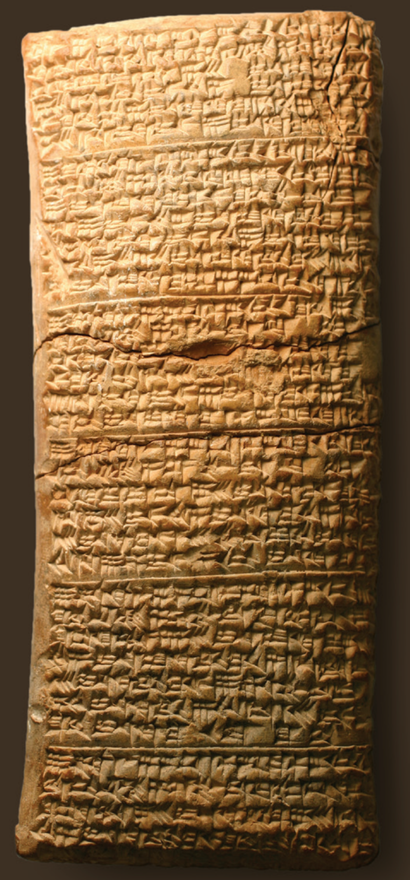
# Before Pythagoras

## The Culture of Old Babylonian Mathematics

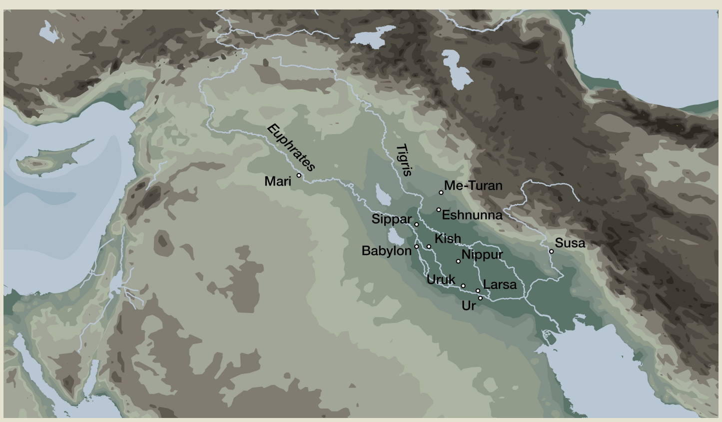
November 12, 2010 – January 23, 2011



*Cuneiform tablets originating in second millennium BCE Babylonian scribal schools preserve exercises and calculations recorded by teachers and pupils, ranging from practical arithmetic to problems well beyond everyday applications. This exhibition presents an unprecedented grouping of tablets from the first golden age of mathematics, highlighting both classroom training and advanced curiosity-driven mathematics.*

# BEFORE PYTHAGORAS
## THE CULTURE OF OLD BABYLONIAN MATHEMATICS

Since the second half of the nineteenth century, thousands of cuneiform tablets dating to the Old Babylonian Period (c. 1900–1700 BCE) have come to light at various sites in ancient Mesopotamia (modern Iraq). A significant number record mathematical tables, problems, and calculations. It was not until the 1920s that these tablets began to be systematically studied by Otto Neugebauer, a young Austrian mathematician who had turned to the history of mathematics during his doctoral studies at the renowned Mathematical Institute at the University of Göttingen. Neugebauer spent two decades transcribing and interpreting tablets housed in European and American museums. His labors, and those of his associates, rivals, and successors, have revealed a rich culture of mathematical practice and education that flourished more than a thousand years earlier than the Greek sages Thales and Pythagoras with whom histories of mathematics used to begin.




Centers of mathematics in Mesopotamia.

This exhibition was made possible through the support of the Leon Levy Foundation.

This exhibition is the first ever to explore the world of Old Babylonian mathematics through a display of tablets covering the full spectrum of mathematical activity, from arithmetical tables copied out by young scribes-in-training to sophisticated work on topics that would now be classified as number theory and algebra. The pioneering research of Neugebauer and his contemporaries concentrated on the mathematical content of the advanced texts; a selection of archival manuscripts and correspondence offers a glimpse of Neugebauer's research methods and his central role in this "heroic age." Recent scholarship, bringing into consideration the archaeological context and material aspects of the tablets, has illuminated their human dimension, tracing the stages by which scribes mastered a curriculum intended to prepare them for professional careers. But the most mathematically rich tablets remain focuses of questions and controversy.

The tablets in this exhibition illustrate three themes that follow a progression from the more elementary to the more advanced texts. The first group of tablets shows how numbers were written in cuneiform, starting with two basic marks made by a reed stylus on clay, representing 1 and 10. Quantities given in the elaborate Babylonian system of weights and measures were converted into a place-value notation analogous to our Hindu-Arabic numerals but based on 60 instead of 10. Tables facilitated arithmetic; and final results were reconverted into the conventional units of measure. The second group comprises tablets from the scribal schools of Nippur, which reveal the methods of elementary mathematical education and how it was interwoven with the study of the Sumerian language.

The third group turns to the advanced training, in which students solved problems of progressive difficulty, inspired by real-world situations such as surveying, building, and public works. Many of these problems were much more difficult than any that they would have to deal with in their professional careers, and their solutions depended on principles that, before the rediscovery of the Babylonian tablets, were believed to have been discovered by the Greeks of the sixth century BCE and after. Thus, the exhibition suitably culminates with two tablets that have acquired iconic status in the history of science since they were first published by Neugebauer and Abraham Sachs in 1945: YBC 7289, which graphically testifies to Babylonian knowledge of the Pythagorean theorem as well as precise calculations of square roots, and Plimpton 322, which links the Pythagorean theorem to whole-number solutions of the relation $l^2 + w^2 = d^2$.

# THE SCRIBE AND SCRIBAL SCHOOLS

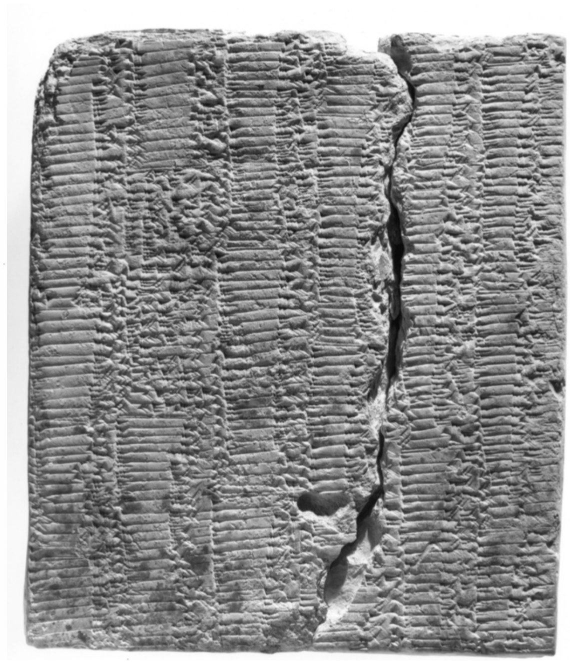
Cuneiform was a kind of script based on shapes impressed by a reed on a clay tablet. The versions of cuneiform that evolved to record the Sumerian and Akkadian languages spoken in ancient Mesopotamia were extremely complex, involving hundreds of distinct symbols. Scribes, who were individuals formally trained in reading and writing, were a small minority of the population and generally belonged to well-off families in which literacy and professional expertise were handed down. While most scribes were male, some females also had access to scribal training. We have little firm evidence for the range of ages for pupils.

Scribal schools most likely existed in Mesopotamia since the introduction of writing in the second half of the fourth millennium BCE, rising to special importance in the state during the Neo-Sumerian period that closed the millennium. During the Old Babylonian period, the city of Nippur in southern Mesopotamia was the most prestigious among the centers of scribal training, with the great majority of the school tablets known to us coming from there. Schools were normally small houses, with rooms opening onto a courtyard where a supply of clay was kept and the schoolwork apparently was done.

Although Sumerian was no longer a living language in the Old Babylonian period, it persisted as the language of written learning, scholarship, and administration. Students learned through copying, beginning with lists of the simplest cuneiform signs, and progressing through lists of hundreds of signs representing the Sumerian vocabulary. Eventually the student practiced copying actual texts, especially model contracts and proverbs. Mathematical training during this stage consisted of copying lists of units of measure and arithmetical tables. Once finished, the school tablets were discarded and often reused for constructing walls, floors, and benches.

In the more advanced curriculum, lexical lists gave way to texts of the literary tradition, in particular, hymns and narratives of myths. On the mathematical side, the scribes practiced calculations and simple problem solving, putting to use the metrological and arithmetical toolbox that they had learned at an earlier stage.

# Before Pythagoras: Objects and labels from the exhibition



**1. Table of reciprocals**
**Yale Babylonian Collection YBC 10529**
Old Babylonian Period, place of origin unknown

**2. Collection of arithmetical tables**
**Yale Babylonian Collection YBC 4678**
Old Babylonian Period, place of origin unknown

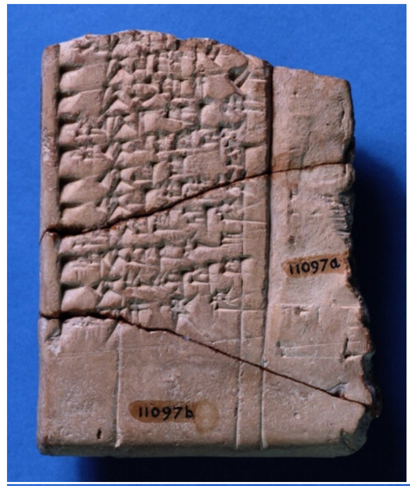
**3. Calculation by a scribal student**
**University of Pennsylvania Museum B11318**
Old Babylonian Period, Nippur

**1.** Scribes used reciprocal tables to perform division, which is difficult to do directly in the sexagesimal notation. The reciprocal of a number is 1 divided by the number. Dividing by a number is thus the same as multiplying by its reciprocal; for example, the reciprocal of 8 is $^1/_8$.

Tables of reciprocals listed 1 divided by a series of numbers, beginning with 2, 3, 4, 5, 6, 8, 9, 10, 12. . . . Scribes avoided doing arithmetic with 7, 11, and similar numbers whose reciprocals cannot be written out completely in sexagesimals (just as the reciprocal of 3 cannot be written out exactly in our decimals). This tablet is an unusual table that includes approximate reciprocals of these so-called irregular numbers.

**2.** This six-column tablet, unusually well preserved for its size, contains a table of reciprocals and twenty-two multiplication tables, the basic tools for arithmetic with sexagesimal numerals. The times-table for base 60, from 1×1 through 59×59, was too big to memorize, so scribes learned multiplication tables listing products of a single number by units (up to 20) and tens (from 30 through 50). The tables on this tablet consist of multiples of numbers decreasing from 50 to $7^1/_5$. The scribe probably intended to write even more tables since a fourth column on the reverse has been prepared with ruled lines, and two more are marked off without rulings.

**3.** This tablet records a student's calculations as he worked through a problem. Problems such as this one required the student to use two kinds of tables learned in the earlier stages of the scribal curriculum: metrological tables giving the relations of units of measure, and arithmetical tables for multiplication and division.




**4. Type I school tablet with arithmetical tables**
**University of Pennsylvania Museum UM 29-15-76**
Old Babylonian Period, Nippur

**5. Type II tablet with word list and tables**
**University of Pennsylvania Museum CBS 2142**
Old Babylonian Period, Nippur, "Scribes' Quarter"

**6. Type III tablet with multiplication table**
**University of Pennsylvania Museum B6063**
Old Babylonian Period, Nippur, "Cassite houses"

**7. Type IV tablet with incomplete calculation**
**University of Pennsylvania Museum 55-21-357**
Mid-18th century BCE, Nippur, "Scribes' Quarter," House F

**4.** Assyriologists recognize four types of school tablets used in scribal training both in the Sumerian language and in mathematics. Type I tablets are large, typically around 15 by 20 centimeters, each face having up to six columns read left to right on the obverse, and right to left on the reverse. The entire tablet consists of lists of one variety of information learned in the elementary curriculum. Mathematical Type I tablets contain tables or lists of units of measure or numerical tables. This fragment belonged to a compilation of multiplication tables. It probably had three columns and was twice the height of the extant fragment.

**5.** Type II tablets were a medium on which students practiced the lists and tables of the elementary curriculum. The obverse was divided by a vertical line. The teacher wrote out a model list on the left, and the pupil copied it on the right. His effort could be erased by scraping off the surface; then he would repeat the exercise. The reverse was used to review a different subject; the pupil would write out a previously practiced list without a model. Type II tablets are valuable evidence of the elementary curriculum because they show the order in which subjects were studied. In this example the obverse is a list of Sumerian words meaning "food" and their Akkadian equivalents. The pupil's half has been scraped off, and only traces of his latest copy are visible. The student's side thus often ended up quite thin. The reverse contains tables of reciprocals and multiples.

**6.** Type III tablets contain texts of similar character as those on the obverse of Type II tablets, but their appearance is different. They are small and relatively narrow, hence their Sumerian name *imgidda* ("long tablet"). The script is practiced and elegant. The end of the text is often marked by a line, and may be followed by the scribe's name and the date. These tablets were demonstrations of the scribe's acquired skill. This Type III tablet is a table of multiples of 18.

**7.** Type IV tablets were known by the name *imšu* ("hand tablets") because their size was convenient to hold in the palm of one's hand. They were used for practice writing and calculations. Mathematical Type IV tablets mostly pertain to an advanced curriculum in which problem solving supplanted the copying of lists and tables. Such tablets sometimes catch the scribes making mistakes. This one records a scribe's search for a reciprocal that was not included in the standard tables. By some confusion, however, he wrote down an incorrect answer.

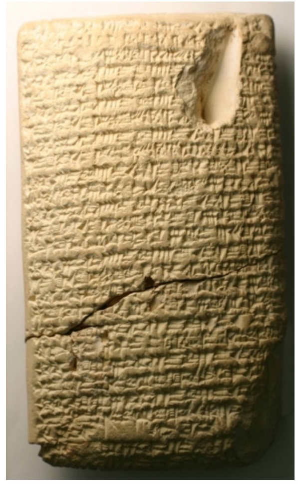
# MATHEMATICS FROM DAILY LIFE

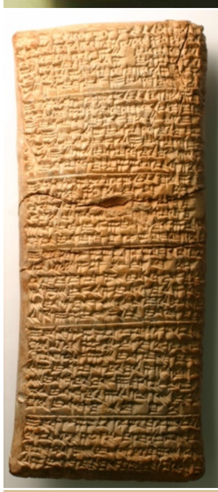
Scribes who had completed their schooling were often destined for administrative positions, especially in the prominent Mesopotamian institutions of temple and palace. Their training was a reflection of their future professions as accountants, project planners, and overseers, who would regularly need to work with quantitative data. School exercises and problems were routinely composed in terms of the situations scribes were going to encounter.

A typical project that might be posed as a mathematical problem is the construction of a dam. Thinking of the dam as a particular shape consisting of earth and having a certain length, width, and height, a basic problem would be to calculate the amount of earth required. This would lead to more complicated questions, such as the number of workers needed for the project, the time it would take, and the total cost. Scribes had to learn information such as how much work one laborer could do in a day and for how much pay, as well as the relationships between many different units employed for measuring lengths, areas, volumes, and weights.

Many problems are about plots of land, how they were surveyed (by measuring along each side with a surveyor's rod), and how one found the area of a square field, a rectangular field, a triangular field, or a trapezoidal field. In more difficult problems, the student had to take into account the varying crop yields of different parts of a plot to calculate the total yield.

"Real-world" problems strikingly similar to those of the Old Babylonians are found in neighboring regions centuries and even millennia later, for example, in Egyptian papyri from the time of the Roman Empire. Little is known, however, of the processes of survival and transmission of this practical tradition.





**8. Calculation of the area of a circle**
**Yale Babylonian Collection YBC 11120**
Old Babylonian Period, place of origin unknown

**9. Problems concerning digging a canal**
**Yale Babylonian Collection YBC 7164**
Old Babylonian Period, place of origin unknown

**10. Problems and step-by-step solutions**
**Yale Babylonian Collection YBC 4663**
Old Babylonian Period, place of origin unknown

**11. Series of abstract problems**
**Yale Babylonian Collection YBC 4713**
Old Babylonian Period, place of origin unknown

**8.** This "hand tablet" records a geometrical calculation in the form of a diagram. The problem is to find the area of a circle given its circumference. The circumference, $1\frac{1}{2}$, is written in sexagesimal numerals above the circle. The first step was to find the square of $1\frac{1}{2}$, namely $2\frac{1}{4}$; this was written to the right, although it is not very legible. Dividing this by 12 yields the area, namely $\frac{3}{16}$, which is written inside the circle. The procedure is approximate since it assumes that $\pi = 3$.

**9.** This is a collection of mathematical problems, all variations on the theme of digging a canal—a real-world premise for a Babylonian. The canal is assumed to have a rectangular cross-section, and each problem involves its dimensions, the number of workers, how much a worker can dig in a day, how much a worker is paid, how many days he works, and so forth. Some of these quantities are given, others are sought. The answers are given without explaining how they are found, suggesting that this is a teacher's manual. The problems can all be solved by basic arithmetic, though some are by no means trivial.

**10.** This tablet contains problems about digging a rectangular trench. The quantities given or asked for stay exactly the same from problem to problem but in each the selection of data that are given and demanded is different. Between the statement of the problem and its answer, the scribe gives a step-by-step calculation of the answer. The statements are written in the Sumerian language and the procedures in Akkadian.

**11.** This tablet belongs to a puzzling category known as Series Texts: long lists of concise statements of problems with no indication of the method of solution. The lists continue through series of numbered tablets; YBC 4713 is tablet 10 of such a series. Its problems concern a rectangular surface and have an abstract, impractical character. Many of the problems are mathematically advanced, leading to quadratic equations. Several problems of this series are equivalent to fourth-degree equations which the tablet's author probably did not expect anyone to solve. Rather, the Series Texts appear to be explorations of structured systems of mathematical relations that had no practical goal.

# REACHING BEYOND PRACTICALITY

While many of the mathematical techniques learned in the scribal schools were intended for use in the scribes' later careers, a large part would never have been applied in practical situations, and can be described as theoretical. This kind of mathematics sometimes looks practical because it is expressed in terms of real-world objects, but the combination of information provided and information demanded is unrealistic. Sometimes the texts seem to operate with abstract lengths, areas, and numbers whose reference to real-world objects is at best tenuous.

The simplest examples of impractical mathematics in Babylonian tablets are puzzles. For example, the student, after being told that a stone has had its weight increased and decreased several times by certain fractions, is asked to find its original weight from its final weight. Another problem might describe a surveyor measuring a distance with a surveying rod that gets shorter every time it is used, and the student has to find the total distance measured by the time the rod has completely disappeared. Puzzles were probably an entertaining way to practice calculations.

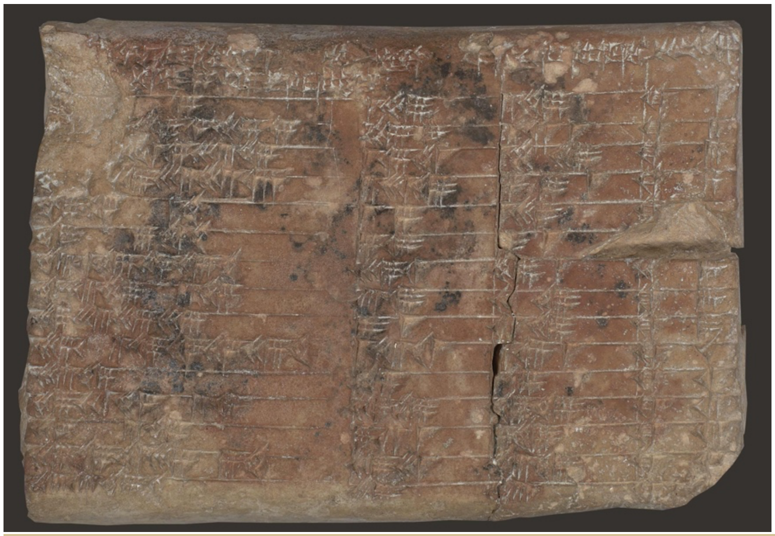
Two of the most remarkable mathematical principles exploited repeatedly in Old Babylonian tablets were of little practical use. Probably by reasoning through rearrangements of dissected geometrical figures, Babylonian mathematicians found the relation of the sides of a right-angled triangle that we call the Pythagorean theorem, as well as how to find the sides of a rectangle, knowing its area and some known relationship connecting the lengths of the sides, which is equivalent to solving a quadratic equation. Before the decipherment of the Babylonian tablets, it was thought that Greek mathematicians of the mid-first millennium BCE discovered these principles.

"Series Texts" are extreme examples of Babylonian interest in mathematics for its own sake: the problems they list are quite abstract, and not even always soluble by techniques known in antiquity. The unknown authors of such tablets and of the list of Pythagorean triples in Plimpton 322 seem to have been exploring mathematical relations inspired by the problems of the schoolroom but reaching into a realm of pure intellectual curiosity.

**12. Tablet illustrating Pythagoras' Theorem**
**Yale Babylonian Collection YBC 7289**
Old Babylonian Period, southern Mesopotamia?

**12.** This famous tablet, one of the few to consist entirely of a geometrical diagram, is a graphic witness that Babylonian scribes knew Pythagoras' Theorem and possessed a method of calculating accurate estimates of square roots. On the obverse, the scribe has drawn a square and its diagonals. According to Pythagoras' Theorem the length of the diagonal is the length of the side multiplied by the square root of 2. An accurate approximation of this quantity in sexagesimal (base-60) notation (1,24,51,10) is written along one diagonal. One side is labeled with its length, 30 units, and the product of 30 by the square root of 2 is also written along the diagonal.

The tablet is of the lentil-shaped "hand-tablet" type commonly used for calculations. It probably records a student's intermediate work on a mathematical problem involving a square and its diagonal. The student himself probably would not have known how to calculate square roots, but would have learned by rote the rule for finding the diagonal.



**13. Table of whole-number sides of Pythagorean triangles**
**Columbia University Plimpton 322**
Old Babylonian Period, Larsa?

**13.** The most renowned of all mathematical cuneiform tablets since it was published by Neugebauer and Sachs in 1945, Plimpton 322 reveals that the Babylonians discovered a method of finding Pythagorean triples, that is, sets of three whole numbers such that the square of one of them is the sum of the squares of the other two. By Pythagoras' Theorem, a triangle whose three sides are proportional to a Pythagorean triple is a right-angled triangle. Right-angled triangles with sides proportional to the simplest Pythagorean triples (3, 4, 5 and 5, 12, 13) turn up frequently in Babylonian problem texts. However, if this tablet had not come to light, we would have had no reason to suspect that a general method capable of generating an unlimited number of distinct Pythagorean triples was known a millennium and a half before Euclid.

Plimpton 322 has excited much debate centering on two questions. First, what was the method by which the numbers in the table were calculated? And second, what were the purpose and the intellectual context of the tablet? At present there is no agreement among scholars about whether this was a document connected with scribal education, as are the majority of Old Babylonian mathematical tablets, or if it was part of a research project.

# OTTO NEUGEBAUER AND BABYLONIAN MATHEMATICS

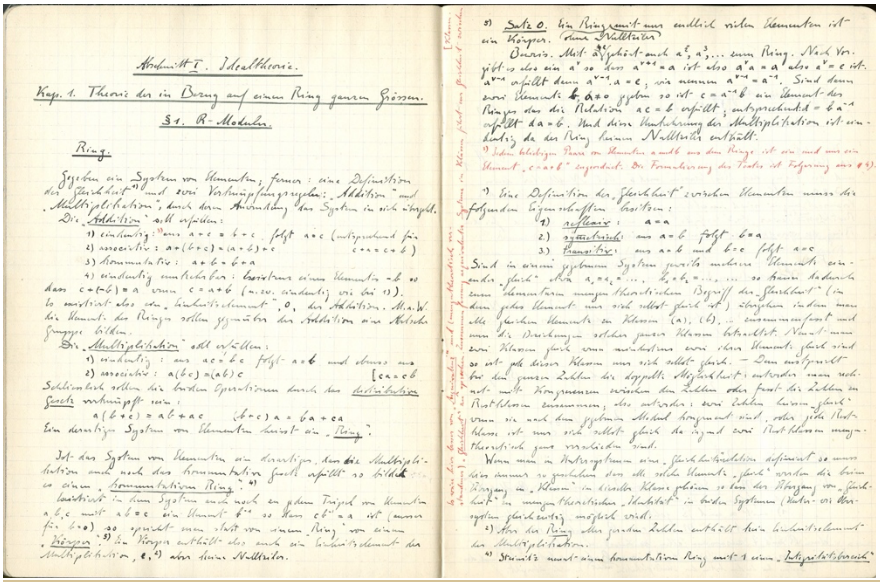
As a student of mathematics at the University of Göttingen in the 1920s, Otto Neugebauer (1899–1990) adopted as his field of research the history of mathematics in the ancient world. His prolific work over seven decades opened up the study of the mathematics of the ancient Near East and brought to light the transmissions and transformations of mathematics and astronomy among ancient and medieval civilizations.

Neugebauer believed that the history of early mathematics should be based on the direct investigation of texts, demanding profound knowledge of ancient languages and scripts together with mathematical insight. As he became aware that hundreds of Babylonian clay tablets containing mathematical tables and texts lay unpublished and unstudied in European and American museums, he undertook a comprehensive edition of them, with transcriptions, translations, and commentaries, to serve as a foundation for the history of what he called "pre-Greek" mathematics.

By the time his German-language edition appeared (1935–37), Neugebauer had left Nazi Germany for Copenhagen. In 1939 he migrated to the USA, joining the faculty of Brown University as well as holding recurring memberships at the Institute for Advanced Study. Brown created for him a Department of the History of Mathematics, which became the principal center for research in the exact sciences of antiquity. For his first colleague at Brown, Neugebauer chose an outstanding young Assyriologist, Abraham Sachs, with whom he began editing the numerous Babylonian mathematical tablets in American collections that had come to light since 1937. The new volume, *Mathematical Cuneiform Texts* (1945), greatly influenced mathematicians' and historians' perceptions of ancient Near Eastern mathematics, above all because it provided the first publication of Plimpton 322, which appeared to reveal the Babylonians as forerunners of Greek and modern number theory.

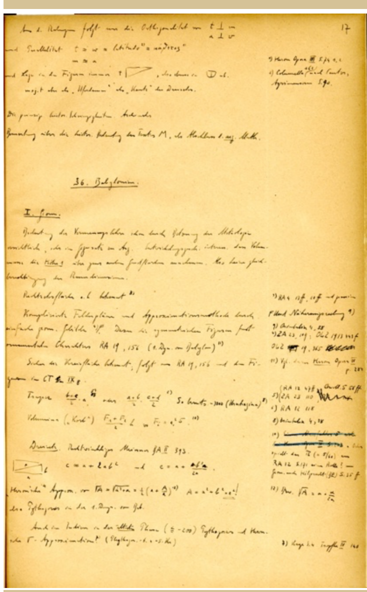
Most of Neugebauer's work after the 1940s was on ancient astronomy. After an interval of comparative inactivity, a new generation of historians renewed the study of Babylonian mathematics in the last decades of the twentieth century, applying linguistic, archaeological, and archival methods to revolutionize our understanding of the texts and their makers.

Photo: Otto Neugebauer, c. 1936. Photo courtesy of the Mathematical Institute, University of Göttingen.



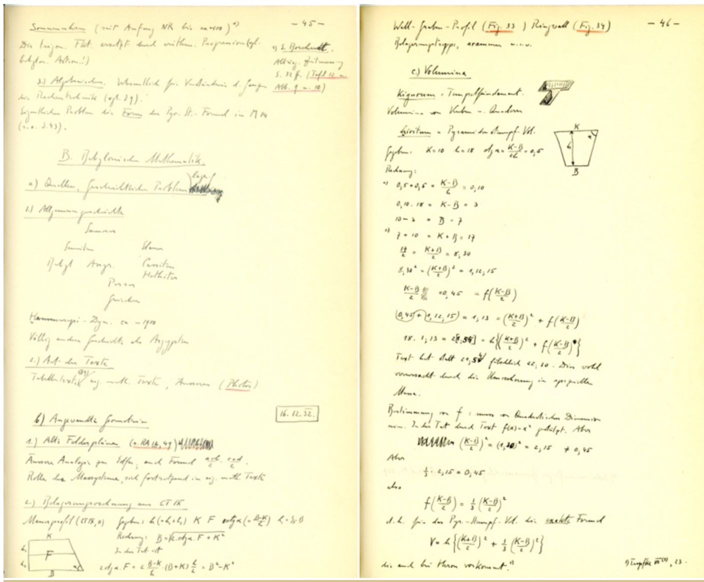
**14. Otto Neugebauer, Notebook from Emmy Noether's course on Algebraic Functions (Göttingen, 1925)**
The Shelby White and Leon Levy Archives Center, Institute for Advanced Study, Princeton, NJ, USA, Neugebauer Papers, box 7

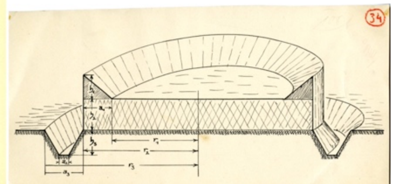
Following studies in electrical engineering and physics at Graz and Munich, Otto Neugebauer began doctoral studies at the Mathematical Institute at Göttingen, where he took courses with many of the leading mathematicians of the time, including Richard Courant (who became his close friend and promoter), David Hilbert, Edmund Landau, and Emmy Noether. His notebooks, valuable documents in their own right for the history of twentieth-century mathematics, attest to his broad training as well as his meticulous work habits. Unlike most mathematicians who turn to the history of their discipline, Neugebauer did almost no work in mathematics proper; he published only one nonhistorical paper, coauthored with his Danish friend and mentor, Harald Bohr.



**15. Otto Neugebauer, Vorlesung über Geschichte der vorgriechische Mathematik (Göttingen, 1928)**
The Shelby White and Leon Levy Archives Center, Institute for Advanced Study, Princeton, NJ, USA, Neugebauer Papers, box 1

Neugebauer's 1926 thesis was on the arithmetic of fractions in ancient Egyptian mathematical texts. The wide-ranging notes for his "Lecture on History of Pre-Greek Mathematics" are one of the earliest reflections of his study of Babylonian mathematics. This section on "relationships between the neighboring cultures" anticipates Neugebauer's later deep interest in the transmission of mathematical methods (especially for astronomy) in ancient and medieval civilizations, though not all the specific connections suggested here between Babylonian, Egyptian, Greek, Indian, and even Chinese scientific traditions would have survived his later scrutiny.





**16. Otto Neugebauer, "Ausgewählte Kapitel über Geschichte der antiken Mathematik" (Göttingen 1932–33)**
The Shelby White and Leon Levy Archives Center, Institute for Advanced Study, Princeton, NJ, USA, Neugebauer Papers, box 1

During the 1930s Neugebauer gave a number of lectures and courses on the history of Egyptian, Babylonian, and Greek mathematics, drawing on the texts that he was currently studying and, in the case of Babylonian mathematics, editing. The course notebook "Selected Chapters on History of Ancient Mathematics" contains analysis of individual Old Babylonian tablets that would soon be published in his comprehensive three-volume *Mathematische Keilschrift-Texte* (1935–37). The page on display belongs to a session concerning problem texts on a tablet at the British Museum (BM85194). A problem concerning the volume of earth needed to construct a circular wall surrounded by a trench is illustrated, on a separate slip, by a characteristic specimen of Neugebauer's draftsmanship.

**Preparing *Mathematical Cuneiform Texts***

Immediately after his move from Copenhagen to Brown University in 1939, Neugebauer began searching for mathematical tablets in American collections that he had missed in his *Mathematische Keilschrift-Texte*. As he and his colleague Abraham J. Sachs were preparing the new volume, *Mathematical Cuneiform Texts*, the Assyriologists Albrecht Goetze and Ferris Stephens were continually finding new tablets for them in the Yale Babylonian Collection. Despite the proximity of New Haven to Providence, Neugebauer preferred to edit the texts from photographs, consulting the Yale Assyriologists when he and Sachs were uncertain of the readings. This display illustrates part of the careful process of editing for the tablet YBC 7164, which is on view in this exhibition (9).


BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND

October 7, 1942

Professor Ferris J. Stephens
329 Sterling Memorial Library
Yale University
New Haven, Conn.

Dear Professor Stephens:

I must once more ask you for your help in a doubtful passage. YBC 4697 is a text published in MKT III, plate 5. I have my doubts as to the correctness of my drawing in reverse I, 16. As far as the words are concerned they follow NE-bi 30-àm. I would be very much obliged to you if you would kindly copy the signs at the end of this line on the edge. I am not able to understand the passage in question, and I would like to get more out of it because it is important for one of the new tablets.

With many thanks,

Sincerely yours,

O. Neugebauer

O. Neugebauer

ON/s

COPY

October 13, 1942

Professor O. Neugebauer
Brown University
Providence, Rhode Island.

Dear Professor Neugebauer:

The head of your gal isn't here. Goetze and I had a laugh about your question concerning the head of your gal. Gal, as you may know, is English slang for girl. The sign in question, Goetze and I agree, is either ES or 30. The ambiguous traces of the first stroke of the sign are visible on the photograph. When we looked at the original the ambiguity disappeared and we feel certain what the sign was. So much for YBC 7164.

We both examined the passage mentioned in YBC 4697. We do not understand it but I send you enclosed the drawing made by Goetze as well as my own. We each drew the signs without seeing the other person's attempt. You will see that our results are very nearly the same and, more over, that they do not differ very far from your drawing in MKT.

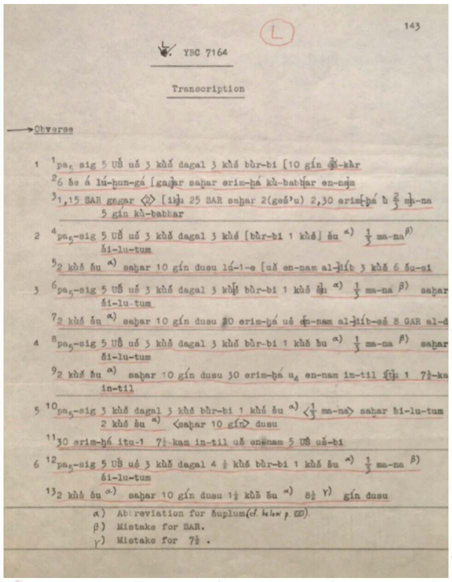
Yours sincerely,

Ferris J. Stephens

FS:DF
2 Encl.

**17. Photographs of YBC 7164 (obverse, reverse, and two edge views) mounted for publication in *Mathematical Cuneiform Texts***
John Britton Collection

**18. Undated, unaddressed handwritten note from Neugebauer (probably accompanying letter from Neugebauer to Stephens, October 7, 1942) and carbon copy of Stephens' typed reply, October 13, 1942**
Yale Babylonian Collection



143

L

YBC 7164

Transcription

Obverse

1 $^{1}$pa$_5$ sig 5 UŠ uš 3 kùš dagal 3 kùš bùr-bi [10 gín ĝá-kàr
$^{2}$6 še á lú-ḫun-gá [gaḫar saḫar erim-ḫá kù-babbar en-nam
$^{3}$1,15 SAR gagar ⟨2⟩ [iku 25 SAR saḫar 2(geš'u) 2,30 erim-ḫá ù $\frac{2}{3}$ ma-na
5 gín kù-babbar

2 $^{4}$pa$_5$-sig 5 UŠ uš 3 kùš dagal 3 kùš [bùr-bi 1 kùš] šu α) $\frac{1}{3}$ ma-na β)
ši-lu-tum
$^{5}$2 kùš šu α) saḫar 10 gín dusu lú-1-e [uš en-nam al-]dib 3 kùš 6 šu-si

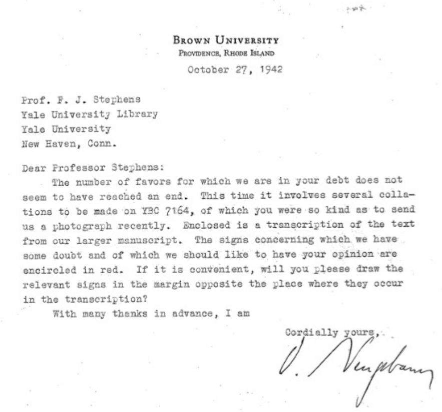
3 $^{6}$pa$_5$-sig 5 UŠ uš 3 kùš dagal 3 kùš bùr-bi 1 kùš šu α) $\frac{1}{3}$ ma-na β) saḫar
ši-lu-tum
$^{7}$2 kùš šu α) saḫar 10 gín dusu 30 erim-ḫá uš en-nam al-]dib-eš 8 GAR al-d

4 $^{8}$pa$_5$-sig 5 UŠ uš 3 kùš dagal 3 kùš bùr-bi 1 kùš šu α) $\frac{1}{3}$ ma-na β) saḫar
ši-lu-tum
$^{9}$2 kùš šu α) saḫar 10 gín dusu 30 erim-ḫá u$_4$ en-nam in-til [itu 1 7½-ka
in-til

5 $^{10}$pa$_5$-sig 3 kùš dagal 3 kùš bùr-bi 1 kùš šu α) ⟨$\frac{1}{3}$ ma-na⟩ saḫar ši-lu-tum
2 kùš šu α) ⟨saḫar 10 gín⟩ dusu
$^{11}$30 erim-ḫá itu-1 7½-kam in-til uš en-nam 5 UŠ uš-bi

6 $^{12}$pa$_5$-sig 5 UŠ uš 3 kùš dagal 4 ½ kùš bùr-bi 1 kùš šu α) $\frac{1}{3}$ ma-na β)
ši-lu-tum
$^{13}$2 kùš šu α) saḫar 10 gín dusu 1½ kùš šu α) 8½ γ) gín dusu

α) Abbreviation for šuplum (cf. below p. [illegible]).
β) Mistake for SAR.
γ) Mistake for 7½.



BROWN UNIVERSITY
PROVIDENCE, RHODE ISLAND
October 27, 1942

Prof. F. J. Stephens
Yale University Library
Yale University
New Haven, Conn.

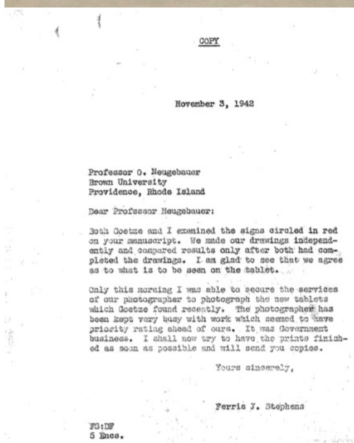
Dear Professor Stephens:

The number of favors for which we are in your debt does not seem to have reached an end. This time it involves several collations to be made on YBC 7164, of which you were so kind as to send us a photograph recently. Enclosed is a transcription of the text from our larger manuscript. The signs concerning which we have some doubt and of which we should like to have your opinion are encircled in red. If it is convenient, will you please draw the relevant signs in the margin opposite the place where they occur in the transcription?

With many thanks in advance, I am

Cordially yours,

O. Neugebauer



COPY

November 3, 1942

Professor O. Neugebauer
Brown University
Providence, Rhode Island

Dear Professor Neugebauer:

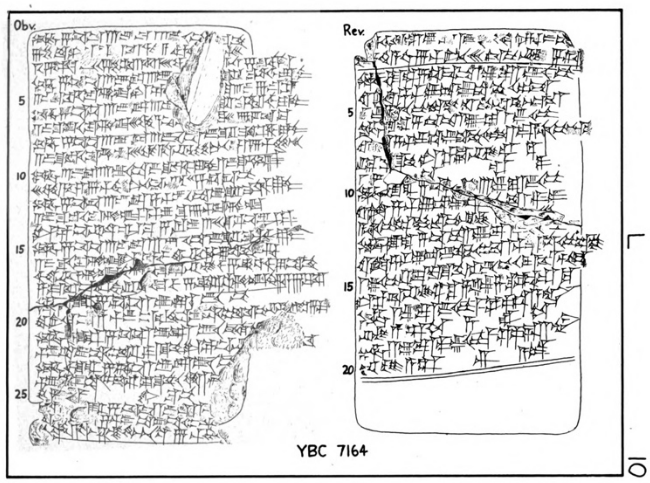
Both Goetze and I examined the signs circled in red on your manuscript. We made our drawings independently and compared results only after both had completed the drawings. I am glad to see that we agree as to what is to be seen on the tablet.

Only this morning I was able to secure the services of our photographer to photograph the new tablets which Goetze found recently. The photographer has been kept very busy with work which seemed to have priority rating ahead of ours. It was Government business. I shall now try to have the prints finished as soon as possible and will send you copies.

Yours sincerely,

Ferris J. Stephens

FS:DF
5 Encs.




**19. Typed transcription of YBC 7164 with handwritten annotations (referred to in the adjacent correspondence [20])**
John Britton Collection

**20. Typed letter from Neugebauer to Stephens, October 27, 1942, and carbon copy of Stephens' typed reply, November 3, 1942**
Yale Babylonian Collection

**21. Neugebauer's hand copy of YBC 7164 as published in *Mathematical Cuneiform Texts* (1945)**
Alexander Jones Collection