in Greek Mathematics* (Cambridge, 1999).

[[2]] *The Transformation of Mathematics in the Early Mediterranean* (Cambridge, 2004).

[[3]] N. does not deny the polemical nature of Greek science, but merely adds a new layer to the interpretation of Hellenistic mathematics. For contentiousness in Greek science, see G.E.R. Lloyd, "Democracy, philosophy, and science in ancient Greece," in J. Dunn (ed.), *Democracy: the Unfinished Journey* (Oxford, 1992) 41–56; T.E. Rhill, *Greek Science* (Oxford, 1999) repr. Cambridge, 2006.

[[4]] G.E.R. Lloyd, "Mathematics as a Model of Method in Galen," in R.W. Sharples (ed.), *Philosophy and the Sciences in Antiquity* (Aldershot, 2005) 110–30; "The Meno and the Mysteries of Mathematics," *Phronesis* 37 (1990) 166–83; Katherine Clarke, "In Search of the Author of Strabo's *Geography*," *JRS* 87 (1997) 92–110; Roger Brock, "Authorial voice and narrative management in Herodotus," in Peter Derow and Ruth Parker (eds.), *Herodotus and his world: essays from a conference in memory of George Forrest* (Oxford, 2003) 3–16; Ismene Lada-Richards, "Authorial voice and theatrical self-definition in Terence and beyond: the 'Hecyra' prologues in ancient and modern contexts." *G&R* NS 51(2004) 55–82.

[[5]] Klaus Geus, "Measuring the Earth and the Oikoumene," in Richard J.A. Talbert and Kai Brodersen (eds.), *Space in the Roman world: its perception and presentation* (Münster, 2004) 11–26; Daniela Dueck, "The parallelogram and the pinecone: definition of geographical shapes in Greek and Roman geography on the evidence of Strabo," *AncSoc* 35 (2005) 19–57.

[[6]] S. Cuomo, *Ancient Mathematics* (London, 2001); J. Romm, *The Edges of the Earth in Ancient Thought: Geography, Exploration and Fiction* (Princeton, 1992).