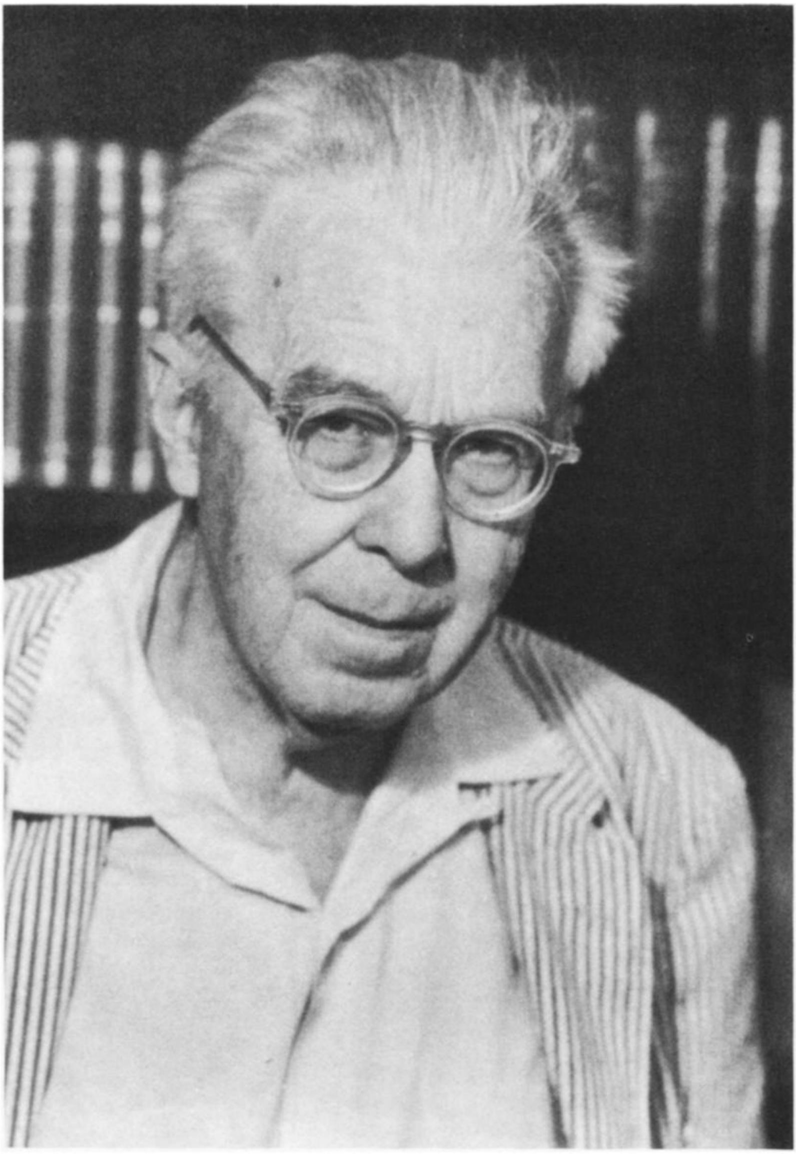
OTTO E. NEUGEBAUER
(26 May 1899–19 February 1990)

There are in any age but few people who by their force of intellect, independence of mind, and quality of work are able to create or transform an entire field of study. The history of the mathematical sciences as an autonomous subject of research has a long and distinguished history. But since its founding in the eighteenth century by Jean Etienne Montucla, no one has altered its direction or raised its standards more significantly than Otto Neugebauer. Through a productive career of sixty-five years, through three generations of colleagues and students, he has entirely reformed and to a great extent created our understanding of mathematics and astronomy from Babylon and Egypt in the early second millennium, through Greco-Roman antiquity, to India, Islam, and Europe of the Middle Ages and Renaissance. And through this entire period he has demonstrated both the continuity of the two oldest exact sciences and their distinctive character in different cultures.

Neugebauer was born in Innsbruck, Austria, the son of Rudolph Neugebauer, a railway construction engineer who was also a collector and scholar of oriental carpets. His family soon moved to Graz where his parents died when he was quite young. He attended the Akademisches Gymnasium in Graz, and in school was interested in mathematics, mechanics, and especially technical drawing, but not at all in the required courses in Latin and Greek. Since his family was Protestant, he was exempted from mandatory instruction in religion. In 1917 it was announced that gymnasium students in their last year who enlisted in His Imperial Majesty's Army would be excused from part of their final examinations and still receive their graduation certificates. Since he did not, as he said, have a chance of passing his Greek examination, he promptly accepted this generous offer and enlisted, finding himself before long an artillery lieutenant on the Italian front, principally a forward observer, relaying the location of Italian artillery while both sides fired over his head. He liked this despite its danger since it gave him a good deal of independence, and later remarked mordantly that these were among the happiest days of his life. At the armistice he was taken prisoner, and since the Austrian government had little interest in the repatriation of large numbers of troops when Vienna was on the verge of revolution, he spent nearly a year in an Italian prisoner of war camp. Provisions were so scarce that at one time he and a fellow prisoner, Ludwig Wittgenstein, had to share the same pencil.



Courtesy of *Centaurus*

In the fall of 1919 he entered the University of Graz where he studied electrical engineering and physics. During this time the hyperinflation of Austrian currency took place, and he found that his inheritance, from the sale of a factory owned by his father, that had been conservatively invested in government bonds, was reduced to the point that when redeemed it was just sufficient to purchase a four-volume set of physics texts. In 1921 he transferred to the University of Munich where he attended lectures by Arnold Sommerfeld and Arthur Rosenthal, and spent a fearful winter with little food and water frozen in his room each morning. In the course of this year his interests changed to mathematics, and in the fall of 1922 following Sommerfeld's advice he moved on to the Mathematisches Institut at the University of Göttingen where he finally found the object of his search. Shortly after his arrival he gave the first report of the year in the seminar of the new director of the Institut, Richard Courant. Courant was impressed, and there grew up between them a friendship that was to last for fifty years until Courant's death in 1972. Another close friend from this period was Paul Alexandroff, who arrived in 1923 and years later wrote his treatise on topology with Heinz Hopf while living in Neugebauer's house. Neugebauer also studied with Edmund Landau and Emmy Noether, and in 1923 became an assistant at the Institut and special assistant to Courant in 1924. Significantly, he was also in charge of the *Lesezimmer,* the library.

But again his interests began to change, this time in an unusual direction. He had read a German translation of J. H. Breasted's *History of Egypt,* from which he learned that there was such a thing as Egyptian mathematics, and he became sufficiently curious to study Egyptian with Hermann Kees and with Göttingen's great Egyptologist Kurt Sethe, with whom he remained in communication after Geheimrat Sethe succeeded Erman in Berlin in 1923. During 1924–25 he was at the University of Copenhagen with Harald Bohr, another life-long friend whom he had met in Göttingen, and Bohr asked him for a review of T. E. Peet's new edition of the Rhind Papyrus (1923), the principal source for Egyptian mathematics, which appeared as his first publication in 1925. The following year he published a paper with Bohr on differential equations with almost-periodic functions, one of Bohr's specialties, which turned out to be his only publication in pure mathematics. For by then he was firmly directed toward the history of mathematics, and had written his dissertation on Egyptian unit fractions. There was no small concern at the Institute about a young mathematician of promise wasting his talent on historical subjects, but both Hilbert and Courant, with support from Paul Ehrenfest, approved his decision on the grounds that it is best to let intelligent people follow their own interests. If he had a philosophy of education, that was it, and no one was more independent both in finding his own way and in encouraging his students and colleagues to do the same. (His customary remark on the principles of education was "No one has yet invented a system of education that is capable of ruining everyone.") In 1927 he received his *venia legendi* for the history of mathematics, and in the fall term became Privatdozent and began lecturing on mathematics—he taught, among other subjects, descriptive geometry—and on the history of ancient mathematics, Egyptian, Babylonian, and Greek. It was through these lectures that B. L. van der Waerden, best known for clarifying and extending Noether's work in modern algebra, became interested in ancient mathematics. At this time Neugebauer married Grete Bruck, a fellow student and very fine mathematician, who later assisted him in much of his work. They had two children, Margo, born in 1929, and Gerry in 1932.

There are two principal interpretations of the history of the mathematical sciences that have an important role in Neugebauer's work, both true, both of value, but not entirely compatible. To borrow a term from Niels Bohr, they are complementary. On the one hand mathematics and the mathematical aspects of other sciences have a continuity and universality that is independent of time, place or the character of any particular mathematician. As Littlewood once remarked to Hardy, the Greek mathematicians "are not clever schoolboys or 'scholarship candidates,' but 'Fellows of another college.'" Every mathematician, paradoxically, is more the creation of mathematics than the other way around. The methods and discoveries of mathematics develop within the rules of its own logic, and, whether in Mesopotamia or Göttingen, all mathematicians explore parts of this abstract and universal edifice. An important representative of this interpretation is Felix Klein's *Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert* (1926-27), the first volume of which Neugebauer and Courant edited for publication from Klein's notes. The other interpretation looks upon the mathematical sciences as a characteristic and fundamental product of each individual culture, and thus the differences between the mathematics of Babylonians, Greeks or modern Europeans are of the greatest significance in coming to understand the character, certainly the creative character, of each civilization. Here, to name another example close to Neugebauer, Kurt Sethe's *Von Zahlen und Zahlworten bei den alten Ägyptern und was für andere Völker und Sprachen daraus zu lernen ist* (1916) and his later studies of Egyptian units of the measurement of time in comparison with other ancient cultures show vividly how such technical studies can fundamentally illuminate the distinctive characters of ancient civilizations. These two themes, the universal and abstract and the cultural and material, are, as we said, not entirely compatible, are in a sense contradictory, for if mathematics is one great edifice, are not cultural differences, as obvious as they may be, merely superficial? At once a mathematician and cultural historian, Neugebauer was from the beginning aware of both interpretations and of the contradiction between them. Indeed, a notable tension between the analysis of culturally specific documents, whether the contents of a single clay tablet or scrap of papyrus or an entire Greek treatise, and the continuity and evolution of mathematical methods regardless of ages and cultures is characteristic of all of his work. And it was precisely out of this tension that was born the detailed and technical cross-cultural approach, in no way adequately described as the study of "transmission," that he applied more or less consistently to the history of the exact sciences from the ancient Near East to the European Renaissance.

But if the truth be told, on a deeper level Neugebauer was always a mathematician first and foremost, who selected the subjects of his study and passed judgment on them, sometimes quite strongly, according to their mathematical interest. And for this we must be grateful, for only a true mathematician would recognize and be willing to expend the effort necessary to reveal the depth of Babylonian mathematics and, more so, mathematical astronomy, which was probably (certainly, in his opinion) his greatest single accomplishment. This is a subject, indeed, the most important subject, in considering Neugebauer's work, to which we shall return. His thesis, called, most significantly at Göttingen, *Die Grundlagen der ägyptischen Bruchrechnung* (Springer, 1926), was principally an analysis of the table in the Rhind Papyrus for the expression of fractions of the form $2/n$, where n is an odd number between 3 and 101, as a sum of different unit fractions, fractions with the numerator 1, i.e. $2/n = 1/a + 1/b + \ldots$, showing the theory underlying this expression and the procedure for its computation, showing, in short, how the Egyptian mathematician thought. Since the original publication of the Rhind Papyrus by Eisenlohr (1877), there has been considerable literature on the $2/n$ table—beginning with no less than J. J. Sylvester (1880), who treated the fractions his own way—that continues to the present day. Perhaps surprisingly, Neugebauer's austere work on *Grundlagen* ignited no small controversy concerning both the computation of the fractions and the character of Egyptian mathematics.

In 1929 he founded, with O. Toeplitz and J. Stenzel as co-editors, *Quellen und Studien zur Geschichte der Mathematik, Astronomie und Physik* (*QS*), a Springer series devoted to the history of the mathematical sciences and divided into two parts, Abteilung A for the publication of sources and B for studies, distinguishing and uniting philological and technical research. In a prefatory note, the study of the historical development of mathematical thought is described, not only as a specialized subject maintaining its own technical standards, but also as the bridge between the so-called *Geisteswissenschaften*, the humanities, and the apparently ahistorical exact sciences (which are more or less what Lord Snow later called the "two cultures"). Neugebauer did not write all of *QS*, but he wrote a lot of it, for it was the perfect medium for his comprehensive approach to the mathematical sciences, and his editorial guidance may be seen in many of its contributions. In 1927 W. Struve of Leningrad had informed him of the existence of the Moscow Papyrus, the second largest source of Egyptian mathematics after the Rhind Papyrus and the most important for geometry. He went to Leningrad in 1928 to assist Struve in preparing the text for publication in *QS* A 1 (1930), following which he published extended papers, the first dedicated to Sethe, on Egyptian computational techniques in arithmetic and geometry in *QS* B 1 (1930–31).

However, since 1927 he had been investigating a more important and interesting subject, namely, Babylonian mathematics, for which he had learned Akkadian and worked in Rome with Father P. A. Deimel, S. J., of the Pontificio Istituto Biblico. The sources for Babylonian mathematics, most dating from the early second millennium, were vastly more extensive than for Egyptian, but very little had been published, and that with an almost unparalleled degree of incompetence. Neugebauer later described with delight how H. V. Hilprecht, in publishing texts found at Nippur in a supposed temple library (1905), had multiplied simple multiplication and reciprocal tables, i.e. $m \cdot n$ and $1/n$, by the factor $60^4 = 12{,}960{,}000$, which he called Plato's "Nuptial Number," and then interpreted them as profound astrological and numerological wisdom about the microcosm and macrocosm. (I have looked at Hilprecht's publication, and it is even more absurd than Neugebauer bothered to mention.) He began studying the texts, and gradually discovered their real content, mostly stated in the form of everyday problems in digging ditches, building walls, measuring and dividing fields, inheritance, and commerce: algebraic procedures for solving or approximating the solutions to equations with one or more unknowns of first, second, third, fourth, and higher degree; exponentiation and the extraction and approximation of roots; arithmetic and geometric series; applications to plane and solid geometry; an essentially complete anticipation of the algebraic procedures of Greek geometry; and of course auxiliary tables beyond counting (including dozens of the sort that had led Hilprecht to his metaphysical fantasies). His first paper on Babylonian mathematics, in 1927, was an account of the origin of the sexagesimal system, and by 1929 he was gathering new material at Berlin and other collections for the publication of a substantially complete corpus of texts. During the next few years, he published a number of articles, mostly in *QS* B, and eventually published the corpus in *Mathematische Keilschrift-Texte* (*MKT*) (*QS* A 3, 3 v., 1935–37). At the beginning of the preface he quoted Anatole France, one of his favorite authors: "L'embarras de l'historien s'accroît avec l'abondance des documents." This was not the last time this was to prove true. The exceedingly complex manuscript was supervised in all its versions and prepared for the press by his wife, to whom he said the book belonged as much as to him. *MKT* is a colossal work, in size, in detail, in depth, and is worth every page, for its contents show that the riches of Babylonian mathematics far surpass anything one could imagine from a knowledge of Egyptian and Greek mathematics.

During the years that he was working on *MKT*, Neugebauer's life changed completely, and part of that change has to do with his contribution to modern mathematics at Göttingen and throughout the world. As we have mentioned, Neugebauer lectured on mathematics, but he was also essential to the Institut in other ways. Courant always gave him credit for designing the new building of the Mathematisches Institut, completed with support from the Rockefeller Foundation in 1929, and in 1930 he became Oberassistant to Courant, carrying out many of the director's administrative duties about which, as is well known, Courant was not exactly enthusiastic. In 1932 he was promoted to Extraordinarius, and at about that time declined the offer of an Ordinarius at Darmstadt. By then he had taken on responsibilities that must be called international. Already in the middle of the nineteenth century, mathematics had become so specialized and publications so numerous that it was nearly impossible to keep track of a single field, let alone the entire subject, and there was clearly a need for secondary journals to publish abstracts or reviews of the ever-increasing literature. The most important of these was the *Jahrbuch über die Fortschritte der Mathematik* founded in 1868. As the title indicates, it was an annual, it could not be less than a year behind, and as the quantity of publication continued to increase so too did the delays, until by the 1920s the situation had become intolerable. Neugebauer therefore proposed to Ferdinand Springer a new publication that would appear frequently, as the bimonthly *Chemisches Zentralblatt* and *Physicalische Berichte* had for years, and through various organizational changes greatly reduce the delay and increase the quantity and utility of reviews. He assembled an international board of editors and many contributors, and on 14 April 1931 the first issue of the *Zentralblatt für Mathematik und ihre Grenzgebiete* (*Zbl*) appeared; described in its first issues as *zunächst monatlich,* it was soon appearing nearly twice a month. In 1932 he began editing *Ergebnisse der Mathematik und ihrer Grenzgebiete,* a Springer series of short monographs on current mathematics, and in 1933, with W. Flügge, the *Zentralblatt für Mechanik,* which was separated from *Zbl.* All this was no small addition to research, teaching, and administrative responsibilities.

Then politics intervened.[1] The year 1933 began with the Mathematisches Institut straitened by the depression, but as yet unharmed by outside interference. On 30 January Hitler became chancellor, and the change was rapid and catastrophic, for almost immediately brown shirts and swastikas appeared among the students and Privatdozenten. Then on 7 April the Law for the Restoration of the Civil Service, which included university faculty, authorized the dismissal of civil servants of non-Aryan descent or of uncertain loyalty. During the following week Neugebauer was involved in discussions between Courant and Max Born and James Franck of the physics faculty about some act of protest. Franck, who held a Nobel Prize, thought it would have some effect to resign, and on 16 April did so, for which forty-two members of Göttingen's faculty issued a statement condemning him for giving the foreign press material for anti-German propaganda. Then on Thursday 26 April a local newspaper carried the notice that six professors, including Born, Courant, and Noether, were to be placed on leave. Courant designated Neugebauer acting director of the Institut, but students were by then agitating to stop the lectures of Edmund Landau and Paul Bernays and

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[1] Parts of the following story are well known, particularly from Constance Reid's *Courant in Göttingen and New York* (Springer, 1976), which I have found very helpful.

attacking Neugebauer as *politisch unzuverlässig,* "politically unreliable" (his political views were always very liberal). That weekend he was required to sign an oath of loyalty to the new government, and when he refused was promptly suspended as *untragbar* and denied access to the Institut building.

Why *untragbar* (unbearable)? Here is one possible reason: A Nazi official once requested that he explain why he was in Leningrad in 1928 since it might be suspected that he was secretly a Bolshevik. His answer was to point out that in 1930 he was at the Vatican, so perhaps they might suspect that he was secretly a Jesuit. Needless to say, this did not endear him to the National Socialists. In May and June he and Kurt Friedrichs wrote a petition on behalf of Courant for which they managed to gather twenty-eight signatures, and sent it to the Ministry of Education. Of course it did no good. Also in May Courant wrote to Abraham Flexner, director of the Institute for Advanced Study, about his own and Neugebauer's situation, following which Oswald Veblen of the Institute, who had lectured at Göttingen in 1932, tried to arrange an interdepartmental position for Neugebauer at Princeton. Then in September there was correspondence between Veblen, Flexner, and Frank Aydelotte, president of Swarthmore and secretary to the Board of Trustees of the Institute, about bringing him to the Institute. George Sarton encouraged this, writing to Flexner that compared to Neugebauer, he considered himself a mere amateur. However, the transfer of *Zbl* to Princeton was seen as a problem (and an expense to the Institute), and a better solution, for the moment, came when Harald Bohr arranged a three-year appointment as professor at Copenhagen beginning in January 1934. At about the same time Courant received a one-year appointment at Cambridge. By the end of 1933 the move, including *Zbl,* was accomplished. Neugebauer managed to get his property out of Germany—although he abandoned a house with a partially paid mortgage—and began a period of relative peace and extraordinary productivity in Copenhagen, his research supported in part by the Rockefeller Foundation.

At Göttingen he had regularly lectured on ancient mathematics, and after arriving at Copenhagen he prepared for the summer term a series of lectures on Egyptian and Babylonian mathematics that became the first of his books directed to a general readership, *Vorgriechische Mathematik* (Springer, 1934, rpr. 1969), published as vol. 43 of Courant's series *Die Grundlehren der mathematischen Wissenschaften in Einzeldarstellungen,* a none-too-translatable title, known to mathematicians from the color of its binding as the "yellow peril" (*gelbe Gefahr*). *Vorgriechische Mathematik* is as much a cultural as a technical history of mathematics; indeed, it is Neugebauer's most thorough and successful union of the two interpretations. By the time he wrote it, he had completed his work on Egyptian mathematics, and *MKT* was also nearing completion. In describing the distinctive characters of Egyptian and Babylonian mathematics, his concern with "how things work" is evident, and he explains matters as basic as how hieroglyphs and cuneiform are written, and how this affects the forms of numbers and the operations with numbers. One can also see here his ingenious use of diagrams, some quite complex and all drawn by himself, for every conceivable purpose, which became characteristic of his work. *Vorgriechische Mathematik* is an outstanding study in both cultural and mathematical history, and should be more widely known to mathematicians and historians. While a Russian translation appeared as early as 1937, the book has never been translated into English, which is a pity.

Vorgriechische Mathematik was intended as only the first volume of a set of three called *Vorlesungen über Geschichte der antiken mathematischen Wissenschaften.* The second was to be on Greek mathematics, specifically Archimedes and Apollonius, and on pre-Euclidean mathematics, showing its relation, where recoverable, to Babylonian. Already in *QS* B 2 (1932) he had published *Apollonius-Studien*, based upon lectures given that year on *Conics* I–IV, examining Apollonius's algebraic procedures in what he called a *Stilgeschichte* for characterizing relations of the individual epochs and cultures of ancient mathematics. The study contains an entirely new kind of analysis of Greek mathematics, and the promised volume would surely have shown an original approach to the entire subject, but as it turned out, he never returned to work of this kind. (In fact, with the main lines of Greek mathematics, he later became, quite frankly, bored.) The third volume was to be on mathematical astronomy, principally on the fundamental work of Ptolemy, still insufficiently appreciated, and the yet more difficult and inaccessible Babylonian astronomy. So far he had written only a single paper touching on Babylonian astronomy, and that was an accident. He had been sent for review *The Venus Tablets of Ammizaduga* (1928) by Langdon, Fotheringham, and Schoch, in which a series of omens from the heliacal risings and settings of Venus dated to days, months, and regnal years were used to establish the absolute chronology of the early Akkadian Dynasty that includes Hammurabi. The book was sent to the wrong Neugebauer; it should have gone to P. V. Neugebauer (*no* relation) of the Berlin Astronomisches Recheninstitut, who had published still indispensable works on astronomical chronology. Nevertheless, the wrong Neugebauer studied the book carefully, and in his review article pretty much demolished the chronology that had been so scientifically established. After the article appeared, no reprints arrived; they were sent to P. V. in Berlin. In 1938 he did something similar to Egyptian chronology by showing the *Bedeutungslosigkeit* of the Sothic Cycle for dating the introduction of the Egyptian calendar, thereby annihilating Eduard Meyer's 19 July 4241 B.C. as "das erste sichere Datum der Weltgeschichte" and reducing the age of the Egyptian calendar by more than a thousand years.

As he later told the story, the three-volume *Vorlesungen* collapsed for the following reason: While working on the mathematical cuneiform texts for *MKT*, he also considered it efficient to write the account of the astronomical cuneiform texts for the third volume. These had originally been identified by J. N. Strassmaier, working in the British Museum, and deciphered by J. Epping in the 1880s. Since many had been published and analyzed with great thoroughness by F. X. Kugler in *Die babylonische Mondrechnung* (1900) and *Sternkunde und Sterndienst in Babel* (1907–24), it appeared not too large a task to summarize Kugler's results in a mathematically concise form and extend them to the few more recently published texts, about fifty in all, most fragmentary. But then the mathematician again came to the fore. The mathematical astronomical texts consist for the most part of columns of numbers, each containing a periodic arithmetic function, their purpose being to compute the time and position of lunar and planetary phenomena, as first visibilities and such. In order to restore damaged and missing sections of texts and check for possible connections between fragments, he developed procedures using linear diophantine equations with the number of periods and the number of excess lines of each arithmetic function as unknowns. The result of these checks was the joining and dating of many previously unrelated fragments, the insight that some functions ran continuously for hundreds of years, and in general a far deeper understanding of the mathematical structure of the texts. He realized that what was now required was nothing less than a new edition of all the texts with a methodologically consistent analysis, and this was at least as large a project as *MKT*, which from its inception took fully eight years to complete.

We shall consider the results of this project shortly, but there was another reason for the discontinuance of the *Vorlesungen*, particularly its second volume, that Neugebauer did not commit to writing. The point of the entire project was to investigate as a mathematical and cultural history the character and interrelations of the exact sciences in Egypt, Babylon, and Greece, an object that continued to some extent through his work, but it also had the appearance of treating Egyptian and Babylonian mathematical science as in some way preparatory to Greek, as the title of the first volume clearly implies. But by the time he had published *MKT* and was deeply engrossed in Babylonian astronomy, his respect for Babylonian mathematical science was far too great for him to treat it as preparatory to anything. In the case of astronomy in particular, he understood, as no one had before, that he had found something fully the equal of Ptolemy in sophistication, and, in its level of mathematical abstraction and power, deeper than Ptolemy and, I may add, than anything before the reduction of mathematical astronomy to celestial mechanics in the eighteenth century. Greek astronomy, as fine as it is, is very simple and very limited compared with Babylonian. These things are hard to believe and are still against all received wisdom, but are nevertheless true, although it takes a good understanding of Babylonian astronomy and some mathematical sophistication to grasp them. Never again was Neugebauer to subsume Babylonian mathematics and astronomy under the title *vorgriechische*, and to the best of my knowledge the corresponding term *pre-Greek* never occurs in his English publications.

When you find something this important, you drop everything else.

So he put aside Greek mathematics and went to work seriously on Babylonian astronomy, and at first the published results came rapidly, beginning with a paper in 1936 on the method of dating and analyzing texts using diophantine equations. He then published a series of papers in *QS* B 4 (1937–38), the first of which set out a proposal for a complete edition of all classes of Babylonian astronomical texts: mathematical, observational, and astrological, that is, celestial omens, with the cooperation of L. Hartmann, J. Schaumberger, A. Schott, and other collaborators as the occasion might arise. In 1936–37 he had lectured on lunar and eclipse theory—mimeograph copies survive—the first results of his new analyses and the basis of two papers in *QS* B 4 in which he showed the applications of his methods. But then came the events of the fall of 1938, and it was to be many years before he, and he alone, completed his part in this great enterprise.

Throughout this entire period, as conditions continued to deteriorate in Germany, there was concern about *Zbl,* edited by Neugebauer with the assistance of his wife in Copenhagen and published by Springer in Berlin. In the summer of 1936 Veblen, then in Copenhagen, asked him for a report on *Zbl* and whether it would be advisable to publish it independently of Springer under the auspices of the American Mathematical Society. Being occupied with the third volume of *MKT,* it was not until the following 4 February that he sent Veblen a brief account of the expenses, and pointed out that any changes would probably increase costs and require more work from him. Thus far, he said, he had complete editorial freedom, "but one can of course never know when something will strike home out of the blue." As long as Ferdinand Springer continued as he had, he wrote, he wished to help him all he could. On 5 January 1938 he wrote to Veblen that Ejnar Munksgaard in Copenhagen was interested in *Zbl* and would step in if necessary, but for now he hoped things would remain the same. But then things began to change. On 14 March Wilhelm Blaschke of Hamburg, a member of the board of editors, wrote to him that in his personal opinion it appeared that the number of German contributors and the proportion of the German language in the *Zbl* had declined steadily; if this continued there would sooner or later be difficulties for the publisher. Neugebauer sent a sharp reply, calling Blaschke's opinion *unverständlich.* From its first day, he wrote, the *Zbl* had been an international journal using the most qualified reviewers. If the proportion of English had increased, this was simply because the production of mathematics in America had increased and the most competent reviewers happened to be American. (In fact at that time about half the 300 or so reviewers were in America and England and only about 60 in Germany, with entire fields completely unrepresented, as should not be surprising. And many of the reviews in German were actually written by Russians.) In conclusion, he told Blaschke that he was sending a copy of the correspondence to Veblen to learn whether he too was of the opinion that the English-speaking world played a disproportionately large role in the *Zbl.* Of course changes of the sort intended by

Blaschke would have destroyed *Zbl*, and Neugebauer told Veblen that he was not in the least prepared to reach any compromise. Now, he wrote, Herr Blaschke believes the time has come to begin his *Wühlarbeit* to the *Zbl*, and while he does not have the means to threaten its existence, we must still count on it that some day its continuation will be impossible. By chance that day one of the most notable Scandinavian publishers (surely Munksgaard) had inquired whether he would be prepared to transfer *Zbl* to his hands, and he asked Veblen if a subvention on the order of $10,000 could be found in America. Veblen wrote back on 19 April that this would be difficult and that eventually *Zbl* might have to be published in the United States, but this should be postponed as long as possible. For the moment, he thought it best to stay with Springer, and if that proved impossible, to publish in Scandinavia, or failing that, in the United States. In May Alexandroff resigned from the board of editors. On 19 October Veblen wrote to Warren Weaver of the Rockefeller Foundation that while *Zbl* did not appear to be in immediate danger, John von Neumann had written him from Copenhagen that Neugebauer and Bohr were worried, and thought it advisable for Neugebauer to move to the United States if a suitable position could be found.

The final collapse had in fact already come. When Neugebauer received the 8 October index issue of *Zbl*, he found that Tullio Levi-Civita had been deleted from the list of the editorial board. He wrote to Ferdinand Springer about this on 11 October, and received a reply, dated 27 October, that Levi-Civita's name had been removed because he had been dismissed from his professorship in Rome due to the (anti-Semitic) legislation in Italy. Springer went on to say that the German mathematicians, the cognizant authorities (*zuständigen Stellen*) and, in common with both, the publisher are of the opinion that there would be no prejudice to the strict scientific and international character of the *Zbl* if the editor would avoid on principle having the work of German authors reviewed by *Emigranten*, and asked that Neugebauer make an unconditional and binding promise to this by 1 December. It is evident that Springer's hand was forced, but it is also evident that conditions had now become impossible. Neugebauer immediately wrote to Springer refusing to accept the terms, and wrote to members of the editorial board informing them that he intended to resign as of 1 December and encouraging them to do the same. Bohr wrote a characteristically analytical and detailed account of the situation to Veblen on 11 November, and on 14 November Courant received a cable from Neugebauer: "Common immediate resignation of American editors very desirable. Neugebauer." Also in November, he sent a printed postcard to all the reviewers:

> Since one of the editors of the *Zentralblatt für Mathematik* has been eliminated (*gestrichen*) without communicating with him, with me or with the other editors, since further it has been demanded of me to consider other than purely objective points of view in the distribution of reviews, I have resigned the editorship of the *Zentralblatt*.
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> I have to thank all my contributors most warmly for their many years of dis-

tinguished service and, above all, for the understanding with which they have accommodated themselves to the demands, not always convenient, that had to be placed upon them. O. Neugebauer

Letters and telegrams of resignation were sent to Springer by Bohr and Hardy, by Courant, Tamarkin, and Veblen jointly in a telegram of 22 November, copies of which were widely distributed, and in the next few weeks, as Veblen later informed Flexner, by a very large number of reviewers. Courant also resigned from the yellow peril. The effect on *Zbl* was certainly dramatic. English-language contributions were greatly reduced by the middle of 1939 and all but gone by the beginning of 1940. (*Zbl* ceased publication in 1944. Since its resumption in 1948, every issue has carried the notice "Founded by O. Neugebauer.")

It was clear that *Zbl* could no longer be relied upon, and in the United States action was immediately undertaken to replace it and bring Neugebauer.[2] Veblen had been in correspondence about the situation with Rolland George Dwight Richardson, secretary of the American Mathematical Society (AMS) and dean of the Graduate School at Brown University. He had also made inquiries about Neugebauer at Columbia and Princeton; Columbia, then headquarters of the AMS, was interested, Princeton less so. Richardson moved fast. There were two principal forces to bring Neugebauer to Brown. One was Richardson, among the first and strongest advocates of the new journal, who arranged for Brown to provide facilities; the other was the encouragement of Raymond Clare Archibald—Archie, as Neugebauer called him—a historian of mathematics who had built up a splendid mathematics collection in the Brown library. In early December Richardson wrote to Stephen Duggen of the Institute for International Education for support for Neugebauer from the Emergency Committee for Displaced Foreign Scholars while President Henry M. Wriston of Brown wrote to F. P. Keppel of the Carnegie Corporation. Veblen had also written to Keppel and to Warren Weaver about providing support for the review journal. It took some time, but everyone eventually came through.

Brown, to its credit, was ready to move in any case. On 20 December Wriston and Richardson each wrote to Neugebauer to offer him a professorship in the mathematics department, and at the same time Richardson wrote in his capacity as secretary of the AMS to ask him to direct the American equivalent of *Zbl*. By January Neugebauer had accepted, and planned to come to Brown in mid-February for ten weeks. He sailed to New York, where he was met by Courant on 13 February 1939, and, after three days in New Rochelle, arrived in Providence on 16 February. Everything must have been satisfactory, for President Wriston formally an-

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[2] The story of the founding of *Mathematical Reviews* has been told before, most recently in E. Pitcher, *A History of the Second Fifty Years. American Mathematical Society 1939–1988*, Providence, 1988, and on that subject I shall be brief. I note that there is a great deal of pertinent contemporary correspondence.

nounced his acceptance of the professorship on 27 February. Press releases by Brown reported that "his survey of Babylonian astronomy has been completed and is almost ready for the press" and that in just a few weeks he "has already examined 25,000 Babylonian tablets at Yale." During the next ten weeks arrangements were made for beginning work on *Mathematical Reviews* (*MR*) that summer with initial subventions of $60,000 from the Carnegie Corporation, $12,000 from the Rockefeller Foundation, $1,000 a year for five years from the sponsoring AMS, and later, $3,000 from the American Philosophical Society.[3]

Neugebauer returned to Copenhagen in May, stopping in Cambridge on the way to give the W. Rouse Ball Lectures at Trinity College, and by mid-summer was back in Providence with his family. He was soon joined by Olaf Schmidt, his and Bohr's student and his research assistant in Copenhagen, a mathematician who read, among much else, Sanskrit, and continued as Neugebauer's assistant while an instructor in the mathematics department. The initial work was of course setting up *MR*: selecting and subscribing to journals, enlisting reviewers and subscribers, arranging for the distribution of articles, and editing, printing, and indexing the reviews. There were 350 reviewers and 700 subscribers—*Zbl* had 500—before the first issue appeared. It was decided to begin with articles published after the middle of 1939, and *mirabile dictu* the first issue appeared on time in January 1940. Still more remarkable, at the end of the first fiscal year, of an anticipated budget of $20,000, there remained a surplus of more than $5,000. Neugebauer is recognized as the founding editor of *MR*, J. D. Tamarkin as co-editor, and Willy Feller, who was appointed a lecturer at Brown and became one of Neugebauer's closest friends, was the "technical assistant." During the next few years Neugebauer turned over much of the editorial responsibility to Feller, who became the first executive editor in 1944, although he still came in every day and remained on the executive committee until 1948.

Neugebauer also turned Brown into the leading institution in the world for the study of the history of the exact sciences. In his first year he taught Babylonian astronomy, a year later he gave a series of public lectures on ancient chronology—a subject on which he wrote, but never published, a sizeable manuscript—and lectured frequently at other universities. Together with Archibald, he founded a new journal of the history of the mathematical sciences called *Eudemus*, to be published by Munksgaard with subvention by Brown. The first issue appeared in 1941, but then the war made its continuation impossible. (An attempt to revive it in 1947/48 with further support from Brown failed when the Carnegie Corporation refused to provide a subvention.) In the spring of 1941 he gave a lecture at the Oriental Institute of the University of Chicago, and

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[3] On 28 October 1939 a subcommittee of the Committee on Publications consisting of H. C. Urey, G. D. Birkhoff, and Veblen recommended that the Society contribute $3,000 a year for five years and become a sponsor. At the meeting of the Society on 18 November, the sponsorship was not approved, but $3,000 was granted for one year (*Yearbook* 1939, 142–46).

there met a young Assyriologist, Abraham Sachs, who had received his doctorate from Johns Hopkins in 1939 and was now working on the *Chicago Assyrian Dictionary,* then as now the WPA of Assyriology. Sachs was interested in Neugebauer's work, about which he already knew something, and he could read any text no matter how obscure or damaged. Neugebauer decided immediately that this was the person to continue the great project of publishing all the astronomical texts, and on the way back to Providence, he stopped in New York to discuss the matter with the Rockefeller Foundation. In the fall Sachs came to Brown as a Rockefeller Foundation Fellow with his wife Janet, who worked both at the university and at *MR.* Then in 1943 Neugebauer received a ten-year grant from the Rockefeller Foundation, mostly to pay for a research associate, and Sachs became the Research Associate. And when the Department of the History of Mathematics was formed in 1947, Sachs joined the faculty, becoming associate professor in 1949 and professor in 1953. For more than forty years Sachs was Neugebauer's closest colleague and closest friend. While they collaborated on a number of publications, this in itself gives no idea of the depth of their working relation. Virtually everything that Neugebauer wrote was discussed at length with Sachs, who also went over every manuscript, and his contributions to both style and substance were invaluable. Indeed, every visitor to the department, and nearly every Assyriologist anywhere, looked to him for advice, which he always gave with his characteristic wit and unfailing kindness (which he firmly denied).

The next appointment was in Egyptology. Charles Edwin Wilbour, who had attended Brown in the 1850s, made a great deal of money as a journalist and associate of the Tweed Ring in New York, and, after he hurriedly left the United States in 1871, became an entirely respectable and magnanimous amateur Egyptologist. A part of his estate descended to his daughter Theodora, who never married, and on her demise in 1947 at the age of eighty-six, Henry Wriston, it is said, was on the next train to New York to make certain that, in strict accordance with her will, half her residual estate, about three-quarters of a million dollars, went to Brown to establish and maintain a Department of Egyptology in memory of her beloved father. Wriston told Neugebauer to find an Egyptologist. The choice itself was not difficult. Since 1945 he had been corresponding on Egyptian astronomy with Richard Parker, an assistant professor at Chicago working on Egyptian calendars, whom he visited in Chicago in 1947. Parker had become the Field Director of the Oriental Institute's Epigraphic Survey at Luxor, a position of honor and eminence, as anyone who has visited Chicago House in Luxor knows. It was not easy to get him, but Neugebauer and Wriston did, and in the fall of 1949 Parker became the Wilbour Professor of Egyptology. So now it was possible to do a proper job on Egyptian astronomy also.

The Wilbour Fund also provided accommodations for Egyptology. Brown acquired an old and derelict former fraternity house, which, with minimal renovation, was renamed Wilbour Hall. Parker invited the recently formed History of Mathematics Department, Neugebauer and Sachs, to move from their offices in the basement of Sayles Hall, which they did, Neugebauer cannily selecting four rooms in the basement that would provide space for his library and peace and quiet, since no one would want to go down there. A few years later, they were joined by the Department of Religious Studies, whose members he always referred to as "the holy fathers," but they eventually left for more elegant and spacious quarters a bit higher up the hill. When in the early sixties Brown was planning to build the new Rockefeller Library on an adjacent site, the old building was scheduled for demolition. A rumor started that if Wilbour Hall went, so would Neugebauer. The rumor was news to him—Parker claims responsibility—but Egyptology and history of mathematics are still in Wilbour Hall (in which I am writing this memoir).

With Neugebauer and Sachs and Parker on the faculty, visitors began to spend days and terms and years at Brown, including a steady flow of Egyptologists and Assyriologists. The first was E. S. Kennedy, a mathematics instructor at the American University of Beirut with an interest in Arabic mathematics and, before long, astronomy. He came originally as a Rockefeller Foundation Fellow in 1949/50, and continued to spend every fourth year at Brown for nearly thirty years. Olaf Schmidt, who had taken his doctorate with Neugebauer at Brown in 1943, had returned to a position at the University of Copenhagen after the war, but he too managed to come from time to time. In 1959 a stunningly brilliant young Oxford classicist, Gerald Toomer, who, to the dismay of his colleagues, had become interested in ancient mathematics, came as a special student for two years, and after returning for successive summers became an associate professor and the third member of the department in 1965. And there was David Pingree, who began working with Neugebauer in the late fifties while a graduate student and then a Junior Fellow in Sanskrit and Classics at Harvard. After eight years on the faculty at Chicago, he became the third theft from the Oriental Institute, joining the department in 1971, two years after Neugebauer's nominal retirement at seventy. Between Neugebauer, Sachs, Parker, Toomer, and Pingree, there was hardly a subject in the history of the exact sciences from antiquity to the Renaissance, and hardly a classical language, that was not covered at Brown.

And there were students. Asger Aaboe, formerly a student of Bohr and Olaf Schmidt in Copenhagen, was teaching mathematics at Tufts. Working with Neugebauer and Sachs from 1952 to 1957, he completed a dissertation on Babylonian planetary theory and has continued to write the most sophisticated mathematical analyses of Babylonian astronomy. Bernard Goldstein, who had studied Near Eastern languages and mathematics at Columbia, worked on Hebrew and Arabic astronomy. Then a third generation of visitors and students began. Noel Swerdlow, a student of Aaboe, Goldstein, and Derek Price at Yale—hence, very much an extension of Brown—first came to Providence as an NSF postdoctoral fellow in 1969/70, and other Yale graduates, John Britton and David King, have likewise continued the Brown tradition in Babylonian and Arabic astronomy. Jacques Sesiano from Zürich, principally a student of Toomer, edited and translated the Arabic Diophantus for his dissertation in the seventies. Jan Hogendijk, a mathematician and Arabist from Utrecht, spent two years on the faculty in the early eighties. A gifted classicist and mathematician from Vancouver, Alexander Jones, came as a graduate student, and after completing an edition of Book VII of Pappus for his thesis, has been working on Babylonian, Greek, and later Byzantine astronomy. The work of all these scholars, of their students, and of other visitors is a direct product of the school created by Neugebauer at Brown, and of course his influence extends through his writings to every serious scholar of the history of the mathematical sciences.

From the moment he arrived in the United States, Neugebauer began writing in English. (He also applied for American citizenship immediately.) During the first several years he published a number of general papers on ancient astronomy and mathematics, describing in outline the content of these sciences, his methods of interpretation, and what he considered the most interesting areas for future research (these papers are reprinted in *Astronomy and History*). From the outset a change of direction can be seen in that his earlier concern with cultural foundations is replaced with a greatly broadened interest in the relations between the sciences and their cultural, social, and economic surroundings, initially in the Hellenistic period and then still later. Why? He once told Gerald Toomer that his writing *and* his interpretations changed when he began to write in English, and that the change of language was itself partially responsible. This is not unreasonable, for confirmation comes from similar remarks by Erwin Panofsky about his own experience of the difference between writing in German and English (*Meaning in the Visual Arts*, 1955, 329–30). "There are more words in our philosophy," Panofsky wrote of German art history, "than are dreamt of in heaven and earth." German, he pointed out, affords the opportunity to disguise trivial thoughts (and meaningless thoughts) behind apparently profound language, while in English "even an art historian must more or less know what he means and mean what he says." Neugebauer never wrote like a German art historian, but the introduction to *Apollonius-Studien* is not exactly easy to follow while, from the beginning, his English writing shows a perfect clarity and complete absence of dense theoretical reflections on method, as well as an irreverent wit in the exposure of pretentious nonsense in any language. The responsibility of a historian of the mathematical sciences is to understand and explain his sources as precisely and objectively as possible, and that is for the most part an exercise in mathematics and philology, not in searching for ineffable, if not entirely imaginary, relations with a deeper cultural character. And did not the German propensity, or obsession, to explain everything in terms of its cultural character give the whole enterprise a bad name?

There is an interesting story connected with Neugebauer's use of English that has become well known among mathematicians. In March of 1941 he received a letter from a former colleague from Göttingen, then in Leipzig and a contributor to *Zbl*, advising him that, as the director of two international journals, if he valued his relations with German mathematicians, he should take the small extra trouble to use his *Muttersprache.* Can you not, he asked, at least show consideration for feelings you do not share? Neugebauer's reply was directly to the point:

> As to the last paragraph of your letter, 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. I regret, however, that you do not know me personally well enough to know that I would prefer to use exactly the language that I want to use, even if I have to interrupt my relations with German mathematicians.

The papers just mentioned were not only Neugebauer's introduction of his interests and methods in English, but more than *Vorgriechische Mathematik*, which appeared in a series notoriously restricted to mathematicians, were his first extensive presentations of his work for a general readership of historians of science and humanists. If one reads these pieces in comparison with the contemporary history of science published, for example, in *Isis*, they are a breath of fresh air. Here is the excitement of a new discovery of the sciences of antiquity, painted in broad strokes but with specific technical examples, the opening of a new world of research much livelier than the tired ruminations of historians of philosophy and classicists about pre-Socratics and the *Timaeus* and such that then formed (and I fear still forms) much of the history of ancient science. Instead of these "nursery stories of ancient popular writers," Neugebauer called for specialization, by which he meant skilled scientific and philological research with new original sources, not reading the same old texts again and again. He also dismissed superficial syntheses naively recording the "progress" of science, as though we, in our great wisdom, are the arbiters of progress, and showed little patience with borrowers of second-hand learning, later referring to the scholarship of one eminent compiler of many volumes of this sort as "reminiscent of the mentality of Isidore of Seville." The culmination of these writings is *The Exact Sciences in Antiquity*, dedicated to Courant, originally presented in October of 1949 as the Messenger Lectures "on the evolution of civilization" at Cornell University and first published in 1951, with a revised and expanded second edition in 1957 which Dover Books has faithfully kept in print since 1969. Now, *The Exact Sciences* really was a synthesis, "whatever this term may mean," of his work to date, covering every field of his interest, a survey of Egyptian and Babylonian mathematics and astronomy, their relation to Hellenistic, not just Greek, science, and Hellenistic science itself and its descendants. But it is far more than a survey of these sciences, for Neugebauer here allowed himself the freedom to wander at will, from the calendar of the *Très riches heures* of the Duc de Berry, to the recovery of cuneiform texts, to the strange invention of the "Saros," to the astrological days of the week. The expert can learn something new from it, and from its notes, every time it is read, and for the general reader it is in my opinion the finest book ever written on any aspect of ancient science. In 1983 he published with Springer *Astronomy and History,* a collection of papers selected as a supplement to *The Exact Sciences.*

But let us return to research. Neugebauer's energy was prodigious, and it can be seen from his annual reports for Brown that there is little he was not working on. With an expert Assyriologist as collaborator, one of the first projects was to return to Babylonian mathematics and examine whatever might be contained in American collections. This was mostly done by Sachs, who found substantial additions to the texts of *MKT.* Their edition and analysis of the new texts, published as *Mathematical Cuneiform Texts* (*MCT*) in 1945 and dedicated to Archibald, is not merely a supplement to *MKT,* but an independent study that has been the standard account of Babylonian mathematics in English ever since. Among much else that was new, *MCT* contains the original publication of Columbia University Plimpton 322, on Pythagorean numbers, that has, for better or worse, since provoked more analysis (and speculation) than all the rest of Babylonian mathematics put together.

Still more extensive were the astronomical cuneiform texts, a project that continued to grow as more texts were discovered. Neugebauer's work was substantially complete by 1945 when F. R. Kraus in Istanbul sent films of more than a hundred fragments from Uruk, enough to require a complete rewriting of the manuscript. In 1949 through Father Deimel, Strassmaier's voluminous notebooks were made available, in which Sachs found another hundred fragments, again requiring rewriting. Then in 1952 Sachs worked at the British Museum on a Rockefeller Foundation grant, where he was given access to copies of texts made by T. G. Pinches and personally examined thousands of tablets. This research provided about sixty new fragments to be taken into account, and also yielded a corpus of many classes of texts, both computational and observational, that Sachs published along with Strassmaier's transcriptions in 1955 as *Late Babylonian Astronomical and Related Texts* (*LBAT*). Again Anatole France was right. By this time, enough was enough. Neugebauer's avowed principle was always to do what you can within reason, and publish the results so that someone else can do more. *Astronomical Cuneiform Texts* (*ACT*), dedicated to the memory of Fathers Strassmaier, Epping, and Kugler, was finally published in three volumes in 1955 (by oversight the date was omitted from the title page) by the Institute for Advanced Study, and immediately marked a new age in the study of the history of ancient astronomy. Neugebauer had assembled in all about three hundred texts, most dating from the last three centuries B.C. Through years of assiduous calculation (which he did when he was too tired to do anything else), he had dated and completed damaged texts and joined fragments, and he set out all this material in facsimile and translation with full philological and technical analysis of the underlying theory, computational procedure, and astronomical application.

Every reading and every page of the manuscript had been gone over repeatedly by Sachs, whose name, Neugebauer always said, really belonged on the publication. The first volume contains ephemerides of lunar theory and eclipses and the procedure texts for their computation, the second planetary ephemerides and procedure texts, and the third the translations of the restored ephemerides and photographs or hand copies of all the texts. In the preface he expressed his respect to the shades of the scribes of Enūma-Anu-Enlil. "By their untiring efforts they built the foundations for the understanding of the laws of nature which our generation is applying so successfully to the destruction of civilization. Yet they also provided hours of peace for those who attempted to decode their lines of thought two thousand years later."

ACT has provided the foundation for all later research in Babylonian astronomy, and likewise its transmission, and has been extended and applied to additional texts both by Neugebauer and his colleagues, in particular Aaboe and Sachs, and by a larger circle of scholars. But this of course was only one part of the plan set out in *QS* B 4 in 1937. Sachs, principally through research at the British Museum, vastly increased the number of observational texts, almanacs, and such to about 1,500. He worked on this material until his death in 1983, and the results are now appearing in *Astronomical Diaries and Related Texts from Babylonia* (1988–) by Sachs and Hermann Hunger of Vienna. The third class of texts, celestial omens and astrology, very diverse and difficult to understand, are slowly in the course of publication by Erica Reiner, David Pingree, and Francesca Rochberg.

Next was Egyptian astronomy. There are two sorts, first from older, purely Egyptian sources, such as tomb ceilings and coffin lids, and then from later, Hellenistic sources, monumental zodiacs and papyri, sometimes showing Greek or Babylonian influences. None of it is very sophisticated, and Neugebauer was always at pains to lay the ghost—unfortunately still very much alive—of profound Egyptian astronomical wisdom. The best way, for reasonable people at least, is to publish and analyze the sources, which he did. During his last year in Copenhagen he published with A. Volten in *QS* B 4 (1938) the demotic Papyrus Carlsberg 9, of the second century A.D., on the 25-year lunar cycle, and in 1940 there appeared with H. O. Lange, who saw it through the press in Copenhagen, an edition of Papyrus Carlsberg 1, also of the second century, but preserving a far older hieratic text with demotic translation and commentary on celestial mythology and cosmology and the decans. Two years later he published the known Hellenistic planetary texts and demotic horoscopes, but the really extensive work was done together with Parker, especially after he came to Brown and they began working on an edition of all Egyptian sources, both monumental and on papyrus. It was a task that took more than twenty years to complete, but at last in 1960–69 the three massive, Egyptology-size volumes (in four) of *Egyptian Astronomical Texts* (*EAT*) were published by Brown and dedicated, appropriately, to

H. M. Wriston. Here it was at last, all the Egyptian wisdom: decans from coffin lids, and decans, constellations and star clocks from tomb ceilings, of the Middle and New Kingdoms, Hellenistic monumental zodiacs and papyri, including those previously published. And what did it amount to? With particular perversity Neugebauer began the ten-page section on Egypt in his later *History of Ancient Mathematical Astronomy* with the provocative sentence, "Egypt has no place in a work on the history of mathematical astronomy." Nevertheless, *EAT* is a fascinating, and beautiful, work of scholarship, and through it the content of Egyptian astronomy is now known and for the most part understood. In fact, Neugebauer was a great admirer of Egypt, its art and monuments. In *The Exact Sciences* he began the chapter on Egypt with, "Of all the civilizations of antiquity, the Egyptian seems to me to have been the most pleasant." Compared with the continual and ferocious warfare in Mesopotamia, this was assuredly true. Nefertiti or the winged bulls of Khorsabad, take your pick. His point was that, in antiquity at least, there was no necessary relation between the quality of civilization and the sophistication of its mathematical science, for even the simplest mathematics and astronomy are entirely adequate to daily life. This was cultural history turned on its head.

Hellenistic sources were far more heterogeneous. In addition to Greek treatises in standard editions and the corpus of manuscript materials published in the *Catalogus Codicum Astrologorum Graecorum* (*CCAG*), there were an unknown number of astronomical and astrological papyri. Neugebauer began gathering whatever he could find—eventually many papyrologists sent him anything with numbers on it—and publishing occasional articles, something that continued for the rest of his life. By luck, the chief librarian at Brown, Henry Bartlett Van Hoesen, was a classicist and papyrologist—this was in the days before university libraries were turned over to magpies with degrees in something called "library science"—and together they began assembling an edition of all known Greek horoscopes, both from literary sources and papyri. As usual, the work took longer than expected, and it was not until 1959 that *Greek Horoscopes* was published by the American Philosophical Society. It remains the standard work on its subject, unlikely to be superseded, and is also an excellent introduction to the techniques of Greek astrology.

But there was a yet larger project, in fact the largest of all. Ever since the promise of the third volume of the *Vorlesungen*, Neugebauer intended to publish a history of mathematical astronomy. The form and extent of the work changed over time. Originally it was to have been on antiquity alone, by the early fifties it was to continue through the Middle Ages and Renaissance as far as Kepler. Neugebauer was indefatigable in taking notes on sources, with detailed analyses that he would one day use in his work. Already in Copenhagen he began analyzing the *Almagest*, since it was intended for the *Vorlesungen*, and over the years his notes extended to most published ancient texts, later Greek texts in manuscript, Indian, Arabic, and medieval Latin sources, and indeed on to Copernicus, Brahe, and Kepler. When, after the publication of *ACT*, he began to write all of this up, Anatole France's dictum proved true with a vengeance. It was in itself a monumental task to write a systematic exposition of ancient mathematical astronomy without attempting to cover another thousand years for which the sources dwarfed anything, and everything, surviving from antiquity. And it was pointless to write a "synthesis" when hardly any of the texts had been read, let alone published. In any case, Kennedy was working on Arabic sources, surveying hundreds of astronomical tables and treatises, Pingree on Sanskrit, examining literally thousands of manuscripts, and Toomer on medieval Latin (before he began his translation of the *Almagest*). Copernicus and Kepler would just have to wait. So in the end the project was again, more reasonably, restricted to antiquity.

A History of Ancient Mathematical Astronomy (*HAMA*) appeared in 1975 in three volumes, dedicated to Abe and Janet Sachs, as the first publication in Springer's *Sources and Studies in the History of Mathematics and Physical Sciences*, the relation of which to *QS* should be obvious. (Neugebauer was asked to edit the series, but he declined in favor of Toomer and Martin Klein at Yale.) Like *ACT*, it had the immediate effect of establishing the history of ancient astronomy on a new foundation, and since the astronomy of the Middle Ages and Renaissance is in most respects a continuation of antiquity, it really placed the astronomy of more than two thousand years on a new foundation. Neugebauer arranged the work, quite simply, to cover the most important things first, starting with an exposition of the *Almagest* (begun nearly thirty years earlier), the best preserved and best understood of all ancient sources, and then considering what can be known of Ptolemy's more or less direct antecedents, Apollonius and Hipparchus, including Hipparchus's use of Babylonian materials. The second part is a systematic exposition of Babylonian astronomy going beyond *ACT* both in breadth of its subject and depth of analysis (although it is not easy to read), a section he was working on and continuously revising until the last minute before publication. After the notorious ten-page "Book III" on Egypt, devoted to demonstrating its insignificance, he takes up early Greek astronomy through the first century B.C. Where most literature on this subject is a farrago (literally, mixed fodder for cattle) of pre-Socratics and philosophy with little real pertinence to astronomy, Neugebauer concentrates upon whatever can seriously be reconstructed of mathematical astronomy, including Babylonian influences, from the surviving texts, unfortunately all elementary, supplemented by papyri, inscriptions, and later sources. The fifth part, on Roman and late antiquity, is devoted mainly to planetary and lunar theory in papyri and astrological sources—including an excursion on Tamil astronomy—and, with more secure texts, to Ptolemy's works apart from the *Almagest* and to later sources, principally Theon's edition of Ptolemy's *Handy Tables*. Finally, the sixth part is an appendix on the chronology, astronomy, and mathematics, including diophantine equations, useful to the study of ancient mathematical astronomy, in which he set out materials and methods assembled over many years both from diverse sources and of his own invention.

For all its 1,200 pages of text and nearly 250 pages of figures *HAMA* is an economical work, more a *Handbuch* than a history, as Neugebauer would be the first to admit (although he would not approve of the term). Its subject is the content of ancient mathematical astronomy, and external, cultural matters are kept to a minimum. The treatment of Babylonian astronomy contains not a single remark on the relation, or lack of relation, of the phenomena computed in the ephemerides to those in the omen series Enūma-Anu-Enlil. Planetary and lunar theory are extracted from Vettius Valens without one word about the astrological content of the treatise. Ptolemy's *Tetrabiblos*, the most important astrological work of antiquity, receives four pages, two of them devoted to a problem in spherical astronomy raised by aphetic and anairetic points used to determine the length of life. I raise these instances of the neglect of astrology—philosophy, of course, is inconsequential—because Neugebauer so often and so strongly insisted upon recognition of the place of astrology along with astronomy in the Hellenistic and later periods. Indeed, in a very well-known, and delightfully wicked, note published in *Isis* in 1951, "On the Study of Wretched Subjects" (reprinted as the first piece in *Astronomy and History*), he reproved the sanctimonious George Sarton for dismissing E. S. Drower's publication of the Mandaean *Book of the Zodiac* as "a wretched collection of omens, debased astrology and miscellaneous nonsense." There he pointed out that astrological texts not only preserve otherwise lost astronomy and show its transmission through different cultures, but also give us "an insight into the daily life, religion and superstition, and astronomical methods and cosmogonic ideas of generations of men who had to live without the higher blessings of our own scientific era." (I do not know whether Sarton caught the irony.) Our task, he said, is "the recovery and study of the texts as they are, regardless of our own tastes and prejudices."

In *HAMA* he was not practicing what he preached, and one may ask why. The most obvious answer is that the task of piecing together ancient mathematical astronomy—after all, the title of the book—from fragmentary and, with the exception of Ptolemy and the Babylonians, incompetent sources is already large and difficult enough without expecting more. Do what you can, he said, and publish for the next person. At the very beginning of *HAMA*, in a section called "Limitations," he stated flatly that he was not going to deal with Archimedes' bath or Tycho's silver nose, or a dozen other subjects that are done to death or beyond his competence. But the relation of astronomy to astrology, which may stand for any cultural relations of the mathematical sciences, was neither. I think the reason, as mentioned earlier, is that Neugebauer was always primarily a mathematician with the taste and judgment of a mathematician, for even through years of allowing that mathematics was grounded in culture, he really believed that in a more profound sense it was not.

Mathematics may begin with local applications and conditions and influences that determine its direction, but is it not evident that already early Babylonian scribes and pre-Euclidean Greek geometers became interested in their subjects as mathematics *per se* in a way differing in degree, that is, in extent of knowledge, but not in kind from a modern mathematician? Indeed, all mathematics worthy of the name, including the problems and solutions of applied mathematics, transcends the circumstances of its origin, and just as it was investigated by its creators as pure mathematical science, so can it also be investigated by the historian. Not only can, but should, because the mathematics is by far the most important part and, as it were, the immortal part. There is much to be said for this point of view, for it is obvious that both the Babylonian scribes and Ptolemy, for example, had a purely scientific interest in their research (a word I use deliberately) that went far beyond its "practical" applications for predicting omina or casting horoscopes. There is also much to be said for the cultural study of Hellenistic astrology, but it tells us very little about the mathematical composition of the *Almagest.*

I have mentioned that at one time *HAMA* was to have covered a longer period. What happened to the rest? Over the years, Neugebauer published parts of it separately, sometimes in collaborative projects, and its parts are substantial. In fact, he was late to come to the Middle Ages, his first important publications being on the astronomy of Maimonides (1949) and a commentary on Maimonides' *Sanctification of the New Moon* translated by Solomon Gandz (1956), in earlier years a contributor to *QS.* It is best to consider the paralipomena to *HAMA* by subject: Byzantine sources based upon Arabic in the astronomical terminology of Vat. gr. 1058 (1960)—later identified by Pingree as translations by Gregory Chioniades—and the commentary on the treatise in Paris gr. 2425 (1969), the treatise itself later published by Jones (1987). Arabic in the translations and analyses of two works on the motion of the eighth sphere and the length of the year attributed (at least one falsely, it now appears) to Thābit ibn Qurra (1962), and a large commentary on al-Khwārizmī's tables (1962) examining in particular their use of Indian methods. Indian astronomy itself in his commentary to Pingree's edition and translation of the *Pañcasiddhantikā* of Varāhamihīra (1970). Renaissance astronomy with Swerdlow in the analysis of Copernicus's *De revolutionibus* (1984).

The last subject Neugebauer took up was Ethiopic astronomy, chronology, and computus, that is, the ecclesiastical calendar. He had long been intrigued by the primitive astronomical section of the *Book of Enoch*, originally written in Aramaic and surviving complete only in Ethiopic (Ge'ez), which appeared to contain simple, or simplified, Babylonian elements, and also noticed from the catalogue of Ethiopic manuscripts in Vienna, passages that suggested a relation with Hellenistic astronomy and calendars. The question was, what was this material about, and was there more of it? Having initially failed to obtain the cooperation of any Ethiopic scholar, he learned Ge'ez himself—the only Semitic language that is not perverse, he called it (since it includes the vowels)—and began reading texts, originally as a respite from work on *HAMA*, compiling his own lexicon of technical terms as he went along. It turned out that the astronomical content was practically nil, but the otherwise unknown calendrical and chronological information preserved from late antiquity and the Middle Ages was very interesting indeed.

Chronology had in fact always been his third subject, in addition to astronomy and mathematics. Besides his negative contributions to Egyptian and Babylonian chronology and the unpublished manuscript on ancient chronology referred to earlier, he had collaborated with W. Kendrick Pritchett on *The Calendars of Athens* (1947), also in part a negative contribution, and analyzed the calendar of the *Très riches heures* for Millard Meiss (1974). Now he again took up chronology seriously. *Ethiopic Astronomy and Computus* (1979) is the summary of what he found, organized by subject in alphabetical order. There is much of interest here, but to name only the most significant result, he was able to reconstruct the Alexandrian Christian calendar and its origin from the Alexandrian Jewish calendar as of about the fourth century, at least two hundred years prior to any other source for either calendar. Thus, the Ethiopic sources carry our knowledge of these calendars back by at least two hundred years, and show how the Jewish calendar was derived, by combining the 19-year cycle using the Alexandrian year with the seven-day week, and then slightly modified by the Christians to prevent Easter from ever coinciding with Passover, which would be a very great sin. Neugebauer was amused to point out that the ecclesiastical calendar, considered by church historians to be highly scientific and deeply complex, was actually primitively simple.

He then published separately the astronomical chapters of the *Book of Enoch* (1981) in his own translation and commentary, both rather different from the literature on Enoch by Biblical scholars. Considerably more complex than either of the preceding was *Abu Shaker's "Chronography"* (1988), an analytical summary of a chronological and calendrical treatise by a thirteenth-century Coptic Jacobite originally written in Arabic. Abu Shaker used recent astronomical parameters and traditional calendrical cycles to compare various ecclesiastical calendars, Christian, Islamic, Jewish, and demonstrate that his own, that of the Copts, was the best. The treatise probably contains more technical information on these calendars than any other source, including the curious fact that the sequence of 29- and 30-day months is identical in the Jewish and Islamic calendars, showing that the Islamic calendar was derived from the Jewish by suppressing intercalation (in accordance with Muhammad's prohibition). Thus far, I know of no reaction to this discovery. Finally, in *Chronography in Ethiopic Sources* (1989), he assembled a great deal of chronographical information, that is, intervals between epochs and dates of events, mostly in tabular form. In all of these publications Neugebauer was concerned with purely technical matters of chronology and calendars; there is little on the underlying theological issues.

A few years after he came to this country, Neugebauer began to spend part of his time, periods of from a few weeks to a full term, at the Institute for Advanced Study in Princeton. In 1945/46 he was there with Sachs, he returned in 1949/50 and from 1950 for the remainder of his life was a long-term member, a continuous association of forty years, perhaps the longest at the Institute. Robert Oppenheimer, then director, had told him he would be welcome permanently any time he wished, but he preferred to remain at Brown and visit the Institute periodically. Over the years he formed friendships with members of the faculty and visitors, the longest and closest with Harold Cherniss, Ernst Kantorowicz, John von Neumann, Herman Goldstine, and Elizabeth Horton, secretary of the School of Historical Studies. He always found the variety of faculty and visitors at the Institute exhilarating, and following his retirement from Brown in 1969 and the death of his wife in 1970, he regularly spent several weeks there each fall and spring. Then, in the fall of 1984 he left Providence and moved permanently to the Institute, where he had many friends and colleagues and was soon joined by more. Marshall Clagett had since 1964 been a member of the faculty, as were Kenneth Setton and Christian Habicht, Harry Woolf was director, and Sandra Lafferty succeeded Elizabeth Horton as secretary; Kennedy, retired from Beirut, where political conditions had become difficult, moved to Princeton, as did George Saliba, a former student of Kennedy in Beirut, who worked in Arabic and had been a regular visitor to the Institute. Eliot Shore, the librarian, became a close friend, and Edith Kirsch, an art historian who had worked at the Institute for many years, came most summers. Through the courtesy of the Historical School, Swerdlow spent part of each year there, and a young philosopher from Hamburg, Gerd Grasshoff, who had seen the light and written a dissertation on Ptolemy, also became a frequent visitor.

These years, his late eighties, were good for Neugebauer, and much of that was due to the consideration of the faculty and staff of the Institute and its excellent conditions for continuing his work. He completed and published his books on Ethiopic chronology, wrote articles, and returned to an analysis of Kepler's *Astronomia nova*. Then in the summer of 1988 he received a photograph of a scrap of papyrus with numbers on it—hardly the first time—and immediately went to work deciphering its content. What he found was truly wonderful: a part of a column concerned with the length of the month from a Babylonian lunar ephemeris, known principally from tablets of the third and second centuries B.C., but here found in a Greek papyrus of the second or third century A.D. Since a single column is of no use by itself, the papyrus must once have contained several columns, if not a complete ephemeris for computing either the first visibility of the moon or the possibility of eclipses each month. This was the most important single piece of evidence yet discovered for the *extensive* transmission of Babylonian astronomy to the Greeks, and just as remarkable, for the continuing use of sophisticated Babylonian methods for four hundred years, even after Ptolemy wrote the *Almagest*, which, without the papyrus, would have seemed unbelievable. As he so often remarked, we know very little. The account of the papyrus was published in a memorial volume for Abe Sachs (1988).

He described the papyrus again in his last article, "From Assyriology to Renaissance Art," published in the *Proceedings of the American Philosophical Society* (1989). The paper is on the transmission of a single parameter, the mean length of the synodic month, from Babylonian tablets, to the Greek papyrus fragment, to the Jewish calendar, to an early fifteenth-century Book of Hours on which he was working with Edith Kirsch. Once again he wrote with the brilliance and perfect clarity of *The Exact Sciences* on the value of these sciences for demonstrating the relations of cultures over many centuries, but now also with the clearest possible statement that the ancient astronomers themselves were above all mathematicians:

> If astronomical phenomena had been considered since the earliest Mesopotamian period as celestial omina (or, in later periods, indicative of astrological facts) the authors of the *ACT* material ("Scribes" from the temples of Babylon and Uruk) dropped all these traditional connections and analyzed lunar and planetary motion in a strictly mathematical fashion comparable only to the approach of Hipparchus and Ptolemy.
>
> That the men who created this new science were fully aware of the revolutionary character of their approach cannot be doubted.

This, of course, is what he always believed, that mathematics does transcend its surroundings and belong to a world of pure science. I have no doubt that he was profoundly right.

Neugebauer was the recipient of many honors. He received his first honorary degree, the one he valued most, in 1938 from St. Andrews, where he had a splendid time and played the only round of golf of his life on the Old Course. Given the choice of degrees, he chose a Doctor of (both) Laws since he had studied neither Justinian nor Gratian. Doctors of Science followed from Princeton in 1957 and Brown in 1971. He was a member of the Royal Danish Academy, Royal Belgian Academy, Austrian Academy, British Academy, Irish Academy, American Academy of Arts and Sciences (resigned 1959), National Academy of Sciences, Académie des Inscriptions et Belles-Lettres, and other learned and professional societies. He received the American Council of Learned Societies' Award for Outstanding American University Professors in 1961, the Award for Distinguished Service to Mathematics of the Mathematical Association of America for his founding and editing of *Zbl* and *MR* in 1979, the American Philosophical Society's highest award, the Franklin Medal, in 1987, and in the same year Brown University's highest award, the Susan Culver Rosenberger Medal of Honor. For various publications he received the John F. Lewis Prize of the Philosophical Society in 1952 for "The Babylonian Method for the Computations of the Last Visibilities of Mercury," the Heineman Prize in 1953 for *The Exact Sciences*, the Pfizer Prize of the History of Science Society in 1975 for *HAMA*, and a second

Pfizer Prize in 1985. In 1986 he received the Balzan Prize of 250,000 Swiss francs which he donated to the Institute for Advanced Study.

A bibliography of Neugebauer's publications through his eightieth year by J. Sachs and G. J. Toomer, with his assistance, was published in *Centaurus* 22 (1979), 257–80. The number of additions since then is not small.

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