Laura Toti Rigatelli. *Evariste Galois 1811-1832*. Boston: Birkhäuser 1996. Pp. 162. ISBN 0-8176-5410-0.

No story from the history of mathematics has so stirred the imagination and passions of mathematicians and scientists the world over as that of Evariste Galois, the 19th-century boy mathematician who was killed in a duel at the age of twenty. So extraordinary is the tale of Galois' brief life that its fame has spilled beyond the realm of the sciences to provide inspiration for a dozen novels, plays and films. Much of the fascination with Galois undoubtedly stems, not only from the tragic nature of his story, but with it alluring incompleteness. Galois did not live long enough to leave a biographical memoir and, at the time of his death, he was yet to be celebrated as a mathematician. Rather, details of his life, and especially of his death, have been passed from generation to generation by rumor, conjecture and even falsification until the Galois known today is largely a legendary character.

Most scientists, to use the term generally, become aware of at least the vague outlines of the legend during adolescence. Evariste Galois was born in the outskirts of Paris in 1811 during the waning days of the Napoleonic empire and came of age during the conservative Bourbon restoration. Sent to a preparatory school as he turned thirteen, within two years his mathematical genius ignited, and once it did he quickly began to neglect his other subjects. Evariste's teachers, misunderstanding his talent, forced him to repeat a year. He twice failed his entrance exams to the celebrated École Polytechnique, where he planned to attend college, the second time hurling an eraser at his dim-witted examiner. Forced to attend the less prestigious École Normale, Evariste, the son of liberal parents quickly found himself at odds with the school's conservative administration. At the same time he began submitting papers to the French Academy, which were lost or thrown

away or pronounced incomprehensible by Cauchy, Fourier and Poisson in turn. Fed up with such ill-treatment, which coincided with the Revolution of 1830, Galois joined secret societies dedicated to the overthrow of the government of Louis Phillipe and was consequently expelled from school. For seditious activities he was imprisoned, twice, and shortly after his second release was lured into an affair of honor by a prostitute or an agent provocateur or both. On the night before the duel, realizing that he might well die at sunrise, Galois wrote out or even created the theory of groups, scribbling time after time in the margins of his papers, "I have not time! I have not time!" The words proved prophetic: The following morning Galois was mortally wounded by his adversary and died the next day in the arms of his brother, Alfred. Alfred and Evariste's best friend, Auguste Chevalier, would circulate the manuscripts for fourteen years until Liouville, convince of their importance, published them. And thus Galois theory (which determines the conditions under which any equation can be solved algebraically) and along with it group theory —which has become central to the subsequent development of mathematics and physics— was born.

These are more or less (probably more) the details of the legend as scientists tell it, or did tell it, until recent years. In this case the source of the legend can be fairly accurately pinpointed: the scientists themselves. The most widely read version of the Galois story was, and conceivably remains, the chapter "Genius and Stupidity" in mathematician E. T. Bell's famous collection *Men of Mathematics* [1937]. Bell, who also wrote science fiction under the pseudonym John Taine, was not one to let facts get in the way of a good story and he did not hesitate to interpret, invent and even invert the historical record. Nevertheless, most scientists, lowering their customary standards of rigor, swallowed Bell's story whole. Bell evidently inspired other scientists to write about Galois. Physicist Leopold Infeld [1948] wrote what would nowadays be called a work of "faction" —a novel that purported to adhere to the known facts, and astrophysicist Fred Hoyle [1977] also penned a shorter study on Galois [1896], which in embellishing Bell's version went beyond any bounds of plausibility.

At the same time, however, scholars were doing serious work on Galois. Over one hundred years ago, the Surveillant General of the École Normale, Paul Dupuy, wrote [1896] a biography of Galois that remains accurate, given the documents that were available at the time. In our own century, the French historian of science, René Taton, unearthed some evidence that the Academy was not quite so dismissive of Galois as had been previously thought: Cauchy himself had planned to present

one of Galois' memoirs before the Academy in early 1830 but for some reason did not. (In any case, at the age of 17, Galois was publishing in the prestigious *Bulletin de Ferrusac*, and was known to other mathematicians). Months later Poisson did reject Galois' most important manuscript, but encouraged him to rework and resubmit it. C. A. Infantozzi managed to track down the indentity of the mysterious 'coquette' who was responsible for Galois' demise, and she turned out to be a figure no more exotic than the daughter of the resident physician at the clinic where Galois spent his final days after release from prison. The duel? André Dalmas in his biography of Galois published a report from the newspaper *Le Precursuer*, written only a few days after the event, which indicated that it was hardly a duel, at all, but something more like Russian roulette, in which Galois and a friend, L. D., were each given a pistol, but only one was charged. Political intrigues evidently played no role: It appears that Evariste and L. D. both fell in love with Stephanie, the doctor's daughter, and decided to resolve the matter in the traditional fashion. Judging from Stephanie's letters, she found herself in a difficult position and wanted nothing more than to get out of it.

It should be understood that many of the pertinent documents had been known since the beginning of the century and certainly since 1962, when the definitive collection of Galois' manuscripts was published by Gauthier-Villars in the edition of Robert Bourgne and J. P. Azra [1962]. Galois' scholarship, at least on this side of the Atlantic, would have been considerably more advanced had someone translated Dupuy's original biography and had note been taken of the supporting documents. However, scientists evidently preferred the mythological version, and it fell to myself, in an article [1982, 1989] to consolidate the historical evidence then available.

Now Italian mathematician Laura Toti Rigatelli has taken the historical line of work one step further. Carefully researched, Rigatelli's book fleshes out the historical context in which Galois lived and presents fuller portraits of the supporting cast than previous works. We learn more about Galois' parents: about Louis-Paul-Emile-Richard, the gifted mathematics instructor who not only encouraged Galois, but who taught many other famous scientists, including the future astronomer Le Verrier, who discovered Neptune; about Francois Vincent Raspail, the famous botanist and Republican who was imprisoned with Galois and whose letters provide the primary source for Galois' months in prison. Even M. Gaugniault, director of the École Normale, who expelled Galois for his impudence, gets a fair hearing. Contemporary

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paintings and photos of many of the sites and personages in the story help convey a vivid sense of the times. A particularly useful chapter is the last, on the mathematical work of Galois, in which Rigatelli goes through Galois' memories, explaining them step by step and pointing out why they were —and remain— so difficult to read. It is the most complete exposition of his original work that I know of. (This chapter, however, will be of interest only to professional mathematicians or advanced students, for it is highly technical.) The best bibliography available on Galois references rounds out the package.

However, there is here perhaps slightly less than meets the eye. It is in fact in filling out the historical context in which Rigatelli excels: about Galois himself there is actually not terribly much new to be found between these covers. After all, he lived only twenty years and ended his life more famous as a Republican than a mathematician, in all probability, most of the relevant documents have already been unearthed. For example, the chapter "The Three Glorious Days", concerning the July Revolution of 1830, is over twenty pages long, but Galois' role in these events consisted of failing to scale the walls of the École Normale to join his comrades on the barricades. To understand Galois' expulsion from school six months later and his subsequent political activities, it is important to have an idea of the political climate of the times; however, this chapter is too short to be a comprehensible history of the revolution and too long to be about Galois. Indeed, Rigatelli seems to play down the difficulties of Galois' character compared to previous authors. She quotes a portion of a letter by mathematician Sophie Germain to her colleague Guglielmo Libri: "[...] he has kept up his capacity for being rude, a taste of which he gave you after your best lecture at the Academy". What is missing here is the conclusion of Germain's letter: "They say he will go completely mad and I fear this is true" [Rothman, 1982, 1989].

At the risk of sounding proprietary, however, it does seem to me that regardless of the considerable merits of Rigatelli's book, or of any disagreements in approach, there has been a breach of the scholarly contract. There can be little doubt that her's is meant to be a scholarly work; it is the eleventh volume of a series whose previous subjects have included Heinrich Heesch, Johannes Faulhaber and Friedrich Bessel, hardly household names to nonmathematicians. Nevertheless, in the first place, Rigatelli's book contains no index, which is extremely inconvenient. In the second place, there is a complete lack of footnotes. Given that the name of the series editor appears before that of the author, it is unclear whether this was an authorial or editorial decision,

but the lack of citations represents more than a mere inconvenience. Left to his own devices, any scholar naturally tends to credit himself more than is warranted. But as Galois himself would agree, scholarship tends to advance incrementally, each investigator adding whatever small contributions he can. In the present case, we witness a complete dismissal of previous Galois scholarship. As a result, the author is able to repeatedly claim credit for 'new' discoveries, which are not new at all. "It is worth deflating the legend of an entirely misunderstood Galois" [p. 49], Rigatelli writes, when René Taton, and the present author as well, took pains to deflate it several decades ago. Astonishingly, about the famous Preface to his memoirs in which Galois unleashes a tirade of insults at the Academy for its treatment of him, we read, "[The Preface] makes for fascinating reading [.] but it has been kept out of print for a long time by the scientific establishment" [p. 100]. This Preface, in fact, was printed with some omissions by Infeld fifty years ago, as much as space permitted was published in my own article and the full text has been available in Bourgne and Azra since 1962 [p. 3-12]. One can hardly accuse the establishment of censorship. Indeed, as far as I can tell, none of the documents in Rigatelli's account appears for the first time. It is perhaps telling that the only earlier biographers of Galois that Rigatelli explicitly mentions in her book are Bell and Infeld, authors of the two most disreputable accounts.

The lack of citations has a more immediate effect than the incitement of priority disputes: it deprives the reader of the right to understand the source of the author's interpretations and conclusions. And be assured, this is interpretive history. For example, Rigatelli repeats the story about Galois throwing the eraser at his examiner. However, the primary source for this story, insofar as I know, is Joseph Bertrand's commentary on Dupuy's biography, and Bertrand states that the story is false. If Rigatelli has new information on this episode, she should tell us, but she does not.

Along the same lines, she writes [p. 41], "Since Cauchy's nomination as a fellow of the Academy in 1816, he had only presented the results of his own research, with only one exception. This explains the astonishment of the fellows of the Academy, when Cauchy presented Galois' memoire entitled 'Researches algébriques,' on 25 May, 1829". It is true that Cauchy 'presented' Galois' manuscripts to the Academy on 25 May and June 1 of that year. However, he probably just mentioned what Galois claimed to have done and was then appointed referee. (These were the manuscripts Cauchy was alleged to

have lost, but which in fact he intended to present to the Academy in 1830.) That the academicians were 'astonished' at the implication that Cauchy had passed a favorable judgement on Galois' work at the time of receipt seems an unwarranted extrapolation from a footnote in an article by Taton, who is in any case not cited.

The issue of erasing previous developments and omitting explanatory footnotes reaches a head with the famous duel. For some reason, every author writing on Galois feels obliged to come up with a new theory to explain his death, rather than take the existing documents at face value. In her Preface, Rigatelli claims [p. 9], "On the basis of the analysis and interpretation of a series of hitherto neglected documents, I have been able to provide a new version of the circumstances leading to Galois' death". The documents she refers to are the newspaper article in *Le Precursseur*, mentioned above, as well as the memoirs written by H. J. Gisquet, prefect of police, and Lucien de la Hodde, one of Louis-Phillipe's spies.

Rigatelli's thesis is based on the evident certainty in Galois' last letters that he will die on the morrow, as well as his declaration, reported by his family, 'If a corpse is need to arouse the people, I will give mine!' According to Rigatelli, Galois decided to sacrifice himself to the Republican cause and arranged to be shot, in order that the secret Society of Friends of the People, to which he belonged, could incite the citizens of Paris to riot. In another words, Galois effectively committed suicide. There is some evidence in Galois' own writings that he harbored suicidal tendencies, and a letter of Raspail (published long after Galois' death) describes a scene in which a drunken Galois does attempt to kill himself while in prison. To what extent adolescent histrionics played a role in such scenes is difficult to judge, but there can be little doubt that Galois was an unhappy young man.

Yet Rigatelli's thesis fails to convince, for the simple reason that she provides no evidence. The article in *Le Precursseur* describing the duel was published by André Dalmas [1956, revised 1982] and reprinted in the 1989 version of my own article. According to the report [p. 77-78], "It is said that love was the cause of the combat. The pistol was the chosen weapon of the adversaries, but because of their old friendship they could not bear to look at one another and left the decision to blind fate. At point-blank range they were each armed with a pistol and fired. Only one pistol was charged"

It seems quite a leap from this account to suppose that Galois intentionally arranged to receive the uncharged pistol, which is Rigatelli's contention. Furthermore, Dalmas makes a good case that the adversary,

L. D., was a good friend, Vincent Duchatelet. The identification is not ironclad because the initials do not match, but perhaps, what we have here is the most common of all errors: a misprint. In any case, Rigatelli makes no attempt to identify L. D. and one is left gaping at such an omission. As for the other 'neglected' documents, the memoirs of Gisquet and de la Hodde, both were known to Dupuy, who cites them as evidence that politics played no role in the affair. If Rigatelli has new material to add, she should present it and allow the readers to decide. She does not.

Ultimately, Rigatelli's book is both satisfying and frustrating. Although it is now the most complete account of Galois' life available, by failing to provide the evidence necessary to support her contentions it ironically becomes a narrative —another story of the type she is attempting to correct. I would hope that in future editions these problems could be addressed. What would at this time be more useful than continued speculation on Galois' demise would be for an historian to write an accessible history of the origins of group theory. For too long, in the popular imagination at any rate, group theory sprang whole from the mind of Galois the night before his duel. Scarce attention has been paid to the contributions of Paolo Ruffini, who proved the insolubility of the fifth-degree equation a quarter century before Abel, or of Legendre. An account of these developments, parsing credit in due proportion would help illuminate a portion of mathematical history not widely known to even scientists.

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