The Review of Modern Logic
Volume 10 Numbers 1 & 2 (September 2004–February 2005) [Issue 31], pp. 117–129.

Anita Burdman Feferman and Solomon Feferman
Alfred Tarski: Life and Logic
Cambridge and New York: Cambridge University Press, 2004
vi + 425 pp. ISBN 0521802407

REVIEW

IRVING H. ANELLIS

In historical writings since at least the days when Herodotus of Halicarnassus (see [13]) sought to account for the Greek victory over the Persians at Salamis and Thermopylæ and determine what were the causes and significance of that war, political history has been the primary subject; and the chief focus has largely, if not exclusively, been laid upon the "great" man or "hero" and the "great" deed, especially the handful of kings, emperors, generals, and statesmen, who "made" history. We may hold emblematic of this approach to history the stele erected to describe Egyptian pharaoh Ramses II's virtually single-handed defeat of the Hittite army at Kadesh, Syria, in 1296 B.C., after Ramses's army abandoned him in the field—despite the fact that history, and the peace treaty which the Hittite king offered soon after the engagement, records the battle as a "draw", if not as an outright Egyptian defeat.

Biography as such developed in the Alexandrine or Hellenistic period, an outgrowth at once of both the hero-worship that attached to Alexander the Great and of the encouragement of philosophical reflection and self-analysis that developed with Socrates and Plato, the teacher of Alexander the Great's tutor Aristotle. Indeed, it was Aristotle's nephew and student Callisthenes of Olynthus (d. 327 B.C.) who inaugurated the field of biography, traveling across Africa and Asia with Alexander as Alexander's official historian (see [12], esp. pp. 374-379, p. 550, n. 36).

In intellectual history, this trend was confirmed by writers such as Plutarch, who, in such treatises as the *Lives of the Seven Wise Men*, of classical Greece (see [31]), took as its primary focus the "great" men and "great" ideas of ancient history, and found further expression in

the *Lives of the Philosophers; De clarorum philosophorum vitis, dogmatibus et apophtegmatibus* of Diogenes Laërtius (see [6]). We should hardly be surprised if, as a consequence, intellectual biography found a ready place in the accumulation of the treatises pertaining to the history of mathematics. Examining the period as late as the mid-twentieth century, when for nearly a century political historians began to turn their attention to broader issues such as economic and social history, J. E. Hoffmann was still concerned, in his works on the history of mathematics of the seventeenth and eighteenth centuries, to claim priority for Leibniz over Newton in the discovery of the calculus (see, *e.g.* [15]), in consonance with the "great" men, "great" ideas approach to the history of mathematics. By this time, it already was, or should have been, plain, from the vast amount of material included in Felix Klein's voluminous *Vorlesungen über die Entwicklung der Mathematik im 19. Jahrhundert* [17] that a "great" man, "great" theorems approach must be inadequate for a thorough and unified account of the history of mathematics Yet it continued to persist, in such works as William Dunham's [7] episodic history *Journey Through Genius: The Great Theorems of Mathematics*, which—as its title indicates—unapologetically and unabashedly takes this approach, and especially B. L. van der Waerden's famous [40] but patently "whiggish" history of algebra from al-Khwarizmi to Emmy Nœther.

We should not be surprised at the rising tide of popularity of biographies of mathematicians (and logicians) in our day, as biographies of Galileo and Newton have already been popular for centuries past. Perhaps the motive is to discern, by examining the lives of these great minds, how they functioned, what secrets of personality, education, or behavior, led them to their brilliant intellectual achievements. Or, in the case of writers such as Eric Temple Bell in his [3] *Men of Mathematics*, Jane Muir in her [30] *Of Men & Mathematics: The Story of the Great Mathematicians*, and Herbert Westren Turnbull's [39] *The Great Mathematicians*, the purpose was to stimulate interest in mathematics through biographies of singular and noted mathematicians, and to thereby encourage the neophyte or prospective neophyte that there is nothing inherently 'peculiar' about mathematicians. Writers such as Bell and Muir, however, went to the opposite extreme, seeking the glamorous in the lives they portrayed; and as historians of mathematics have long been wont to complain, Bell preferred a "good story" to an accurate account, if such a choice was to be had; like Plutarch's account of Pythagoras, myth and history are melded together in some

of Bell's narration, while Muir and Turnbull rely extensively upon secondary sources, rather the way Plutarch relied upon hearsay and the accounts of earlier writers.

Although biographies of individual mathematicians (and logicians) latterly have been considerably more 'professional'—meaning that their authors endeavor to conform their narratives to the facts—than have the aforementioned collected biographies such as those purveyed by Bell and like-minded colleagues, many yet select as their subject those of a 'romantic' personality and focus on the unique, colorfully picturesque, or adventurous aspects of their personal lives; I have in mind here, by way of example, Don Kennedy's [16] *Little Sparrow*, in which Sonya Kovalevskaya is the dainty romantic who enters a marriage for purposes of leaving the family nest in order to gain independence pursuant to a career in mathematics and is divided, as an adult, between literature and mathematics, an image, incidentally, which Kovalevskaya promoted for herself (see [18]); and Anita Burdman Feferman's [8] biography of Jean van Heijenoort, whose work in logic comes across to her readers as a mere counterpoint to his cloak-and-daggeresque adventures as a member of the revolutionary entourage of Leon Trotsky, enhanced by his James-Bondish personality and movie-star good looks. (I except, as belonging to an entirely different class, all the necrologies and memorials, of various lengths, that dot the pages of professional journals, the intentions of which are to encapsulate for their peers the intellectual achievements of deceased mathematicians and to elucidate the influences which they and their work have had upon their colleagues and on the field.)

Among serious, professional biographies of mathematicians, we may count the late Walter Kaufmann Bühler's [4] of Gauss, the end product of a long-term research project by the dean of Springer Verlag's mathematics editors. Turning to biographies of logicians, John William Dawson Jr.'s treatment of Gödel [5] is the first unified and systematic effort to provide an integrated portrait of both the man and his work. Dawson, who catalogued the Gödel *Nachlaß* and then served as a member of the team that published Gödel's collected works, provided a sympathetic yet balanced portrait of Gödel's life, while integrating into that account an exposition of the historical background to, and conceptual development of, Gödel's own contributions to mathematics, and especially logic and set theory, and philosophy. Only by reading Irving Anellis's [1] exposition of Jean van Heijenoort's intellectual biography *in concert with* Anita Feferman's [8] life biography of van Heijenoort, would one approach the effort undertaken by Dawson in his life of Gödel. That this is the case, despite the brief "Appendix: Jean van

Heijenoort's Scholarly Work, 1948-1986" [10] by Solomon Feferman to Anita Feferman's biography, renders the Feferman biography of van Heijenoort closer in spirit to Kennedy's biography of Kovalevskaya than to Dawson's biography of Gödel.

Now, however, the efforts of the husband and wife team of Solomon and Anita Feferman have come together to bring us an integrated, all-encompassing and rounded intellectual and personal biography of Solomon Feferman's teacher Alfred Tarski, an affectionate but honest portrait, warts and all, of the man and the mathematician who influenced the direction of several generations of logicians working in logic, most especially in algebraic logic, universal algebra, and model theory, as well as to their applications to foundations, and of philosophers working in semantics and the theory of truth. Tarski molded the shape and direction of the development of these fields, serving as a pioneer himself in formulating the problems of a significant portion of logic that had lain most nearly dormant, if not entirely defunct, with the retirement from active research of Charles Peirce and the death of Ernst Schröder and the subsequent revival of logic, along entirely different lines at the hands of the Russell of the *Principia Mathematica*. Tarski brought renewed vigor to the algebraic approach to logic that had during the periods between the First and Second World Wars yielded to Frege and Russell's logicism and the function-theoretical approach.

It is obvious that Anita Feferman is an excellent writer with a well-honed capacity to capture the personality of her subject, the subject's relation with his environment and with the social world in which he moves, as was demonstrated also in her treatment of van Heijenoort and of Georg Kreisel [9]. In many ways, Tarski's relations with others could be seen as *très outrés*, not unlike those of Kreisel; he was known to impose himself upon his female students, to take drugs, and to be imperious towards his doctoral students, expecting them not only to live up to his expectations of them as mathematicians, but to accommodate their lives and working habits to his, on occasion assigning them extracurricular tasks which had little to do with their own research but with his own. In the case of the logicians who have been the foci of her narratives, her personal acquaintance with her subjects, established through social interaction with them through her husband's collegial connections with them, vastly enhances the depiction.

Solomon Feferman, himself a doctoral student of Tarski's, and a "star" in his own right in the logical firmament, best known for his work in metamathematics and, more lately for his turn towards history of logic, exemplified by his service as editor-in-chief of the *Collected Works of Kurt Gödel* [11], brings to this biography of Tarski an acquaintance

with Tarski and many of the other figures involved in Tarski's personal and professional life, and, more importantly, a deep knowledge of the mathematics in which Tarski and his students worked. In succinct and lucid expositions characterized as "interludes" interspersed throughout the biographical narrative as separate chapters, Solomon Feferman deftly provides straightforward technical accounts of the most significant aspects of Tarski's mathematical achievements, as well as those of his students and collaborators, and provides historical background to the problems which Tarski undertook. This is all done so well that any well-educated logician can comprehend Feferman's exposition and appreciate the merits and significance of Tarski's work. It is done so well that, taken together with Anita Feferman's biographical narrative, we have an integrated and flowing account of the evolution of Tarski and his work, of Tarski the man and of Tarski the mathematician.

Indeed, I would have only three very minor quibbles with the present work, each relating to comparatively obscure and insignificant omissions that I should like nevertheless to have seen dealt with.

(1) Although Henryk Hiż [Henry Hiz] has been interviewed by Anita Feferman for the Tarski volume, the particular insight which he offered (see [14]) on the study of algebraic logic, and especially of the regard with which Charles Peirce's work was held by Tarski and his teacher Jan Łukasiewicz, at the University of Warsaw while Tarski was Łukasiewicz's student there, was left unused, despite the fact that Tarski himself recorded the significance of the work of Peirce and Schröder. Thus, in the years when he first began his own work on the calculus of relations, Tarski wrote in "On the Calculus of Relations" [36, p. 74] that, for all the suggestive problems and open questions that they left behind, he found it "amazing that Peirce and Schröder did not have many followers." This same point was reiterated by Tarski and his co-author Steven Givant, in the note in their preface [38, p. xv] to Tarski's culminating work *A Formalization of Set Theory without Variables*, that Tarski's initial inspiration originated in and answers the question posed by Schröder in his *Vorlesungen über die Algebra der Logik* [34, p. 551], of whether all elementary statements about relations are expressible as equations of the calculus of relations. Thus, the authors state that the mathematics of their book [38, p. xv] is "rooted in the calculus of relations...that originated in the work of A. De Morgan, C. S. Peirce, and E. Schröder during the second half of the nineteenth century". By way of illustration: a centerpiece of "On the Calculus of Relations" is Tarski's proof ([36, pp. 86–89]) of Schröder's metalogical theorem [34, p. 153] that: *Every sentence of the calculus of relations*

can be transformed into an equivalent equation of the form "R = S," and even of the form "T = 1" (see also [2, p. 299]).

(2) In his review of the corrected second printing of Jean van Heijenoort's [41] anthology *From Frege to Gödel*, Gregory H. Moore [28] noted the absence of any contribution of any of the significant algebraic logicians of the period (1879-1931) covered by the anthology, and he considered this gap in the coverage a defect. Moore also indicated that van Heijenoort seriously considered the inclusion in the volume of some work of Tarski's, but also suggested that van Heijenoort changed his mind. Willard Van Orman Quine [32] (see also [1, p. 104]), however, recalled that van Heijenoort had very much desired to include some work of Tarski's, but had been constrained by Tarski himself, who feared that the inclusion of one of his works in van Heijenoort's volume would infringe upon the copyright of his own [37] *Logic, Semantics, Metamathematics*. In their discussion of John Corcoran's work on a second (1983) edition of *Logic, Semantics, Metamathematics*, we have only the enigmatic statement by the Fefermans (p. 366) that Tarski "had had disagreements" with Oxford University Press concerning the first edition. It would indubitably help clarify both the personal and historical issue relating to van Heijenoort's and Tarski's decisions to include or exclude a contribution of Tarski to *From Frege to Gödel*, and to the historiographic questions arising from the decision and its rationale, were it possible to have testimony upon the matter from Tarski's perspective.

(3) In a consideration of Łukasiewicz's work on many-valued logics, we find that there evidently was some question in the past about the role of Tarski in the development of multiple-valued logics and the connection of Tarski's work to Łukasiewicz's. In a letter of 17 April 1977 to Michele Malatesta of the University of Naples (and reprinted in the journal *Metalogicon*, of which Malatesta was the editor), Łukasiewicz's widow Regina Łukasiewicz [27, p. 54] asserted[1] that Joseph Henry Woodger, who compiled and edited the original edition of Tarski's collection of papers [37], Ludwig Wittgenstein, and Clarence Irving Lewis "falsified" the history of multiple-valued logic "and ascribed the multi-valent logic to Tarski from the work of Jan Łukasiewicz *Untersuchungen über den Aussagenkalkül.* {1951}." She went on to complain, presumably referring to the two editions [19, 21] of Lewis's *Survey of Symbolic Logic*, his "Note Concerning Many-Valued Logic Systems"

[1]Regina Łukasiewicz's handwritten insertions into the original typescript of her letter to Malatesta are enclosed here within curly brackets, { , } . The original spelling errors, grammatical construtions, and punctuation—and lacks thereof, of her letter are here left uncorrected.

[20], Łukasiewicz and Tarski's famous [26] "Untersuchungen über den Aussagenkalkül", and Woodger's edition of Tarski's *Logic, Semantics, Metamathematics* [37], that:

> Prof. C.J. Lewis of Harvard University of USA made a mistake in his textbook and atributed unjustedly to Teitelbaum-Tarski my husband's discoveries of three and multivalent logic. Lewis corrected it in a Reprint from the Journal of Philosophy Vol.XXX.No 13 June 22.1933 but nobody knows that such a note exists. He did not correct it in his textbook and that mistake circulates among the young and old scientists in the whole world.
>
> The book of Tarski appeared in 1956 after the death of my husband and there was a footnote of my husband explaining that Jan Łukasiewicz is a sole creator.
>
> My husband strongly protested in Oxford against the falsification of prof. J.Woodger from London; prof.Lewis from Harvard University USA and Witkenstein from Cambridge and demand that it is corrected and returned according to the text of the original german work A note was inserted and it was corrected.
>
> [...]
>
> After reading the footnote of Woodger and Tarski it makes an impression of a dirty trick. They waited on the death of my husband for 5 years until the book of Tarski appeared.

The problematic footnote, appearing at [37, p. 38, n. ‡], to which Mrs. Łukasiewicz evidently referred in her letter to Professor Malatesta, it should be pointed out, directs readers to Lewis's [20] correction, and Mrs. Łukasiewicz adds in her letter that "in spite of" this correction, the mistaken joint ascription still persists, and she therefore states categorically that "the many-valued logics" treated in "Untersuchungen über den Aussagenkalkül" "are entirely due to Łukasiewicz alone and should not be referred to Łukasiewicz and Tarski." Moreover, Tarski tells us explicitly (at [37, p. 40, n. 2]) that "Łukasiewicz was...the first to define by means of a matrix a system of the sentential calculus different from the usual one, namely, his three-valued system" and again (at [37, p. 47, n. 2], referring to [23, 24, 25] respectively), that

> [w]hat is called the *three-valued* system of the sentential calculus was constructed by "Łukasiewicz in the year 1920 and described in a lecture given in the year 1920 to the Polish Philosophical Society in Lwów. A report by

> the author, giving the content of that lecture fairly thoroughly was published in the journal *Ruch Filosoficzny*, vol. 5 (1920), p. 170 (in Polish). A short account of the n-valued systems, the discovery of which belongs to the year 1922, is given in [24, pp. 115 ff.]. The philosophical implications of n-valued systems of sentential calculus are discussed in the article of Łukasiewicz, 'Philosophische Bermerkungen zu mehrwertigen Systemen des Aussagenkalküls'....

One may perforce have to take at least some of Mrs. Łukasiewicz's accusations *cum gran salis*, however, since she also asserted, in that same letter to Malatesta, but without supplying either example or evidence, that Tarski disseminated political slanders regarding her husband.

So far as background to antipathy between Tarski and his former professor, the Fefermans (pp. 41, 102) trace it to the anti-Semitism of the 1930s, when neither Łukasiewicz nor Stanisław Leśniewski would invite Tarski to sit at their table in the café. From the account given by the Fefermans (pp. 100- 102), it would not be far-fetched to infer that Leśniewski in particular was ouspokenly vituperative in his anti-Semitism and in his animosity in particular towards Tarski, and moreover (p. 101) probably suspected Tarski of plagiarizing the work of others. Whether this view was fully shared in all its ramifications by Łukasiewicz himself is problematic; but Regina Łukasiewicz's letter, taken at face value, makes it likely that, at the minimum, Łukasiewicz expressed, if only privately, a belief that Tarski was prone towards, if not guilty of plagiarism. The sensitive portrait given by Jan Woleński [42] of the congeries of personal, social, cultural, and intellectual milieux in the life of logic in Poland from 1900 to 1939 and in which Tarski lived, studied and worked in this period bears directly upon an appreciation of many aspects of this situation, and would have been well worth at least a cursory consideration by the Fefermans in dealing with this aspect and period of Tarski's life and career.

Nevertheless, in virtue of the sensitivity which Tarski had shown on matters of priority and the assignment of credit for results, and the history of his relations with his teacher, as narrated by the Fefermans, this is an issue, it is reasonable to suppose, with which Tarski would have wanted to deal. Since, as the Fefermans assert, Tarski himself was always scrupulous in his own work in assigning credit to others for their work, and was a stickler as well in demanding proper credit from them for his work, it is owed Tarski that this matter be clarified, insofar as circumstances permit.

Moreover, if Madame Łukasiewicz could find something sinister in the fact that Woodger and Tarski "waited" five years from the death of her husband to publish the collection of Tarski's papers, one might in the same vein ask why she waited twenty-one years to publish her complaint, and in a comparatively obscure journal at that.

Consider the information that it was, as the Fefermans (p. 194) noted, in 1950 that Woodger and Tarski agreed, while Tarski was on a visit to Oxford, to undertake the publication of the collection of Tarski's papers which became Tarski's *Logic, Semantics, Metamathematics* [37], and that Łukasiewicz personally protested, already that very same year, according to Madame Łukasiewicz, regarding the offending footnote—which in fact ascribes credit to Łukasiewicz, not to Łukasiewicz *and* Tarski. If Madame Łukasiewicz is correct in claiming that her husband saw the offending footnote when Tarski and Woodger were just beginning to plan the volume and to select the papers for inclusion, that suggests, at the very least, that he was privy to the planned contents of the work from the start. With *whom*, then, did he lodge his objections, and what were the nature of his objections? Madame Łukasiewicz's account seems to be confused at best.

Consider too that the *Logic, Semantics, Metamathematics* appeared in print in 1956, while Jan Łukasiewicz died on 13 January 1956. There is something obviously discordant about Madame Łukasiewicz's claim that Woodger and Tarski "waited...for 5 years" until the book appeared, unless she meant to suggest that it was actually ready for publication in 1951, and was withheld from publication until after Łukasiewicz died simply so that an apparently offending footnote could be foisted upon an unsuspecting world. But the footnote [37, p. 38, n. ‡] makes it clear that reference must be had to Lewis's 1933 correction, while additional footnotes ([37, p. 40, n. 2] and [37, p. 47, n. 2]) duly credit *Łukasiewicz alone* for devising trivalent sentential logic and the matrix system used for defining that logic.

Finally, it is evident from nearly everything written on the history of multiple-valued logic, Madame Łukasiewicz's express concerns to the contrary, that Jan Łuskasiewicz has always been given full and unstinting credit for his pioneering contributions to that field. For example: Like so many histories, Nicholas Rescher's [33] declares that the true origin of many-valued logic is to be located in Łukasiewicz's [23] article on three-valued logic; while Peter Simons [35, p. 251] noted that Łukasiewicz first mentioned three-valued logic in a talk which he gave in 1918 (which was published as [22]).

If then, we set aside the the underlying and vaguely generalized expression of suspicion in Madame Łukasiewicz's letter, the closest we

have to any clue that Tarski might have given the impression that Łukasiewicz's work in multiple-valued logic had anything to do with him that one can find in the account by the Fefermans concerns Tarski's lectures in February 1930 to the Mathematics Colloquium in Vienna organized by Karl Menger, at which "Tarski presented various results concerning the sentential calculus that were the distinctive product of researches in Warsaw, including work that he had done on Łukasiewicz's three-valued logic" (p. 81). As stated by the Fefermans, there is, however, nothing to indicate that Tarski did not distinguish his own contributions to trivalent logic from Łukasiewicz's, and nothing to suggest that Tarski claimed or sought to claim credit for Łukasiewicz's work in whole or in part. Thus, the mystery embodied in Madame Łukasiewicz's claims, and her impugning of Tarski's (and others') miscreance in her letter in *Metalogicon*, remains. We can, at most, speculate that some undisclosed personal animosity towards Tarski was at work, perhaps originating in the anti-Semitism, detected by the Fefermans, that Jan Łukasiewicz expressed in Warsaw in the 1930s. But, so far as the documented historical record indicates, there is little to support Madame Łukasiewicz's assertions that Tarski, rather than her husband, is credited for pioneering work in multiple-valued logic. Either she has misunderstood the entire situation, or she has puposefully (?) ignored the import of the relevant footnotes crediting her husband with the development of trivalent logic to some ulterior (?) purpose of discrediting Tarski.

Whether or not the views expressed in the letter by Madame Łukasiewicz were those of Łukasiewicz himself, we owe it to the principals—Tarski and Łukasiewicz—and for the sake of history and their reputations, to clarify the issue, if not resolve the dispute and remove, by validating or invalidating, the imprecation.

I do not know whether the Fefermans were in a position to deal, definitively or otherwise, with these three issues; or if so, whether they chose not to raise them, either considering them as of scant significance (*e.g.* (2)) or as unconditionally scurrilous and utterly unworthy of serious attention (*e.g.* (3)). Personally, I should like to have seen them dealt with, for the reasons which I indicated.

In every other respect, however, the Fefermans clearly did their homework. They have produced a remarkably full and supple portrait of Tarski the person, Tarski the professor, and Tarski the logician, of his influence upon his students and colleagues and of the significance of his work; and they clearly went to great lengths to ensure the accuracy of the information which they presented.

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