OBITUARY

NATHAN JACOBSON (1910–1999)

Nathan Jacobson, who died on 5 December 1999, was an outstanding algebraist, whose work on almost all aspects of algebra was of fundamental importance, and whose writings will exercise a lasting influence. He had been an honorary member of the Society since 1972.

Nathan Jacobson (later known as 'Jake' to his friends) was born in Warsaw (in what he describes as the 'Jewish ghetto') on 5 October 1910 (through an error some documents have the date 8 September); he was the second son of Charles Jacobson (as he would be known later) and his wife Pauline, née Rosenberg. His family emigrated to the USA during the First World War, first to Nashville, Tennessee, where his father owned a small grocery store, but they then settled in Birmingham, Alabama, where Nathan received most of his schooling. Later the family moved to Columbus, Mississippi, but the young Nathan entered the University of Alabama in 1926 and graduated in 1930. His initial aim was to follow an uncle and obtain a degree in law, but at the same time he took all the (not very numerous) mathematics courses, in which he did so well that he was offered a teaching assistantship in

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mathematics in his junior (3rd) year. This marked a turning point; he now decided to major in mathematics and pursue this study beyond College. During his final year at Alabama he applied for admission and financial aid to three top graduate schools in the country: Princeton, Harvard and Chicago. He was awarded a research assistantship at Princeton; after the first year he was appointed a part-time instructor for two years, and during his fourth year he was appointed a Procter Fellow. The stipend was enough to enable him to make a grand tour of Europe by car in 1935, in the company of two Princeton fellow-students at the time: H. F. Bohnenblust and Robert J. Walker.

Princeton during the 1930s was an exciting place for a mathematician, especially for a young man from Alabama. The Faculty included many distinguished mathematicians such as J. W. Alexander, A. Church, L. P. Eisenhart, M. S. Knebelman, S. Lefschetz, T. Y. Thomas, O. Veblen and J. H. M. Wedderburn; the latter was Jacobson's thesis adviser, the only algebraist on the Faculty. Mathematics PhDs at Princeton at the time included J. H. C. Whitehead, A. W. Tucker, S. C. Kleene, J. B. Rosser, N. E. Steenrod, A. M. Turing and many others who would later gain fame. Jake obtained his PhD degree in 1934, with a thesis on cyclic algebras [**1**], which he described by means of skew polynomial rings, which had only recently been introduced by Ore ⟨**6**⟩. His adviser Wedderburn's work on algebras without a finite basis ⟨**8**⟩ inspired some of Jacobson's later work on general associative rings [**31**–**34**].

About this time the Institute for Advanced Study came into existence. Hermann Weyl arrived in 1933 and gave several courses, including one on continuous groups. His assistant was to be Richard Brauer, but as he was unable to come until late in 1934, Jake was asked to fill the gap and wrote up the lecture notes for the first part of the course. Weyl in his lectures proposed an independent study of the 'infinitesimal groups', later known as 'Lie algebras' and suggested a 'rational' derivation of their properties (that is, without extending the base field). This formed the subject of Jake's first paper on Lie algebras [**4**]. Over the next three years he wrote on different aspects of Lie and non-associative algebras [**7**, **9**–**11**, **14**] as well as topological rings [**6**, **13**].

In 1935 Emmy Noether left Germany and took up a position as Professor at Bryn Mawr College, and once a week she came to the Institute to lecture on class field theory. At her sudden death in April 1935, Jake was offered a one-year lectureship at Bryn Mawr, his first full-time teaching experience. The following year he held a National Research Council fellowship, which he spent mainly at the University of Chicago working with A. A. Albert; later he returned to Princeton, which was regarded as a better vantage point for seeking a regular teaching position. His interest in Lie algebras continued; since the original classification of Lie algebras over the real and complex numbers by E. Cartan in 1894 there had been much research on Lie algebras over more general base fields and on the representation theory. Most of the simple Lie algebras studied were 'normal', that is, they remained simple under base field extension. In [**15**] Jake made a study of Lie algebras over arbitrary fields of characteristic zero, that were simple but not normal. Another interesting result, Morozov's theorem, the proof of which contained a gap, was given a correct proof in [**45**] (it is now known as the Jacobson–Morozov theorem), and an extension to Jordan algebras in [**61**].

This was still the time of the Great Depression; moreover, many US universities including some top-flight departments either had no Jews on the staff or placed a strict limit on their numbers. An exception was the University of North Carolina, where Professor Archibald Henderson, a Southern gentleman of the old school, hired Reinhold Baer, a recent emigré from Germany, as assistant professor and Jacobson as an instructor and arranged light teaching loads to allow them ample time for research. In addition to linear algebra [**16**, **17**, **21**] Jake turned his attention to Galois theory and adapted the methods of Artin and Baer to apply to skew fields (then called 'quasi-fields', see [**20**]). He also made a detailed study of restricted Lie algebras in [**22**–**24**]; a concrete form of these algebras had been defined by him in [**11**], but had hardly attracted any attention. It was at North Carolina that he wrote his first book: *The theory of rings* [**B1**]; this was a highly original account of various topics of current interest, such as the theory of modules and of algebras, but also a theory of general principal ideal domains which had not received a book treatment before. Here he also had his first doctoral research student, Charles L. Carroll Jr.

Soon after the United States was drawn into World War II, the Navy established a Pre-Flight School for training pilots on the campus of the University of Carolina, with the teaching duties carried out by the younger faculty members. Jake was 'Associate Ground School Instructor'; in 1942 he was granted leave by the Navy to marry Florence Dorfman, a mathematics student who was working for her PhD with A. A. Albert.

In 1943, when the Navy eliminated civilian instructors at the Pre-Flight School, Jake accepted a position as associate professor at Johns Hopkins University; the Chairman, F. D. Murnaghan was keen to hire an algebraist and the faculty included O. Zariski. Here he was to stay for four years, during which he wrote some of his most important papers. Chief of these was the structure theory of general rings. In 1942 Perlis had given a characterization of the radical in an algebra ⟨**7**⟩. Jake took this up in [**32**] and showed how it could be used to define a radical in any ring, making the quotient semi-primitive, and this notion is now generally known as the *Jacobson radical*. He also developed a general structure theory for simple rings with either minimal or maximal right ideals, using a natural topology, in [**31**]. At the same time he continued to work on field theory, investigating extensions of Galois theory to non-normal field extensions [**25**] and to purely inseparable extensions [**28**], and he continued to develop Galois theory for skew field extensions [**36**]. In the two years 1944–45 he wrote ten papers, many of which have had a lasting influence.

There had been some internal tensions in the department at Johns Hopkins and when in 1947 Jake was offered an Associate Professorship at Yale, he decided to accept this position, even though the President of Johns Hopkins, who appreciated the excellence of his undergraduate teaching, tried to keep him by offering him a full Professorship. This was the first time a Jew had been appointed to a tenured teaching position in the Mathematics Department of Yale University. He now turned his attention to Jordan algebras; these algebras had been introduced by Pascual Jordan in the study of quantum mechanics in 1933, but it was only in the mid-1940s that mathematicians turned their attention to them (cf. ⟨**1**⟩). Jake developed the representation theory of Jordan algebras in several papers [**37**, **38**, **41**], as well as a joint paper with his wife [**40**], and he often returned to this theme. In an amusing little note [**43**] he made a study of one-sided inverses; as in much of his other work, this is characterized by a very general approach, which however gives surprisingly detailed results. In 1956 he wrote an AMS Colloquium volume on ring theory [**B5**], which gave a modern treatment of the structure of rings, including many of the ideas he himself had introduced. Firstly there was the theory of rings without finiteness conditions, including the Jacobson radical. Then came his treatment of Galois theory of skew fields, in which the basic result has become known as the Jacobson–Bourbaki correspondence. Thirdly, there was an account of the results on Kurosh's problem ⟨**5**⟩: 'is every algebraic algebra locally finite?' In [**33**] Jake had used his structure theory to prove that any finitely generated semisimple algebra, whose elements are algebraic of bounded degree, has a finite basis and he had also shown how to reduce Kurosh's problem for nil algebras of finite characteristic to Burnside's problem. His structure theory and the method of linearization was used by Kaplansky ⟨**4**⟩ to prove that any primitive algebra satisfying a polynomial identity is finite-dimensional over a field. This and other work by Levitzki, Amitsur, Herstein and others received a clear and coherent treatment. This book (and its enlarged revision published in 1964) served as the bible for many algebraists. Another of his books that found wide acclaim were his *Lectures in abstract algebra* [**B2**–**4**], which appeared in 1951–64; it was intended as an introduction for students and soon became a standard reference work. Later, in 1974 and 1980, he wrote *Basic algebra* in two volumes [**B10**, **12**], another general introduction for a somewhat more mature audience. In 1962 his book on *Lie algebras* [**B6**] appeared, a clear and concise introduction to the subject, which also soon became a standard reference and which almost at once was translated into Russian and Chinese. When Zelmanov finally solved the Burnside problem, Jake was very excited, and was especially pleased that the proof used deep results from the theory of Jordan algebras, a subject that he felt was not fully appreciated. Though he did important work in associative algebras, his main interest was in the non-associative sort, which were not quite so mainstream, and this may account for the fact that he received the Steele Prize only in 1998. He had been elected a member of the National Academy of Sciences in 1954, and a member of the American Academy of Arts and Sciences in 1960.

I first met Professor Jacobson in 1952 in Paris and was struck by his relaxed and friendly manner. He listened with interest to my somewhat nervous account of my work and was most encouraging. Later, in 1960, when I wrote to him about my solution of a problem in his book ([**B13**], see ⟨**3**⟩), he wrote back inviting me to Yale, and during our year there in 1961–62, he did much to make me feel at home.

From 1971 to 1973 he was President of the American Mathematical Society and from 1972 to 1974 he was Vice-President of the International Mathematical Union; at their meetings he had to argue strongly with L. S. Pontrjagin, who had expressed anti-Semitism; he won the argument that speakers for the International Congress should not be chosen by National Committees, but unfortunately this did not help Russian Jewish mathematicians.

He was to remain at Yale for 34 years, becoming in turn full Professor in 1949, James E. English Professor in 1961, Henry Ford II Professor in 1963 and Department Chairman in 1965. His relaxed personality helped to make it a very congenial but also productive department. During his time at Yale he had 32 doctoral students, many of whom would later become professional researchers. He also developed the theory of Jordan algebras further in a number of papers; a connected account appeared in his Tata Institute Lecture Notes [**B8**] and in his AMS Colloquium volume on Jordan algebras [**B7**], which soon became a standard reference on the subject. For his retirement in 1981 a conference in his honour was held at Yale, where algebraists from many countries met; their work was published in an AMS volume *Algebraists' homage* ⟨**2**⟩. Over the years he was invited to many universities all over the world; besides many US universities his visits included France, Germany, Switzerland, Turkey, Russia, India, China, Japan and Australia.

His activity continued, with a study of generic norms in associative and Jordan algebras [**79**, **80**] which he had introduced for Jordan algebras in [**63**], and he wrote a number of expository papers on PI-algebras [**B11**, **12**, **13**], on Emmy Noether's work [**E15**, **16**] and on generic norms [**E20**, **21**]. In 1989 a collection of all his papers was published in [**B14**]; this included a detailed account of his life and work, extending to over 110 pages, which he had specially written for this purpose. His last book, on division algebras [**B15**], appeared in 1996: a beautifully clear account of the subject, using skew polynomial rings to simplify the presentation, going into detail over p-algebras and simple algebras with involution and taking account of much recent work.

In 1992 he suffered a stroke and was confined to a wheelchair; he still kept his *joie-de-vivre*, but these were difficult times; his wife died in 1996, a great blow since they had been completely 'a team'. However he recovered his spirits and spent his last years listening to music and he often enjoyed company and telling stories, especially about mathematicians. They had a son and a daughter, who is now a professor of linguistics.

In writing this note I have been greatly helped by notes on which his account in [**B14**] is based, which Jake sent me a few years ago ('A personal history'). I have also had help from his daughter, Polly Jacobson, and some of his colleagues and former students: Walter Feit, George Seligman, Earl Taft, Kevin McCrimmon and Carl Faith. My warmest thanks go to all of them.

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