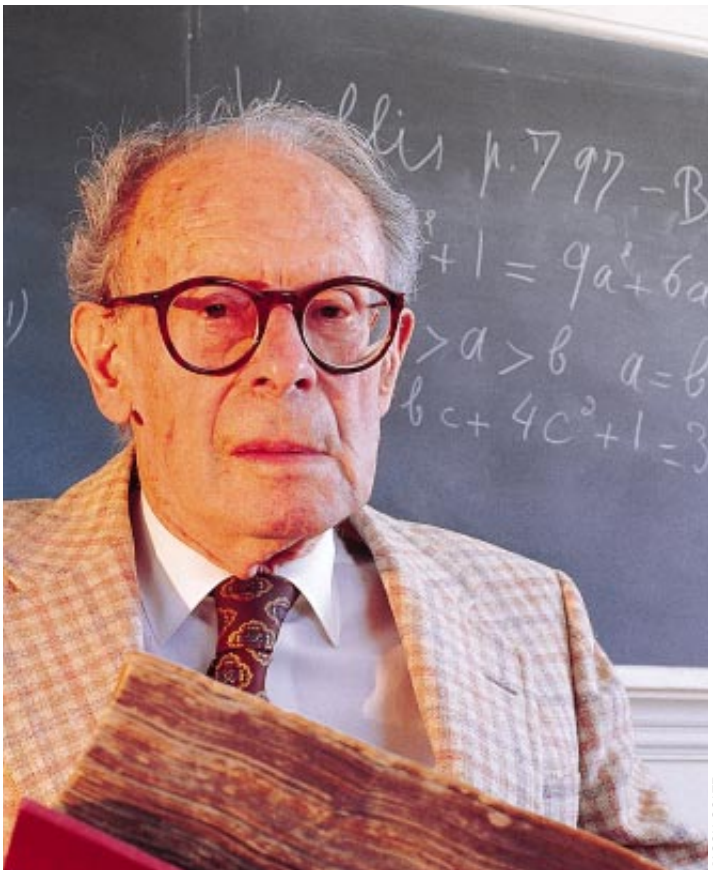
The Last Universal Mathematician

In 1939 a 33-year-old French mathematician proved that a profound conjecture about the behavior displayed by prime numbers as they meander toward infinity holds true for certain limited but crucial cases. The achievement, which is known as the proof of the Riemann hypothesis on the Zeta function for field functions, is a jewel of modern number theory. It is all the more remarkable because its author first scribbled it down in a French military prison.

This is only one in a series of extraordinary incidents in the life of André Weil, who eventually left his prison cell to become one of the 20th century's greatest mathematicians. Yet so isolated is mathematics from the rest of human culture that Weil, now a professor emeritus at the Institute for Advanced Study in Princeton, N.J., remains largely unrecognized outside his field. When Weil's autobiography, *The Apprenticeship of a Mathematician,* was published three years ago, not a single nonmathematical publication reviewed it. Weil's younger sister, Simone Weil, a philosopher and political activist, is more widely known in spite of the fact that she died more than 50 years ago.



JASON GOLTZ

ANDRÉ WEIL: "Always after what was essential."

Professional colleagues are therefore eager to praise Weil. They call him the last of the great "universal" mathematicians. They point out that he was a founder of Bourbaki, a legendary group that in the guise of a fictitious sage—Nicolas Bourbaki—wrote a series of monumental treatises that brought order and unity to mathematics. Weil himself navigated all the major tributaries of mathematics—notably, number theory, algebraic geometry and topology—erecting proofs and conjectures that, like levees, determined the future course of inquiry. One of these conjectures played a crucial role in the celebrated "proof" of Fermat's Last Theorem, perhaps the most famous unsolved problem in mathematics, announced last year by Andrew Wiles of Princeton University.

Weil's style has been as influential as his specific contributions. One number theorist likens him to a medieval monk doing work with "tremendous simplicity and purity and no unnecessary ornament." Weil "was always after what was essential," another agrees. Weil was reportedly feared for his sharp tongue as well as admired for his brilliance. One compatriot, comparing Weil to a violin whose strings have been stretched too tightly, recalls that "he suffered fools very badly." The colleague suggests Weil may have mellowed with age.

Indeed, Weil is 88 now, equipped with a hearing aid and plastic hip joints. And during an interview at the Institute for Advanced Study, he seems, at times, almost serene. Asked if he is bothered by the fact that so few people know of his work and even fewer can appreciate it, he gives a Gallic shrug. "Why should I be?" he replies. "In a way, that makes it more exciting."

Unlike some modern purists, Weil is also unconcerned by the growing collaboration between mathematics and physics (spurred in part by Edward Witten, a theoretical physicist whose office abuts Weil's). "I have lived through a period when physics was not important for mathematics," Weil comments. "Now we are coming back to a period where it is becoming important again, I think, and that is a perfectly healthy development."

Yet there are flashes of acerbity. When asked his opinion of Wiles's assault on Fermat's Last Theorem, Weil jokes at first that centuries hence historians will think he and the similarly named Wiles are the same person. Then his smile fades, and he adds, "I am willing to believe he has had some good ideas in trying to construct the proof, but the proof is not there. Also, to some extent, proving Fermat's theorem is like climbing Everest. If a man wants to climb Everest and falls short of it by 100 yards, he has not climbed Everest."

Explaining why his autobiography describes his life only through World War II, Weil offers another barbed response. "I had no story to tell about my life after that," he says. "Some of my colleagues have written so-called autobiographies, which I think are very boring. They consist entirely of saying, 'In the year such and such I was appointed to such and such an institution, and in such a year I proved this or that theorem.' "

Weil's life, at least its first half, was almost excessively eventful. He was born in Paris in 1906. Both his father, a

physician, and his mother devoted themselves to all aspects of culture. By his early teens Weil had become "passionately addicted" to mathematics. He graduated from the University of Paris in 1928, after having delivered a Ph.D. thesis that solved a 25-year-old problem about elliptic curves posed by Henri Poincaré.

Weil had renounced philosophy as a fatuity years earlier, after he received a good grade on a philosophy test despite having read none of the relevant texts. "It seemed to me that a subject in which one could do so well while barely knowing what one was talking about was hardly worthy of respect," he wrote in his autobiography.

Not that he lacked other interests. His fascination with Indian culture—and in particular the Hindu epic the Bhagavad Gita—contributed to his decision to accept a teaching position in India in 1930. After two years, he became entangled in India's arcane academic politics and was fired, but not before meeting Gandhi. Weil sipped tea with the Indian leader as he was planning the revolt that toppled the British Raj.

On his return to France, Weil became a professor at the University of Strasbourg. In 1937 he married Eveline, who had a son by a previous marriage (she died in 1986). Two years later, as Germany grew increasingly belligerent, the French government ordered Weil to report for military service. Instead he fled to Finland, which at that point the Soviet Union had not invaded. Weil admits to some lingering ambivalence over his decision to avoid service. "My basic idea, which was correct, I think, was that as a soldier I would be entirely useless, and as a mathematician I could be of some use," he says. "Of course, that was in the days of Hitler, and I was entirely of the opinion that the world should not yield to Hitler, but I couldn't see myself taking part in that effort."

Unfortunately, the young professor typing abstract symbols hour after hour in the countryside aroused the suspicions of the Finns, who were fearful of a takeover by the Soviet Union. The Finnish police arrested Weil and—according to one account related to Weil subsequently—nearly executed him before learning that he was merely a French mathematician avoiding the draft. Weil's troubles did not end there. The Finns turned him over to the French authorities, who promptly convicted him of desertion and imprisoned him again.

Weil spent six months in jail, where he created his theorem on the Riemann hypothesis, before being released in exchange for agreeing to join the French army. His ability to make the most of his incarceration provided much amusement for colleagues in later years. Once when Weil made an uncharacteristic misstep during a lecture, the eminent mathematician Herman Weyl suggested that Weil return to prison so he could work out the problem.

After the Germans routed the French army, Weil fled to England. He eventually made his way with his wife and stepson to the U.S., where he began searching for a job. Weil was already sufficiently filled with self-regard that he was chagrined when the only institution that initially offered him a paid position was Lehigh University in Pennsylvania. On leaving Lehigh after two unhappy years in what they felt was an intellectual wasteland, he and his wife vowed never to utter its name again. Henceforth they would call it "the unmentionable place." In his autobiography, Weil uncharitably recalls Lehigh as a "second-rate engineering school attached to Bethlehem Steel."

In 1947, after a stint in Brazil, Weil moved to the University of Chicago, where he resumed his work on Bourbaki. The project had begun in the mid-1930s, when Weil and half a dozen French colleagues, concerned about what they felt was the lack of adequate texts on mathematics, vowed to write their own. They decided that rather than publishing under their own names, they would invent a pseudonymous figurehead: Nicolas Bourbaki, an eminent professor who hailed from the (also fictitious) eastern European nation of Poldavia.

At first, few people beyond their immediate circle guessed the true identity of Bourbaki. As the group churned out vast treatises on virtually every field in mathematics, however, doubts grew. In 1949 Ralph Boas proclaimed in an article in the *Encyclopaedia Britannica* yearbook that Bourbaki was a pseudonym and did not exist. Weil wrote a letter, in high dudgeon, denying the accusation. Bourbaki's members then began circulating rumors that Boas did not exist.

Although younger mathematicians have continued to perpetuate the legacy of Bourbaki, its influence has waned. Weil himself, who resigned from the group in the late 1950s, thinks "in some ways the influence has been good. In some ways it has not been good." Perhaps the most important contribution of Bourbaki was to carry out a famous proposal made by the great German mathematician David Hilbert in 1900 that mathematics be placed on a more secure foundation. "Hilbert just said so, and Bourbaki did it," Weil declares. Bourbaki's emphasis on abstraction and axiomatics was sometimes carried too far, but Weil emphasizes that it was not Bourbaki itself but its followers who perpetrated these crimes.

Weil dismisses the argument of some philosophers that a celebrated theorem proved by Kurt Gödel in the 1930s shows that attempts to systematize mathematics are ultimately futile. "It's a perfectly good mathematical proof," he says. "The philosophical importance is something else that does not interest me." So averse is Weil to philosophizing that he even claims to be an agnostic on the old question of whether mathematical truths are discovered or invented. In his autobiography, Weil describes "the state of lucid exaltation in which one thought succeeds another as if miraculously, and in which the unconscious (however one interprets that word) seems to play a role." Yet he denies that such inspiration might stem from an external or even divine source. Tapping his forehead, he exclaims, "I think it's *there!*"

In 1958 Weil came to the Institute for Advanced Study, where he kept probing for deep links between arithmetic, algebra, geometry and topology. These unification efforts spawned what has become arguably the most vital field of inquiry in modern mathematics. Although he officially retired from the institute in 1976, Weil still goes to his office almost every day. There he pursues an old passion, the history of mathematics. He is currently helping to edit the works of two previous French giants, Jacques Bernoulli and Pierre de Fermat.

The last universalist confesses he has difficulty following recent developments in mathematics: "Mathematics has passed me by, which is as it should be, of course." Although he thinks computers can be useful tools, he rejects the suggestion that they may become crucial for constructing proofs as mathematics becomes more complex. He contends that the use of computations in certain proofs—such as the famous four-color theorem—is only a temporary crutch. "I'm sure when something is proved by computers it will later be proved without computers."

On the other hand, Weil doubts whether any human can ever again have a grasp of all of mathematics. One problem, he says, may be that there are too many mathematicians, especially good ones. "When I was much younger, I thought there was a danger that mathematics would be stifled by the abundance of mediocre mathematics being produced. And now I am inclined to think that its greatest danger is that too much good mathematics is produced. Things are going too fast. Nobody can keep up with it all." —*John Horgan*