books

Cracking the codex's ancient code

The Archimedes Codex

How a Medieval Prayer Book Is Revealing the True Genius of Antiquity's Greatest Scientist

Reviel Netz and William Noel
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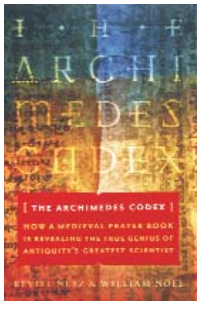
Reviewed by Henry Mendell

On the afternoon of 29 October 1998, Christie's auction house in New York sold off a scrappy, late Byzantine prayer book for $2 million. A very wealthy, anonymous American won the prize. It was a big event in the small world of Greek mathematics, for underneath the prayers were rubbed-out works of Archimedes (287–212 BCE). Prior to the sale, only Johan Ludvig Heiberg had ever studied the undertext. Heiberg had spent his 1906 summer vacation in Constantinople photographing and transcribing it. The palimpsest contained the only known Greek text of *On Floating Bodies*, a work whose Latin translation was important for the emergence of early modern science; a scrap of the *Stomachion*; and the *Method*, a masterpiece unlike any other extant work of ancient Greek mathematics.

Sometime in the 1920s the prayer book disappeared. Quiet attempts were made to sell it in the 1930s and again from the 1960s on, with potential buyers including Yale and Stanford universities and the J. Paul Getty Museum. The text today is not what Heiberg saw. He was not allowed to undo the binding to examine each page; glue, mold, forged illuminations, and missing folios now inhibit the modern reader. Newer technologies were needed to reveal the undertext. The result is that although Heiberg saw things that we may never see, researchers can now see much that he couldn't.



Reviel Netz and William Noel's *The Archimedes Codex: How a Medieval Prayer Book Is Revealing the True Genius of Antiquity's Greatest Scientist* consists of two personal introductions to the palimpsest, its history, the work in reading it, and its mathematics—especially in recent discoveries (see the article by Netz in PHYSICS TODAY, June 2000, page 32). Noel is curator of manuscripts at the Walters Art Museum in Baltimore, Maryland, where the owner deposited the palimpsest, and is the director of the Archimedes Palimpsest Project. Netz, professor of classics and philosophy at Stanford University and one of the most creative historians of mathematics of our time, has worked extensively on the palimpsest. In alternating chapters with Netz, Noel narrates with some verve his own story in learning about the palimpsest; he surveys both the document's history from the origins of the undertext to its sojourn at SLAC at 2006 for advanced imaging and the discovery of works by other ancient Greek authors.

Two interesting discoveries in the mathematics of the text have been made. In the *Method*, Archimedes uses indivisibles (a misnomer) to treat an n-dimensional figure as being composed of n–1-dimensions, such as a triangle of parallel lines or a cylinder of rectangles. He combines that method with the principle of the balance; however, proposition 14 of the *Method* works only with indivisibles. Archimedes uses a lemma he proves elsewhere that is appropriate to finite-sized sets and saw no problem in generalizing to the infinite: He calculated with infinities. Did he, as Netz claims, have a notion of equinumerous sets as having a one-to-one correspondence?

Initially, the purpose of the *Stomachion*, or "Bellyache," the translation plausibly suggested by Netz, was unknown, except that it involves a game with 11 triangles, two quadrilaterals, and one irregular pentagon that together can form a square. Building on recent work of Fabio Acerbi showing that Hipparchus (c. 180–125 BCE) had engaged in sophisticated combinatorics and reading more of the text than Heiberg could, Netz reasonably proposes that the *Stomachion* also engages in combinatorics: How many ways can 14 figures form a square? Does this mean that Archimedes and Hipparchus studied combinatorics, or did they just work two different counting problems that happened to be difficult combinatoric ones?

Much of *The Archimedes Codex* is delightful. The story of the palimpsest is exciting, and few can explain difficult issues in Greek mathematics with the simplicity and elegance that Netz achieves. However, I cannot recommend the book without deep reservations. Both authors indulge everywhere in extravagance and occasionally even in melodrama. Some hyping, including the book's title, is harmless journalism, if not to my taste, but a discussion of the many harmful instances would exceed the space of a short review. My brief examples center on two issues: the noble goal of explaining to a general audience the importance of studying the language of texts and Netz's adaptation of the already extravagant quip of 20th-century philosopher and mathematician Alfred North Whitehead on Plato, that the history of modern science is a footnote to Archimedes.

After disparaging all reports of Archimedes' life in ancient sources, Netz proposes his own implausible, linguistic recovery of Archimedes' life—that Archimedes' father had philosophical interests in choosing his son's name. For the record, "Archimedes" means something like "Chief Counselor," not Netz's proposed "the Mind of the Principle" (page 36).

Archimedes certainly is the central and greatest figure in ancient Greek

Henry Mendell is a professor of philosophy at California State University in Los Angeles. His interests are in ancient philosophy, particularly the history of philosophy that focuses on astronomy and mathematics.

mathematics and in its revival, which was crucial for the emergence of 16th- and 17th-century mechanics. However, if all you knew of Greek mathematics was from Netz and Noel's book, you might incorrectly conclude that Archimedes discovered the method of exhaustion, conic sections, the notions of infinity and indivisibles, mathematical mechanics, and more. Netz also goes on to turn Archimedes into a scientific magician. In describing (very elegantly, I might add) how Archimedes finds the center of mass of a triangle in his *On the Equilibrium of Planes*, Netz says that Archimedes has told us "without even looking how the world must behave, where a triangle must balance," and Netz calls it an "act of magic" (page 147). Maybe, but Archimedes does begin the treatise with a series of seven crucial, empirically grounded assumptions about centers of mass and balances, and he consciously employs an idealization that the triangle, a plane figure, has uniformly distributed weight.

Netz hypes Archimedes' importance. Surely, many basic concepts in early modern science are absent from Archimedes—for example, experimentalism, algebra, probabilistic and genetic explanations, even mechanism. Archimedes was uninterested in biology, medicine, and the nature of matter. Netz's claim, based on six lines of the *Method*, that Archimedes "foresaw a glimpse of Set Theory" (page 202) baffles me inasmuch as Archimedes' argument about infinite sets generates paradoxes discovered in the 17th century and not resolved until the 19th century.

The *Method* and the *Stomachion* are important works, and Netz is doing some great things with them, and with the rest of the mathematical texts in the palimpsest. Yet barely a shred of evidence exists that the *Method* influenced anyone; only Hipparchus was perhaps influenced by the *Stomachion*, and even the evidence for that is circumstantial at best.

The Archimedes Codex is a fun read. When it succeeds, it does so very well. But I worry that readers will not know when it does not—when a conjecture is wild, an inconvenient manuscript omitted, the study of chronology twisted to serve an entertaining but false thesis, and so forth. The subject is so interesting and the authors so uniquely positioned to present it that I wish they had chosen a more restrained approach. The book is also a clever ploy to attract interest in finding the missing folios. And in that attempt, we can all wish the authors luck.

Einstein's Struggles with Quantum Theory

A Reappraisal

Dipankar Home and Andrew Whitaker

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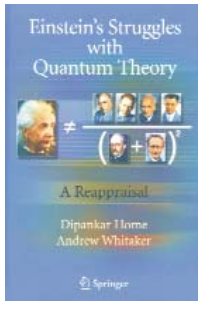
In 1986 John Stachel, founding editor of the ongoing series *The Collected Papers of Albert Einstein* (Princeton University Press, 1987), wrote the article "Einstein and the Quantum: Fifty Years of Struggle," which also appeared later in his book *Einstein from "B" to "Z"* (Birkhäuser, 2002). He started with the following quote from a letter Einstein had written late in his life to his friend Michele Besso: "The whole fifty years of conscious brooding have not brought me nearer to the answer to the question 'What are light quanta?' Nowadays every scalawag believes that he knows what they are, but he deceives himself."



More than 20 years and 10 volumes of Einstein's collected papers later, I was expecting that a book with a title similar to Stachel's article would offer an update on our current understanding of the physicist's broodings on the quantum. Yet that is not what *Einstein's Struggles with Quantum Theory: A Reappraisal* is about. Apart from a passing reference to the first volume of the collected papers, authors Dipankar Home, a professor of physics at Bose Institute in Kolkata, India, and Andrew Whitaker, a professor of physics at Queen's University Belfast in Northern Ireland, make no use of the published volumes of Einstein's papers and mention very little of the pertinent, specialized history-of-science literature on the subject. Nor did they do any research in the Albert Einstein Archives at the Hebrew University in Jerusalem. "Fifty years of conscious brooding" has left its traces in unpublished manuscripts, correspondence, and other documents, analysis of which would make for an interesting read. I should expect that such an account would put Einstein's response to the physics of his time in a broader historical context. But the authors are not historians, and their focus is not on Einstein as a historical figure.

Nevertheless, despite the misleading first part of its title, the book is serious, competent, and most engaging. Its declared aim is a reappraisal of Einstein's critical attitude toward quantum theory. The authors argue against the widely shared view that Einstein's refusal to accept the orthodox Copenhagen interpretation is merely an expression of a stubborn unwillingness to accept the results of modern physical research. Quite to the contrary, they argue, the case can be made that much of the most interesting, cutting-edge research in quantum physics today vindicates Einstein's critical insistence on questioning the conventional Copenhagen dogma. What they see as Einstein's crucial legacy is mostly the famous Einstein-Podolsky-Rosen incompleteness argument.

Home and Whitaker also discuss some of his earlier work and especially the famous Einstein–Bohr debate. They agree with historians and philosophers of science who recently have been debunking the myth of the grand victory of Niels Bohr and his followers in their standoff with Einstein. The authors evaluate Einstein's position on the basis of his published works and some of his published correspondence. Despite their not-so-much historical yet systematic interest, they give a fair characterization of his position, although their analysis of his realism as pragmatic seems excessively benign. A more detailed historical evaluation may have revealed his position to be more nuanced, one that also changed over time and was perhaps not always consistent.

The authors' historical claim that Einstein's critique of quantum theory was justifiable does not derive from an assessment of the physics of Einstein's day. It rests on identifying a line of development that leads from David Bohm and John Stewart Bell to today's research in quantum information theory, quantum computation, quantum cryptography, and efforts to test quantum mechanical effects on mesoscopic and macroscopic scales. In fact, the book's full strength unfolds in its later chapters, where the authors discuss recent developments in those fields in light of their earlier treatment of Einstein's criticisms. A crucial observation emphasized by the authors is that the ubiquitous notion of entanglement traced back to Einstein's earlier interventions is now being explored as a rich resource rather than as a stumbling block for the standard interpretation.

Home and Whitaker give expert overviews and brief characterizations of various nonstandard quantum interpretations, the development and cur-