

A portrait of Vito Volterra, a man with a full white beard and mustache, wearing a dark suit and a white shirt with a dark tie. The portrait is set against a dark red background.

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Vito Volterra

 Springer

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Introduction

The Italian mathematics community experienced what is probably its most brilliant period during the decades at the turn of the twentieth century. When the different states of the peninsula were united in 1861, annexing them to what had been the Kingdom of Sardinia and would go on to become the Kingdom of Italy, the field of mathematics already boasted several illustrious scholars. However, apart from these individuals, it struggled to be seen as a large and recognised entity. In the course of thirty to forty years, the situation changed radically, and Italy's being assigned as the third venue of the International Congress of Mathematicians (held in Rome in 1908, following the 'rehearsal' in Zurich in 1897, and the congresses in Paris and Heidelberg in 1900 and 1904) sanctioned its new role within the international community. In his report of the Rome congress for the French newspaper *Le Temps*, Henri Poincaré wrote: 'For thirty years now, the Italian mathematical movement has worked very intensely, in Rome as well as in universities in other provinces: I could cite a large number of names who occupy an honourable place in the history of sciences, but seeing them gathered together in this Congress makes it much easier to see how active Italian scientific life has been'.

The rapid, and in some ways surprising, developments in Italian mathematics were not accomplished solely on terrain that was properly scientific and through relations with the scholars most acclaimed on the international level, but were also accompanied by the increasingly large influence that mathematicians exerted on Italian society. They dealt with problems of education at all levels of schools, not only universities (it is easy to imagine the criticism that the newly created government of Italy had to face in creating a national system of education); they were active within other scientific communities; they engaged in dialogue and an exchange of ideas – not always harmonious – with the world of philosophy; they intervened in national politics; they placed their experience at the service of accelerating the modernisation and industrialisation of the country. In short, this was what has been referred to as the *spring* or *golden age* of Italian mathematics.

Taking part in this were outstanding researchers such as Guido Castelnuovo, Federico Enriques, Francesco Severi, Luigi Bianchi, Giuseppe Peano, Salvatore Pincherle, Giuseppe Vitali, Leonida Tonelli, Guido Fubini, Gregorio Ricci-Curbastro,

Tullio Levi-Civita and others, some already established, and some who would realise their full potential during the period between the two world wars. Even Poincaré, in his *Le Temps* report, was hesitant to name names, ‘because I fear, in fact I am sure, that I will forget someone important’.

Among the remarkable figures just named, that of Vito Volterra stands out. It is no overstatement to call him one of the greatest Italian mathematicians of the day, certainly the most influential, and noteworthy for both his international relations and the duties he performed out in academic and political institutions. For this reason the story of his life makes it possible to come into contact with some of the most significant research in analysis and mathematical physics of the final decades of the nineteenth century and first decades of the twentieth, and to span a long period – up to the years just before the tragedy of World War II – of events in the international mathematics community, the fates of the scientific institutions in various countries as they grappled with the problems, opportunities and expectations that emerged from the previous world war, and the travails of Italian political life during the crucial period of the passage from liberal governments to the Fascist regime.

Of particular significance in Volterra’s mathematical formation is the moment when the young student of the Scuola Normale in Pisa decided to focus on the physics-mathematics teaching of Enrico Betti rather than that of Ulisse Dini, the greatest follower in Italy of the rigorism of German analysts, who had provided the orientation for his studies during his first two years of university. This would mean that the Notes written by Volterra, at the time still a student at the Scuola Normale, on pointwise discontinuous functions and the relationships between derivatives and Riemann integrals (Notes which were crucial for the history of the theory of integration) would have no sequel. Instead, there would shortly appear the Memoirs on functional analysis, and the articles on integral and integro-differential equations, all accompanied by a concern for showing how the most abstract mathematical formalism, thought of as free to travel unexplored paths, was in reality always somehow oriented by the study of nature and by the urgency or curiosity to get to the bottom of some physical problem.

This balance between basic, curiosity-driven research and applications (not only to physics), surely a legacy of his apprenticeship with Betti, constitutes one of Volterra’s most important lessons in mathematics, even at a distance of more than a hundred years. We find deep traces of it in his lectures, both official and for a general public; in his interest in the then young field of mathematical economics; in his “Leçons sur la théorie mathématique de la lutte pour la vie”, which along with the so-called Lotka-Volterra model, elaborated by a mature Volterra, inaugurated a new phase in the study of population dynamics; in his correspondence with colleagues, where he calmly but firmly reiterates (for example, in some of the letters written to Maurice Fréchet) the correctness of his choice not to pursue generalisations that seemed to him to be ends in themselves. This is the conviction of one who does not limit himself to proving theorems, but constructs theories, and wants these theories to have meaning, not without, naturally, asking himself what meaning a mathematical theory can have.

Then there is Volterra involved in society, not entering directly into the political arena, but using the authoritativeness acquired in the field of mathematics to remind Italian society what science is and what it can offer for the progress of the nation. In fact, his faith in science becomes a social commitment. This is Volterra the Senator of the Kingdom; it is Volterra the founder, at the beginning of the twentieth century, of the Italian Association for the Advancement of Science, with which he calls researchers and scholars to a greater awareness of the role that they can play and which politics must sooner or later recognise; it is Volterra the founder, immediately after the first world war, of Italy's National Research Council, fruit of the work undertaken during the war and of collaboration with other allied nations to find a way to make coordinated use in peacetime as well of the advantages offered by science and technology, and of the attempt to make science the basis of a new model for Italy's future development.

By now we are many decades away from the experience of Fascism, and yet the lesson drawn from the stand taken by Volterra seems more relevant than ever. He was a moderate, and would remain so his whole life. Rather, his anti-Fascism was based on an opposition to the tyranny with which politics – Mussolini's politics – sought to impose its laws on the world of knowledge, and on the conviction, moreover, that such tyranny was unfounded. Volterra's judgment on the political class in the form it took under the regime was harsh. His refusal to take the oath of allegiance imposed on university professors by Fascism in 1931 remains an unequivocal word of warning. He knew full well that the majority of his colleagues – only twelve would refuse to swear allegiance – would give in and obey, either out of conviction, indifference, opportunism or desperation. He also knew full well that his refusal could have no other immediate outcome than his being fired from the university, or as it turned out, forced into early retirement. And yet, he couldn't bring himself to swear. He believed that there are moments in which one can and must say no.

Chapter 1

Chronicles of Italian Life

1.1 The Family

In the spring of 1860, Ancona was living out its final months under the dominion of the Papal States, which was destined to end the following September. It was in this city in the Marches that Vito Volterra was born, on 3 May 1860.

His parents were members of the Jewish community, which at that time lived in the ancient ghetto established in the sixteenth century.¹ His father, Abramo, came from a family of local merchants. His mother, Angelica Almagià, was the niece of Saul, one of the notables of the community. After losing her father when she was 7 years old, she grew up (together with her brother Alfonso) in close contact with the four children of his uncle Saul: Roberto, Edoardo, Vito and Virginia. This network of relationships, and in particular the close, affectionate ties of Angelica with her brother Alfonso and her cousin Edoardo, would have an profound influence on the life of the future mathematician.² Angelica and Abramo Volterra married on 15 March 1859, after a 2-year engagement. As was rather common at the time, their first son was given the name of his maternal grandfather.³

The destiny of young Vito immediately, and suddenly, changed in 1862 when his father died, leaving his young widow and child without any economic resources.

¹The first 'ghetto' for Jews was established in Venice in the fourteenth century; from here the name given to the confined area in which the Jews were forced to live spread throughout the world. The Jewish communities of Ancona and Rome were the only ones saved in 1569, when a decree issued by Pope Pius V expelled the Jews from the Papal State. The Ancona ghetto was abolished in 1848, but in actual fact the Jews continued to be confined to the area that had always been assigned to them, on the slopes of Monte Guasco, one of the two plateaus that make up the city of Ancona.

²This piece of information and others concerning Volterra's family are drawn from the book by Judith Goldstein, *The Volterra Chronicles* (Providence: American Mathematical Society–London Mathematical Society, 2007).

³Angelica Almagià's father, Vito Almagià (1797–1843), was a teacher in one of the Jewish schools in the ghetto.

Angelica and Vito moved in with her brother, Alfonso, who lived with his mother and unhesitatingly assumed responsibility for maintaining his sister and nephew. Vito thus grew up with his uncle, mother and grandmother. In autumn 1863, his uncle was hired by a company that contracted for the railways, and moved to Terni, along with the rest of the family. Then, in January 1865, he began a new job with the Banca Nazionale and was transferred to the central headquarters in Torino. These were the months immediately following the September Convention of 1864, in the very midst of the transfer of the capital of the fledgling Italian nation from the city in Piedmont to Firenze. In July, the Banca Nazionale also transferred, and Alfonso Almagià packed his bags one more time. He had gone to Torino alone, the rest of the family having returned to Ancona, but now his mother, sister and nephew joined him once again, and it was in the Tuscan capital that Vito Volterra would spend the years of his early education.

1.2 Uncle Alfonso's Concerns

Vito's young mother, now widowed, devoted all of her attention and affection to her child. Her upbringing, in a family with a certain level of education, made her very attentive to the pre-school education of her son, and Vito responded well to her affectionate proddings (Fig. 1.1).

At the age of 3 he learned to write, and showed an early inclination towards studies in physics and mathematics. He himself, in an autobiographical memoir written many years later, told how at the age of 9 his imagination was fired by the book of popular science by Jean Macé entitled *Histoire d'une bouchée de pain* (*History of a Mouthful of Bread*), dedicated to the chemistry and physiology of human and animal life, and how, at more or less the same time, he had discovered on his own that the oscillations produced by a twisted string are isochronic, like those of a pendulum.⁴ In short, young Vito began to be drawn to the observation of natural phenomenon and to his first exercises in deductive reasoning. Let there be no mistake: we are speaking about a boy just 10 years old, but all the same these first intellectual experiences – by a 10-year old boy – take on a certain significance in light of later developments. In 1873, Vito read Jules Verne's *De la Terre à la Lune* (*From the Earth to the Moon*), and decided for fun to look into what would become a classic problem of space travel in the twentieth century, and to calculate,

⁴See 'Matériaux pour une biographie du mathématicien Vito Volterra', *Archeion* 23 (1941): pp. 325–359. This autobiographical recollection was written anonymously; the author may have been either Joseph Pérès or Elena Freda. The French mathematician Pérès, who we will learn more about in chapter VIII in particular, enjoyed a long, affectionate friendship with Volterra and his wife Virginia. Freda (1890–1978), who earned a degree in mathematics under the advisement of Guido Castelnuovo, was the author of a 1937 book (in French, with a preface by Volterra) on hyperbolic partial differential equations.

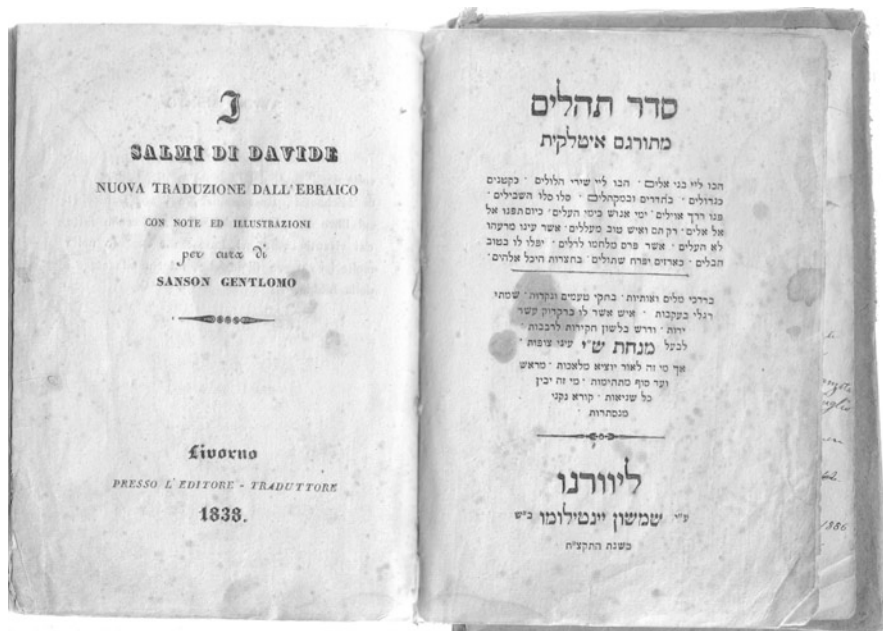


Fig. 1.1 Note recording the birth of Vito Volterra (*above right*) on the flyleaf of the *Salmi di Davide* (Psalms of David), translated with notes and illustrations by Sanson Gentilomo, Livorno, 1838; immediately following is a note recording the death of his father, Abramo Volterra

again for fun, the trajectory of the rocket which in the book is launched from the earth. The technique he used would lead him unawares to apply the ideas that form the basis of infinitesimal analysis. It was precisely to this adolescent experience that Volterra would refer in some passages of a lecture given in Paris in 1912 regarding the evolution of the fundamental ideas of infinitesimal calculus.⁵

Beginning in elementary school, Vito delved into in a wide range of readings and activities that regarded the humanities and history as well. In the summer of 1869, he returned to Ancona with his mother for a long visit with his Almagià cousins. During this stay, in addition to doing the schoolwork assigned for the summer holidays (a long-standing tradition in Italian schools, consisting even then in special reading assignments, essay writing, arithmetic exercises and word problems), always under his mother's watchful eye, he read several popular works of ancient history and literature. It was his mother who taught him French. This part of his youthful formation would make itself evident in later years in his book collecting, his attention to the history of science, his always wide-ranging and up-to-date

⁵See Goodstein, *The Volterra Chronicles*, op. cit. The work by Volterra cited by Goodstein is 'L'évolution des idées fondamentales du calcul infinitésimal', in *Leçons sur les fonctions des lignes* edited by J. Pérès (Paris: Gauthier-Villars, 1913).

reading, as well as a particular interest in the world in general and in French culture in particular.

Having completed elementary school, the boy went on to attend lower secondary school at the Scuola Tecnica Dante Alighieri in Florence. It was during this part of his education that he began to tell his family that when he grew up he wanted to be a mathematician. It's a fact that at the age of 11 he read, on his own, Joseph Bertrand's *Arithmétique* and Adrien-Marie Legendre's *Géométrie*!

By the end of lower secondary school, the boy's intentions had begun to firm up. Some years earlier, in April 1870, his little family had undergone a change. His uncle Alfonso had married, and in a short time, after the birth of his children, the family grew to 9. Vito's determination to continue his studies (in the field of science) was a cause for inner satisfaction for his mother and uncle, but also a source of worry. The family situation seemed to call for Vito to begin work as soon as possible in order to contribute to expenses and ultimately become independent and assume responsibility for supporting his mother. However, a first compromise made it possible for him to enrol for 3 years in the Istituto Tecnico Galileo Galilei.

In the liberal period, this type of school was the forerunner, institutionally speaking, of that which under the Gentile educational reform of 1923 would be called the *liceo scientifico*, the upper level secondary school specialised in scientific subjects. In effect, the two decades that followed Italian unity saw the establishment of a great number of technical institutes in the larger cities in order to provide more opportunities for high quality technical education. The country was greatly in need of this, in order to achieve modern standards of living and foster industrial development. The technical institutes provided access to the scientific faculties in the universities and to schools of engineering. The network of technical instruction was placed under the supervision of the Ministry of Agriculture, Industry and Commerce, which was also responsible for a series of institutions at the university level.

This was the education itinerary that young Volterra looked to in order to follow his own vocation. In the meantime, he had begun to read the textbook for differential calculus by Bertrand, and to calculate centres of gravity and moments of inertia for various solids, dividing them into increasingly smaller parts and thus discovering intuitively the procedures underlying the operations of derivation and integration. Towards the end of the first year of secondary school, family pressure to leave his studies and begin to work began to mount. As so often happens, the only effect this had was to strengthen the boy's determination to finish the course he had begun. In autumn 1875, Vito was victorious in his cause thanks to an important ally: his uncle Edoardo, his mother's cousin. Born in 1841, Edoardo had studied in Florence and then enrolled in the University of Pisa. In 1861 he received his degree in applied mathematics and became a civil engineer, working first in the area of railways and later in that of construction. It was Edoardo who carried out the modernisation and enlargement of the port of Ancona. Beginning in 1867, he and some partners had formed their own firm and had won the contract to construct several stretches of railway in southern Italy. By the 1870s, building railroad lines and laying tracks in the south of the Italian peninsula had become his principal activity.

Edoardo was immediately aware of Vito’s gifts and his determination, and he offered to contribute to ease the financial burden that his cousin’s family had to bear to allow the aspiring mathematician to continue his studies. Uncle Alfonso was not in agreement. Seriously worried about family finances and his nephew’s future, in summer 1867 he renewed his campaign to dissuade Vito from enrolling in the final year at the technical institute. At the same time, he attempted to convince Edoardo to hire the boy to work in his firm, or at least, to find him a job in the construction field. He had already been aware for some time that office work or a desk job would run too contrary to Vito’s inclinations. Although he did not admit it openly to his cousins, Edoardo wanted Vito to finish his education. He thus adopted a delaying tactic, postponing Vito’s hiring from month to month, and finally convincing Alfonso to allow him to complete the third year at the technical institute. Edoardo’s personality would have a certain influence on the direction that Vito’s mathematical studies would take: basically, his interest in applications of mathematics can be traced back to this period and to the advice of Edoardo Almagià.

Among other things, in the final year of his studies, one of Vito’s professors was Cesare Arzelà (1847–1912), who had studied at the Scuola Normale Superiore of Pisa before holding the chair of algebra at the University of Palermo and that of infinitesimal calculus in Bologna. Arzelà is one of the ‘historic’ figures in the birth of functional analysis in Italy, and is still remembered today for the so-called Ascoli-Arzelà theorem. In a certain sense, the path taken by his research would develop in the opposite direction from that followed by Volterra: after having grappled with some questions of algebra and mathematical physics under the influence of Enrico Betti, Arzelà would dedicate himself to an in-depth examination of various topics of real analysis (inspired by the studies of Ulisse Dini) before meeting up with Volterra in the terrain of functional analysis. Their friendship would develop over the coming decades, but for the time being Vito was only a student in his final year at the technical institute, and Arzelà his professor, older by about 15 years. The depth of their friendship is immediately clear in the letter that Arzelà wrote to his friend on 15 July 1905: ‘I can truly say that you are not only the most beautiful mind but also the most beautiful soul of all among our mathematicians’.

1.3 The University: ‘Always Go Forward with the Same Tenacity of Purpose’!

It is easy to imagine how Vito’s diploma and excellent scores, especially in mathematics, reopened family discussions about the young man’s future. His uncle Alfonso continued to be worried and pessimistic about the possibility that, by enrolling in university, his nephew would effectively improve his prospects for employment.

It was at this point that the young man gained, in addition to his cousin Edoardo, another valuable ally: the physicist Antonio Ròiti (1843–1921), who had been Vito’s professor at the technical institute and would become another friendly source

of support. Ròiti became a trusted and compassionate advisor, especially during the years to come when, the young man's exceptional gifts having finally been acknowledged both by his family and by the academic world, it came time to guide his first steps towards a brilliant career. At this point, convinced of Vito's outstanding potential, Ròiti tried to convince Uncle Alfonso to spare no efforts in obtaining the funds to allow him to undertake studies at university: 'My dear sir, a portion of the funds assigned by the Province for places for students at the Central School in Paris are still available. The scholarship for your nephew Vito should be drawn from those funds. Today I will write to this purpose to the attorney Commendatore Niccolò Nobili, to advise him that you or your nephew will go see him'.⁶ Obtaining the funds turned out to be more arduous than expected, in spite of the untiring efforts of the young but determined professor. He wrote once more to Alfonso, 'Most esteemed sir, I am writing to tell you that I have spoken with Commendatore Nobili who, if he finds it difficult to obtain a subsidy from the province for you nephew, hopes in any case to obtain it in some other fashion. To follow up on the steps he has taken, I recommend sending Vito to Cavalier Palagi, secretary to the Provincial delegation, along with the attached letter'. Ròiti did not stop at this suggestion: 'I had a letter written to Pisa [to ask] if there are places for students open there this year, and for your part you might speak with Professor Cesare Finzi, with my best regards. Finzi will probably be in the country, but I know that he comes to Florence quite often. You might ask him if Vito could apply for a Lavagna place. And do not forget to tell him that he distinguished himself in the diploma examinations. In the meantime, in order to know how to proceed in the measures I will take myself, I would like to know if Vito wants to dedicate himself to teaching or to engineering. In the first case he could perhaps continue his own studies in Florence at the Institute for Specialisation and obtain a scholarship in that way. But it is a good idea not to say anything about this to Finzi'. A few days later Vito told Ròiti about the outcome – not very encouraging, if not actually bad – of the attempts to obtain funds from the province and of Finzi's skepticism about the so-called 'Lavagna places', a kind of scholarship. Apart from everything else, he is still not sure what he wants to do in the future: '... if my studies could be continued in Florence, I would not hesitate to choose [the career] of teaching, because staying in this city where my family lives would be such a huge advantage; but in the case where I would pursue my studies at university, I would, if possible, put off a definitive decision until the end of the coming biennium'.

⁶Ròiti's letter is dated September 1877. It is part of the collection of Volterra's correspondence housed in the 'Fondo Volterra' of the Accademia dei Lincei in Rome. Some of this correspondence has already been published. See in particular the large selection published in the exhibition catalogue *Vito Volterra e il suo tempo (1860–1940). Mostra storico-documentaria* edited by Giovanni Paoloni (Rome: Accademia Nazionale dei Lincei, 1990), which also contains the letter by Alfonso Almagià quoted earlier. Many of the other letters which will be quoted further along are published in their entirety in this catalogue.