

The Archimedes Palimpsest: Old Science Meets New Science

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I'm going to give you the goat's point of view. Imagine if you will a goat grazing peacefully in the fields outside Istanbul almost exactly 1,000 years ago. It had a nice life. Then, together with about fifty other goats, it was slaughtered. Its blood was drained. It was skinned. The skin was soaked in a lime solution for about a week, then stretched on a frame and left to dry in the sun. Then the skin was scraped, and cut to size. Then it was written on with a reed pen by a scribe who used an ink of ferrous sulfate mixed in an acid solution. This is the remains of that goat. Not pretty; not surprising.

Now the goat was presumably not happy about its fate. But this goat is one of the very few individual goats who have made a difference. In fact, it is uniquely important in the history of western thought. On the back of this goat, and of its close genetic relatives, exist words that do not exist anywhere else in the world.

We know much about the prehistory of these words. They are over twice as old as the goats on which they are written. The ancestors of these words, now deceased, were first created by Archimedes, the ancient Greek mathematician, in Syracuse, Sicily, in the third century B.C. These words are the last surviving material witnesses to many of the thoughts of Archimedes. Specifically, on these goats is the only surviving text of Archimedes' "Method of mechanical Theorems" in which Archimedes uses Mechanical examples to come to abstract mathematical proofs in ways that anticipate calculus. Also they are the support for the only text of the Stomachion, a lighthearted treatise of reflections on a sort of tangram game; and the only surviving Greek text of his famous treatise "On Floating Bodies". These are then, uniquely important goats.

The deceased ancestors of these words were not written on goats; they were written on parchment, and they were written on scrolls. Seven hundred years later, in the fourth century AD the book was invented. The idea of preparing animal skins, nesting them together into conjoint pages like newspapers and stitching these newspapers together between wooden boards covered in leather was a brilliant one, particularly for works of reference and religious practice; and the book is also a wonder of medieval technology. The form of the book has not changed much in 1,700 years. But in the grander scheme of things the book is merely transitional technology in the service of ideas. The book is very nearly dead; new science is replacing old science.

To move from the general to the specific, you might have thought that the survival of this particular book was a near certainty, considering the importance of what it contains. This is not the case. The goats that make up this particular book are on their very last legs: they have been reused, they have traveled widely, they have been in a fire, they have been mutilated, they have become moldy, they have been repeatedly sold. This, very briefly, is their story.

To start off with life was good. The original manuscript was a highly prized object. Unusually for a mathematical treatise, it was a rather splendid production. Large, written out in two spacious columns of text, with wide margins. It's creation was only possible in a culture that prized abstract mathematical learning, and it is the sort of book that was made to the specific order of a highly regarded scholar, or group of scholars, probably in the imperial court of the Emperor of Byzantium, possibly Constantine VII Porphyrogenitos or Basil II.

Two hundred years later, however, the goats were not nearly so highly regarded. Constantinople was besieged, and, in 1204, ransacked by western soldiers on the third crusade - one of the true great disasters in the history of Western Civilization. This was not a time for speculating on the nature of mechanical theorems or floating bodies. This was a time for saving souls. To save souls, of course, you need religious texts on parchment, and to make parchment you need goats. However, even getting goats and preparing parchment in Constantinople in the early thirteenth century was very difficult. It was easier by far to get parchment that was already prepared. So two hundred years after the goats were turned into a book containing the works of Archimedes, they were horribly mutilated. The book was taken apart. The Archimedes text was scraped off, the parchment sheets were cut in half and stacked in no particular order, together with other books now deemed to be useless. These sheets were then written over with a Christian prayerbook, or Euchologion, at an angle of 90 degrees to the original Archimedes text. Archimedes was effectively obliterated. What you see here therefore is not the Archimedes text, but the prayerbook text. The Archimedes text, barely visible and in places invisible to the naked eye was palimpsested - written over. There were worse fates for texts that were considered unimportant. The greatest enemy of the book is not malice or over-reading, but neglect. The Christian prayerbook was not neglected,

and Archimedes survived in a holy disguise. For at least 400 years it was treasured and used at the monastery of Mar Saba on the West Bank, between Bethlehem and the Dead Sea.

Meanwhile, in Basle in 1544, there was a crucial publication in the history of mathematics. A publication that was of enormous importance for Galileo and for Newton, the *Editio Princeps* of Archimedes. Johannes Herwagen's publication of the works of Archimedes was considered complete at the time. However, two works by Archimedes were not in it, and *Floating Bodies* was only published in Latin. The only Greek text of "On Floating Bodies", was regularly on the altar of a monastery in a desert, and being overlooked by a monk performing baptisms and exorcisms.

By 1846 the Archimedes Palimpsest was no longer at Mar Saba, but rather at the Metochion, or Daughter House, of the Church of the Holy Sepulchre in Jerusalem, which itself is in the Greek quarter of Constantinople, present day Istanbul. We know this through a truly extraordinary circumstance. The famous scholar, and somewhat dubious character Constantine von Tischendorf visited the Metochion in that year. He said he found nothing of particular interest except a palimpsest containing mathematics. He did not say that he took a sheet from the manuscript. But he did. He took the page between the present folios 2 and 3. It was sold to Cambridge University Library by the executors of his estate in 1873. This leaf was only identified as coming from the Archimedes Palimpsest in 1983, by Nigel Wilson of Lincoln College Oxford.

In 1899, the library of the Metochion was catalogued by Papadopoulos-Karameus. He catalogued the prayerbook and noted that it was a mathematical palimpsest. On the strength of this description, the Professor of Philology at the University of Copenhagen, Johan Ludwig Heiberg, visited the community in 1906, and discovered the true importance of the document. He started to transcribe it. But he did not have very long in Istanbul, so he got a local photographer to take pictures of it, and he did nearly all the work from these photographs, back in Copenhagen. The palimpsest consisted of 177 folios, but for some reason Heiberg did not order photographs of the entire manuscript. He only ordered sixty five. He seems to have ordered photographs of those texts that he could find nowhere else. In 1907 he published his transcription of the *Method of Mechanical Theorems*, and caused a sensation that made front page news in the New York times.

Heiberg was a brilliant man, and this is a brilliant publication. With the help only of photographs, he transcribed about four fifths of the text. There are problems with the edition. Most important are the diagrams. Heiberg was a philologist. He was not particularly interested in the diagrams that accompany the text, and in the edition the diagrams are not copied from the palimpsest, but recreations based upon the transcribed text by a mathematician called Zeuthen. Mathematicians think in diagrams, but the diagrams in Heiberg's edition tell us no more about Archimedes thought than the text. They tell us about Zeuthen, not Archimedes. The diagrams in the Palimpsest

itself may be the unique source for the diagrams that Archimedes himself actually drew. The scholarly world is excited about the diagrams, and rightly so.

The scholarly world is still, I think, skeptical of the importance of the palimpsest for the text of the method. Heiberg could not read into the gutter of the book, however, and some pages he just could not seem to read. Heiberg is thought to be very difficult to improve upon. If he could not read it, no one can.

Heiberg's photographs of the palimpsest were considered lost. However, last year we found them. In the past people looked for the photographs in Heiberg's archive, which was given to the Royal Library in Copenhagen upon the great scholar's death. Last year, Reviel Netz, Professor of Ancient Science at Stanford University, and one of the scholars now working on the palimpsest, tried again, and asked for the help of Professor Marinas Taisbeck and Erik Petersen, Keeper of Special Collections at the Royal Library. Petersen found them, in the photo collection of the Royal Library. As a good humanist, Heiberg gave the photographs to the Library after he had finished with them, in 1916. Long before his death.

Netz and I traveled to Copenhagen last year, and the photographs reveal a remarkable story. Somehow, the photography went wrong. Heiberg failed to identify some pages correctly, and so didn't order them. But also, the photographer seems to have taken shots of the wrong pages. There are photographs of some pages of text that Heiberg should not have been interested in, like Archimedes Treatise "Spiral Lines", for which there are witnesses elsewhere. And the extraordinary thing is that it is precisely in those pages of the "Method" for which Heiberg did not have photographs that he did not transcribe in his edition. These pages in the palimpsest itself are not better or worse than any others in the book today, and we hope to provide a completely new edition of the method, incorporating 20% more of the original treatise than Heiberg managed. Incidentally, so far Netz has identified three new folios of "On Floating Bodies" in the manuscript, that Heiberg either could not read, or which he misidentified. We hope for more. The long and the short of this is that the Palimpsest is far more important than it was considered to be even two years ago.

The manuscript did not stay in the Metochion in Constantinople. There has been much speculation as to how it left the community, none of which can be substantiated. There is incontrovertible eye-witness evidence that the manuscript was in the hands of the Guersan family in the 1960's. The condition of the Palimpsest had deteriorated very markedly from the time that Heiberg's photos were taken. The main problem is mold. The manuscript had been left in very humid conditions, and the mold had eaten away at the parchment to such an extent that chunks of text are now missing, and the mold is also obscuring much of the remaining text. The book is now in extremely fragile condition.

The book was also deliberately mutilated, certainly after 1929, and probably before the 1960's. The book now

contains four portraits of the Evangelists – Matthew, Mark, Luke and John. Someone had tried to turn the Prayerbook into an illuminated Gospel Book. These are forged miniatures, designed to look as if they were painted in Constantinople in the year 1000, but actually copied, on a one-to-one, scale from images of Manuscript Grec. 64 in the Bibliotheque Nationale in Paris that were reproduced in Henri Omont's "Manuscrits Grec dans La Bibliotheque Nationale", which was published in Paris in 1929. Consider this page as a sandwich: on top is a forged Byzantine miniature, below is the Euchologion text, below that is the Archimedes text, followed by parchment, more Archimedes text, more prayerbook text, and finally glue and, believe it or not, a sticky blue substance that may have been used to attach the individual pages to some kind of mount.

The degree of mutilation suffered by the Archimedes palimpsest is much greater than this description would imply, and the motives for it are not yet completely apparent. Suffice it to say at the moment, that three further leaves are missing from the book since it was in the Metochion, one of which has a crucial "Method" page that Heiberg did not have photographed. Also the book has been rebound, and it actually looks as if, for some reason, the Palimpsest was rebound into two volumes. This was probably done in the 1960's, since the spine one of these two "volumes" was reinforced with a synthetic glue, which was a common practice at this time. The trouble with this is that the glue is actually harder than the parchment itself, and of course it covers the gutter of the book, which contains Archimedes text that Heiberg could not read.

The Palimpsest was sold at Christie's in New York on October 1998 for 2 million dollars to an anonymous private collector. I wrote an email to his representative in London, and on January 17, 1999 it arrived on my desk at The Walters Art Museum in Baltimore. It then became my headache, a headache which I soon gave to those most qualified to solve.

Our goal is to digitally recreate the Archimedes Manuscript of the tenth century as closely as possible, as it was before it was palimpsested around the year 1200, and to do this without in any way harming the document itself. There are three aspects to the Palimpsest Project, and I want to cover them all briefly.

First of all there is the problem of conservation. The book has to be disbound, detritus removed, glue removed from the spine, and the parchment stabilized. The final problem will be to decide whether or not to rebind the book in its present format, or to leave it in disbound sheets so as best to reveal the Archimedes text.

Secondly there is the scholarly problem of reproducing an edition of the text. The residue on the goat skins is not the only source for making an edition, even of the Method of Mechanical Theorems. The edition has to take into consideration Heiberg's edition, the evidence of Heiberg's photographs, the ink that can be seen with the naked eye at present, and the ink that can only be seen with processed digital images.

The third problem is of course the difficulty of imaging the book, and this is why I am introducing the subject at this table. Retrieving the Archimedes text is difficult in itself, but the imagers have the added problem of working in Museum laboratory conditions. They cannot just "image the manuscript to death"; they have to abide by strict lighting and handling protocols imposed upon them by the Conservation Department of The Walters Art Museum.

Before handing over the floor to my colleagues, I want to say a few words about how we chose our imaging team. We had many people contact us suggesting that they could image the palimpsest, and, as scholars and conservators of medieval manuscripts, we no way of understanding a word that they were saying. We were, however, contacted by Mike Toth, technical consultant with R.B. Toth and Associates, who has extensive experience with government in imaging and program management. He offered to help us choose an imaging team. We had a competitive phase of imaging last year, in which the two teams who put forward the best proposals were given the same five leaves to image. Their results had different strengths and weaknesses, and so we decided to combine their talents for the imaging of the entire manuscript. Thus the imaging team of the Archimedes Palimpsest project now combines the forces of the Johns Hopkins University, The Rochester Institute of Technology, and the Xerox Corporation.

In the Palimpsest project, Old Science is meeting New Science. Not only is the thought one of the founding fathers of the Western Scientific Tradition being rescued by modern scientific imaging techniques, but also that triumph of medieval technology, the manuscript book, is being rescued by the compact disc. We will once again be scrolling, not leafing, through Archimedes treatises, only this time we will be doing it with a computer, and not a papyrus roll. We hope to create a work that will replace the original to the extent that if you want to read Archimedes Treatises, it is most visible not in an extremely fragile medieval parchment manuscript, but rather on a DVD. As for the goats, well they will nonetheless remain of the greatest importance. We do hope that their will be less need for scholars to consult them, but their duty as bearers of meaning will never be over.

Biography

Dr. William Noel is Associate Curator of Manuscripts, The Walters Art Museum, Baltimore MD. He was awarded his Ph.D. in 1993 at Cambridge University, England. His Ph.D. is published as "The Harley Psalter", Cambridge University Press, 1995. He was Assistant Curator of manuscripts The J. Paul Getty Museum, 1991-2, British Academy Post-Doctoral Research Fellow, The Department of Art History, University of Cambridge, 1993-7, and has worked at The Walters Art Gallery since 1997. The Archimedes Palimpsest was deposited on his desk on January 21, 1999, and his life has not been the same since.