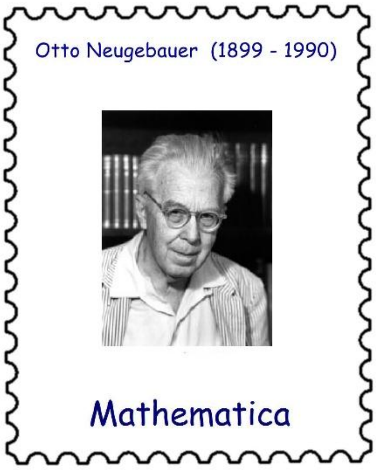
OTTO NEUGEBAUER (May 26, 1899 – February 2, 1990)

by HEINZ KLAUS STRICK, Germany



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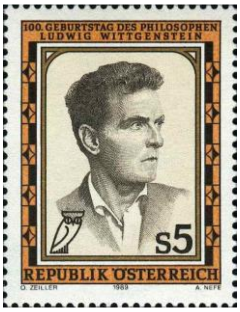
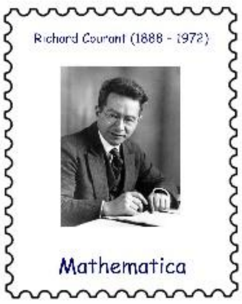
Faced with the choice of joining the army and receiving his school leaving certificate without exams, or completing his schooling normally, the 18-year-old opted for military service at the front, as this allowed him to avoid the upcoming *Abitur* exam in Greek. We are talking about OTTO NEUGEBAUER, the later lecturer in the history of mathematics of antiquity …

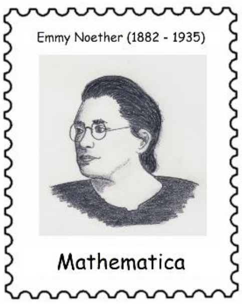
OTTO NEUGEBAUER was born in Innsbruck, the son of a Protestant railway engineer. The family soon moved to Graz, where the boy attended the classical *academic high school.* However, OTTO was more interested in mathematics, physics, and technical drawing than in Greek and Latin. He considered it a pleasant privilege that, as a Protestant, he was not required to attend the (otherwise obligatory) Catholic religious instruction. His parents died while he was still in school, and from then on, OTTO lived with an uncle.

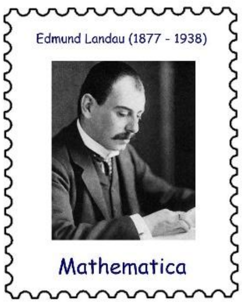
In the army, he was quickly promoted to lieutenant in the artillery and assigned to an observation post near the Italian front. He eventually became an Italian prisoner of war. There he befriended LUDWIG WITTGENSTEIN (1889-1951), with whom – as he later liked to recount – he shared a pencil as a writing implement.




In the autumn of 1919, he was finally able to return home and began studying electrical engineering and physics at the University of Graz. In 1921, he transferred to Munich, where he attended lectures by ARNOLD SOMMERFELD, among others. By this time, his financial resources were exhausted. His entire inheritance was invested in (Austrian) government bonds, which had become practically worthless. During the lean winter of 1921/22, his interests shifted more towards mathematics, and so he followed SOMMERFELD's advice to continue his studies in Göttingen. There, he attended lectures by RICHARD COURANT, the new director of the *Mathematical Institute*, as well as by EDMUND LANDAU and EMMY NOETHER. He became friends with COURANT, and in 1923 he obtained an assistant position at the institute. In 1924, he became an assistant to COURANT himself, and he was also responsible for the “reading room” (library).







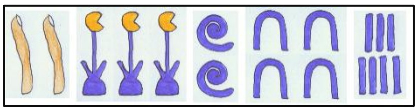
After a stay in Copenhagen with Harald Bohr (the younger brother of Niels Bohr), he published a paper on *almost-periodic functions* together with Harald Bohr in 1926. This remained Neugebauer's only contribution to pure mathematics, as his area of interest had once again shifted. After reading an article about the *Rhind Papyrus*, he began studying ancient Egyptian to learn more about mathematics in ancient Egypt. (This famous papyrus – it was found in 1858 during illegal excavations near Luxor – was named after the Scottish antiquarian Alexander Henry Rhind, who acquired it.)

Neugebauer convinced Courant and David Hilbert that it would be worthwhile to research the mathematics contained on the papyrus and to write a doctoral dissertation on the subject. In his dissertation, Neugebauer specifically examined a table from the Rhind Papyrus that listed fractions of the type $2/n$ (for odd n from 5 to 101) as the sum of (various) unit fractions. He explained in detail how Egyptian calculators arrived at the given decompositions. This table served merchants and officials in everyday life to divide rations fairly.

Otto Neugebauer writes in his dissertation "The Foundations of Egyptian Fraction Calculus":

> *All Egyptian mathematics rests on two pillars: the natural numbers and the natural fractions. They are connected by the dyadic algorithm, which finds its foundation in counting.*

In ancient Egypt, natural numbers were represented – according to their decimal development – using special symbols for the individual powers of 10 , possibly by repeating the symbols. (The image on the right shows, for example, the representation of the number 23247).



The operation of *addition* corresponds precisely to this form of representation: numbers are grasped by counting the symbols; when performing an addition, a group of ten may need to be replaced by the symbol of the next higher power of ten. *Subtraction* is not considered a separate operation; rather, it simply involves *supplementing* a number to make a larger number, which is essentially also done by counting. The *multiplication* of two natural numbers is also interpreted as *an addition problem*: the second factor is doubled until an additive representation of the first factor using powers of two is possible; the corresponding numbers then simply need to be added.

The example on the right shows the scheme for the multiplication problem $5 \cdot 7 = 35$ In the left column, 5 is decomposed into the summands 1 and 4, and on the right, the sum 7 + 28 is to be formed.

1	7
2	14
4	28

Accordingly, *division problems* also only involve determining a suitable *complement.* This can be quite challenging, as Neugebauer demonstrates with the example $80 : 3\frac{1}{2} = 22 + \frac{2}{3} + \frac{1}{7} + \frac{1}{21}$ (see second figure).

1	$3+\frac{1}{2}$
10	35
20	70
2	7
$\frac{2}{3}$	$2+\frac{1}{3}$
$\frac{1}{21}$	$\frac{1}{6}$
$\frac{1}{7}$	$\frac{1}{2}$

Such calculations demonstrate the routine of Egyptian calculators to represent fractions as the sum of unit fractions (where the fraction $\frac{2}{3}$ was still considered "natural").

To express fractions of the form $2/n$ as a sum of proper fractions, the method of repeated division is also used. For example, to express 2/5, the number 5 is broken down into terms by division in such a way that the sum in the right-hand column is 2; this gives: $\frac{2}{5} = \frac{1}{3} + \frac{1}{15}$ (see the table on the left below).

1	5
$\frac{2}{3}$	$3+\frac{1}{3}$
$\frac{1}{3}$	$1+\frac{2}{3}$
$\frac{1}{15}$	$\frac{1}{3}$

The representation $\frac{2}{13} = \frac{1}{8} + \frac{1}{52} + \frac{1}{104}$ is obtained by first halving 13 repeatedly, then the fraction $\frac{1}{13}$, so that the sum 2 results in the right-hand columns (see right).

1	13
$\frac{1}{2}$	$6+\frac{1}{2}$
$\frac{1}{4}$	$3+\frac{1}{4}$
$\frac{1}{8}$	$1+\frac{1}{2}+\frac{1}{8}$

$\frac{1}{13}$	1
$\frac{1}{26}$	$\frac{1}{2}$
$\frac{1}{52}$	$\frac{1}{4}$
$\frac{1}{104}$	$\frac{1}{8}$

NEUGEBAUER quickly expanded his field of research. After also learning Akkadian, he researched Babylonian mathematics at the Vatican, publishing an article in 1927 on the origin of the hexagesimal system in this culture.

As early as the winter semester of 1927/28, NEUGEBAUER was able to offer a lecture on the history of ancient mathematics. His enthusiasm for this previously neglected field of research inspired BARTEL LEENERT VAN DER WAERDEN, one of his students at the time, to also delve into the subject. VAN DER WAERDEN's 1950 book, *Awakening Science,* is still considered a classic in the field.

NEUGEBAUER travelled to Leningrad to assist VASILY VASILIEVICH STRUVE in preparing an exhibition on the *Moscow Papyrus*, the most important document on Egyptian geometry.

His further research into ancient mathematics was supported by his wife, GRETE BRUCK, a former fellow student. Their happy marriage, which began in 1926, produced two children.

With OTTO TOEPLITZ and the philologist JULIUS STENZEL, he founded the series *Sources and Studies on the History of Mathematics, Astronomy and Physics* for the Springer-Verlag publishing house, in which he also published his own treatises on Egyptian computational methods.

In 1931 he was one of the founding editors of the still existing *Zentralblatt für Mathematik* (*und ihre Grenzgebiete*), in which reviews of specialist books, reports on specialist conferences and articles in specialist journals are published.

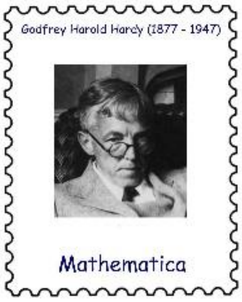
After HITLER's rise to power, all Jewish lecturers in Göttingen were suspended from their posts in April 1933, including COURANT and NOETHER. Student groups agitated against LANDAU, BERNAYS and also against NEUGEBAUER, who had been appointed by COURANT as acting head of the *Mathematical Institute.* When NEUGEBAUER was asked to swear an oath of allegiance to the new government, he refused.

He was already considered politically unreliable, having been in Leningrad in 1928. He had tried in vain to ridicule the suspicion that he was *secretly a Bolshevik*: Was he also suspected, because of his stay in the Vatican, of having *secretly become a Jesuit*?

In January 1934, NEUGEBAUER accepted a professorship in Copenhagen, which his friend HARALD BOHR had arranged for him. From there, he continued to publish the *Zentralblatt* (with the assistance of his wife), which was printed by the Springer publishing house in Berlin.

A lecture series on pre-Greek mathematics led to the first volume of a planned trilogy on ancient mathematics. However, it remained a *single* volume, as he soon set himself the goal of first presenting a comprehensive overview *of all available ancient mathematical texts.* In 1935/37, the three-volume collection *Mathematical Cuneiform Texts* was published, which to this day forms the basis of all publications on Babylonian mathematics. Further standard works on ancient astronomy also emerged. In the following decades, he published *Astronomical Cuneiform Texts* (1955) and *Egyptian Astronomical Texts* (1960-69). Since the original texts, often found in a damaged state, contained gaps, he developed methods to fill them in appropriately.

In 1938, a dispute escalated regarding the internationally staffed editorship of the *Zentralblatt*, in which more publications were now in English than in German – partly due to the forced emigration of numerous Jewish mathematicians from Germany.



After the Italian co-editor TULLIO LEVI- CIVITA lost his professorship in Rome due to anti-Semitic legislation in Italy, JULIUS SPRINGER was instructed by the Nazi regime to remove his name from the journal's imprint. Furthermore, it was to be prohibited in the future for the work of *German* mathematicians to be reviewed by foreign reviewers. Following NEUGEBAUER's resignation, COURANT, BOHR, GODFREY HAROLD HARDY (Oxford, Cambridge) and OSWALD VEBLEN (Princeton) also stepped down from their posts. In the following years, the *Zentralblatt* declined in importance. It reappeared in 1948, with the subtitle "*founded by O. Neugebauer*".

NEUGEBAUER received an offer to take up a professorship at the prestigious *Brown University* in Providence, Rhode Island, and to publish a new journal*, Mathematical Reviews,* with the support of the *American Mathematical Society* (AMS). Immediately after moving to the United States, he applied for American citizenship and from then on, he wrote all his contributions in English.

When a former colleague from Göttingen asked him if he could not write his correspondence with German authors in his mother tongue, he replied: *I must remark that the language I use in my letters does not depend on my mother but on my secretary. It interests me very much that the so-called German mathematicians now require the editor of an international journal to use their language. During the time I was editor of the Zentralblatt, no American mathematician required that I use the English language ...*

Over the next 30 years, he succeeded in establishing an international centre for the history of mathematics at *Brown University* – partly through targeted recruitment from other universities, so that eventually four professorships on the history of mathematics were located there.

His most important work, *A History of Ancient Mathematical Astronomy*, was published in 1975 as the first publication in the new Springer series *Sources and Studies in the History of Mathematics and Physical Sciences.* Thanks to his comprehensive source work, he was able to trace the line of development that began with Babylonian astronomers and led, via PTOLEMY's *Almagest*, the pinnacle of Greek astronomy, through Indian and Arab scientists of the Middle Ages, to COPERNICUS, BRAHE and KEPLER.

NEUGEBAUER also worked on a number of occasions at the *Institute for Advanced Studies* in Princeton (New Jersey), where he settled permanently in 1984 – following his retirement in 1979 and the death of his wife in 1980.

The highly honoured scientist was an honorary member of numerous international academies. He was twice invited to give plenary lectures at ICM meetings (Bologna 1928 and Oslo 1936). A prize awarded every four years by the European Mathematical Society (EMS) for outstanding contributions to the history of mathematics is named after him.

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