

## CHAPTER 7

# VITO VOLTERRA AND THE MAKING OF RESEARCH INSTITUTIONS IN ITALY AND ABROAD

GIOVANNI PAOLONI AND  
RAFFAELLA SIMILI

### SCIENCE AND POLICY MAKING: THE CONTRIBUTION OF VITO VOLTERRA

Vito Volterra (1860–1940) is generally considered one of the greatest mathematicians of his time. “His most important contributions”—according to the *Dictionary of Scientific Biography*—“were in higher analysis, mathematical physics, celestial mechanics, the mathematical theory of elasticity, and mathematical biometrics. His major works in these fields included the foundation of the theory of functionals and the solution of the type of integral equations with variable limits that now bear his name, methods of integrating hyperbolic partial differential equations, the study of hereditary phenomena, optics of birefringent media, the motion of the earth’s poles and, in his last years, placing the laws of biological fluctuations on mathematical bases and establishing principles of a demographic dynamics that present analogies to the dynamics of material systems.”<sup>1</sup>

The following pages, however, will not go into these aspects of his work, which are cited here mainly to point out the scientific standing of the scholar, but will describe other, no less important contributions that the distinguished mathematician made to research policies in Italy, as well as his close ties with the international milieu before and after the Great War.<sup>2</sup> After all, abroad, he was called *Mister Italian Science*, a nickname coined especially for him in 1918 by the famous American astronomer George Ellery Hale, who considered him “the leading spirit—Mr. Italian Science, if you will—of his embattled nation.”<sup>3</sup>

This part of Volterra's activity was for a long time suppressed in our country due to the very effective operation of "damnatio memoriae" undertaken to his detriment by the Fascist regime which he strenuously opposed;<sup>4</sup> it is indeed not an overstatement to affirm that Volterra's role in organizing the research system in Italy is of an importance comparable to his contribution to the progress of the scientific disciplines he tackled as a researcher.

As we know, it was during the course of World War I that the first national science policies were born in the United States and Europe, due to the urgent need to acquire more powerful military technical instruments, as well as by virtue of the institutional planning of several scientists who were then in the vanguard on this level, including Volterra.

While, on the one hand, this planning was born of the necessity to construct a renewed alliance in the international academic community, boosting national Academies and, at the same time, utilizing the bodies created during the war period, on the other hand, it originated from a prior emigration of ideas born much earlier, precisely in the first decade of the century.

#### THE IMPORTANCE OF SCIENCE FOR A YOUNG NATION

"In the fall of 1858, three young Italian mathematicians set out on a scientific trip to visit foreign Universities . . . the trip undertaken by Betti, Brioschi and Casorati marks a date well worth remembering: Italy was about to construct her unity and take part in international scientific proceedings, making her own contribution. I am all the more pleased to recall this date today that such a large number of mathematicians have assembled for a fertile exchange of ideas."<sup>5</sup>

So began Vito Volterra's presentation at the inaugural session of the II International Congress of Mathematicians (Paris, August 6, 1900)—which had been personally invited by the great Henri Poincaré—underlining how that journey gave rise to a cordial and reciprocal collaboration between Italian and foreign scientists, a collaboration also strengthened "by the same sentiments of devotion to science and the same faith in the high destiny of mankind, symbol of the brotherly ties between the two Latin countries."<sup>6</sup>

A few years later, 1908 to be exact, at the IV Congress of Mathematicians held in Rome, Volterra resumed speaking about the crucial importance of science for a young nation, emotionally evoking the achievement of independence in 1860: "Italy was then fully aware of having a high intellectual mission by virtue of her ancient traditions and the new position she was occupying in the civilized world."<sup>7</sup>

By the time Rome had become the capital of the newly created state of Italy in 1870, the mathematical community was undergoing a rebirth of its own. Mathematicians such as Enrico Betti, Francesco Brioschi, and Luigi Cremona had become members of Parliament.

On becoming minister of Public Education in 1862, Carlo Matteucci, a “physicist of genius”<sup>8</sup> who had specialized in 1829–31 in Paris at the *École Polytechnique* and at the laboratory of Arago, hurried to advocate the scientific cause of the nation that “in order to be free and great, does not live by soldiers and railways alone, and it would be mistaken to consider Italy resurrected as a nation, if in the arts, letters and sciences, it did not reclaim the position that had distinguished it in other times before.”<sup>9</sup> So he began a reform of universities, later defeated, which provided for the institution of only a few centers of excellence for higher education and research. Matteucci resumed this reasoning in a significantly titled piece, *Del metodo sperimentale e delle scuole di scienze fisiche e naturali*: “first and foremost, Italy needs two or three centers of advanced education endowed with the most generous means for experimental research and recruiting the most distinguished men we have. We need groups of laboratories and research units where a select number of young people, already well prepared at Universities, will train in the use of instruments and the invention of methods, where they will learn to truly love their work and its fruit.”<sup>10</sup> He went on to specify: “I said two or three large centers . . .,” because “chemistry is studied spending the day in a laboratory, medicine in a clinical school, astronomy in an observatory, engineering in a school of mechanics and drawing.” For this reason, it was necessary to reform the charters of universities and institute special scientific courses of study there: “experimental mechanics, technological physics, and industrial chemistry require particularly prepared teachers, and appropriate studies, laboratories and methods.”<sup>11</sup> “We are tormented by lack of financial resources—acknowledged the Minister—but the Italian universities need the astronomical observatories, laboratories, museums, and clinics that physics, chemistry, natural history, botany, physiology and medicine require.”<sup>12</sup>

Minister of Finance Quintino Sella, an engineer who had specialized at the *École des Mines* in Paris and a member of a family of distinguished industrialists of Turin, followed Matteucci’s inspiring principles in reaffirming the urgency for the country’s institutional apparatus to acquire a solid technical-scientific knowledge.

“We cannot but have a cosmopolitan purpose in Rome: that of science,” he confided to historian Teodore Mommsen, while in Parliament he declared: “Italy has a debt of honor towards humanity . . . for we in Rome, science is a supreme duty.”<sup>13</sup>

The question of the University of Rome was placed at the center of this incessant and extraordinary union between the old and the new, with the precise purpose of making it a modern university or, rather, the best, the university of the city of Rome, capital of Italy. In illustrating the bill specially drafted for this purpose that proposed a substantial financial outlay for the creation of experimental institutes of physics and chemistry, the indefatigable Sella, no holds barred, declared that “the University of Rome is lacking everything concerning the experimental sciences. It has collections but does not possess a true laboratory. We therefore want to institute a new school in the University

of Rome [...] today, this means introducing the great Italian school, the Galilean school, the school of experiments” so that it may be “a scientific center of illumination, one of the major Universities, constructed chiefly on the principles of experimental observations, which are always impartial and without preconceived ideas [...].”<sup>14</sup>

At the same time, however, and contrary to Matteucci’s indications, he did not delegate the technical-scientific preparation of the new nation to a few university centers of excellence, but instead to central institutes directly dependent on the State. The point of departure was the attribution of the then-crucial tasks in the geological field to the *Corpo delle Miniere* (Mines Corps), a body in the service of the government, analogously to what had been done in other countries of Europe. The Mines Corps was also assigned the task of drawing up the geological Map of Italy.

The institution of the Geology Office of the Mines Corps was followed by that of the Office of Statistics and various other centralized bodies, especially after 1870.

Indeed, in 1889, on the occasion of the twenty-fifth anniversary of the *Istituto Tecnico Superiore* (today the Polytechnic) of Milan, the mathematician Brioschi summarized the data relative to the career achievements of the former students of the institute he founded and directed, stressing how most of them were working “in the service of the State, namely in the Engineers Corps, in that of the Mines, in the Tobacco Manufactory, Salt-works, Land Registry, Technical Sections of the Finances and in the Construction of municipal roads.”<sup>15</sup>

Five years before (in 1883) Stanislao Cannizzaro, the distinguished chemist living in Paris in exile at the time of the first Italian wars of independence, where he assiduously frequented the laboratories of Chevreul and Dumas, had proposed a law that introduced financing for the creation of a state chemistry laboratory specifically equipped for all research pertinent to the manufacture of tobacco. Three years later, other national chemistry laboratories for customs controls started operating; finally, in 1888, and again on Cannizzaro’s proposal, municipal chemistry laboratories dealing with health matters were set up.

Volterra arrived at the University of Rome in 1900 after having taught at Pisa and Turin, summoned by Cannizzaro and physicist Pietro Blaserna to take the chair of mathematical physics. At the time of his Parisian speech, great steps forward had been made since the realization of the unitary state in building a national research system, despite the fact that the arduous equilibrium between the few economic resources and the activity of university laboratories, as well as the almost nonexistent relationship between public and private, had not yet produced the hoped-for fruit.

The system indeed suffered not only from serious financial and organizational shortcomings in the various university laboratories, but also from a strong disengagement of industry on this front.

And yet, since 1893, well-known engineer and industrialist Giuseppe Colombo,<sup>16</sup> teacher at the Polytechnic of Milan and founder of the Italian branch of Edison, forerunner of the large European power plants, had denounced the lack of studies in applied science and of laboratories in the schools of higher education, despite the fact that Milan was the principal center of development of the mechanical and electrotechnical sectors.

It is no coincidence that in those years and especially later, from 1902 to 1906, important agreements were made between the state, local authorities and universities, for important academic building developments and the endowment of scientific equipment (Padua, Parma, Bologna). In itself, this brought advantages to the universities and the cities of the North, while worsening the divide with Southern Italy, where universities were few and industrial installations definitely rare.

When in 1908 Volterra took part in the IV Mathematical Congress, he had already been a senator for a few years.

His inaugural lecture at Rome at the commencement of the academic year 1901–1902 (On the attempts to apply Mathematics to the Biological and Social Sciences), showed his profound interest in the possible applications of mathematics to these sectors, and received wide consensus in Italy and abroad. His intervention promptly attracted the not always sympathetic attention of economists. Later, in the 1920s, Volterra and American biologist Alfred Lotka successfully placed on mathematical bases the study of the biological fluctuations between different species of the prey-predator equilibrium. The choice of the topic for the inaugural lecture brought into focus the stance of Volterra who, in those years, was maturing an interest for the relationship of scientific research with economic-social development. This interest had assumed well-defined connotations precisely in coincidence with his move to Rome, and projected him into the process of renewal of the ruling class, which was underway in the Italy of industrial development under the political guidance of Giovanni Giolitti and Francesco Saverio Nitti.

Indeed, until then, Volterra had been principally involved in traditional academic activities such as committees, competitions, congresses and scientific journals, where he had made international contacts and given proof of his remarkable organizational skills. He had very close ties with the French mathematical world and with Gustav Mittag-Leffler, whom he had met for the first time in 1880 in Pisa. It was precisely with Mittag-Leffler that he undertook his first trip abroad in 1888 to Switzerland, where he had met Sofia Kovalevskaya, Karl Weierstrass and Georg Cantor, among others. In the spring of that same year, he went for the first time to Paris, where he would often return during the course of his life, even for long periods. Here he struck up important, long-lasting friendships with Henri Poincaré and later with Joseph Pérès, in addition to meeting personalities such as Émile Picard,<sup>17</sup> Émile Borel<sup>18</sup> and Paul Painlevé.<sup>19</sup> In 1904, he was inducted into the Institut de France and, in later years, into the

Imperial Academy of St. Petersburg (1908) and the Royal Society of London (1910). His friendship with Mittag-Leffler facilitated his relations with Sweden, whose scientific and technological importance was growing in the first years of the twentieth century, due to the results obtained by industry in the field of explosives, electric technologies and telephone communication, as well as by the rapidly won prestige of the Nobel Prize. Elected a member of the Academy of Sciences of Stockholm in 1908, every year Volterra received requests to designate candidates for the Nobel.

In Giolitti's Rome, Volterra's institutional involvement improved as of 1903 when he was summoned, along with Stanislao Cannizzaro and Valentino Cerruti, to be part of the commission that was to deal with organizing the future Polytechnic of Turin, an extremely significant experience on the level of the relationship between pure and applied research.

Exemplary under this profile is the speech he gave at the Italian Senate in 1906 after visiting important European venues, including mainly the French, Swiss and German polytechnic schools:

Technical education directly touches the sources of the production of national wealth. [. . .] I therefore feel that Italy must reorganize its advanced technical schools [. . .] observing the organization here, we note an excess of theoretical studies compared to applied studies [. . .] the matters of application are the ones that must go to the forefront.<sup>20</sup>

In 1906, Volterra began to promote the formation of the Società Italiana per il Progresso delle Scienze (SIPS) on the model of analogous societies existing in more advanced countries. With his election to serve as dean of the Faculty of Sciences of Rome in 1907, the fruitful conclusion of the works of the commission for the Polytechnic of Turin and the inaugural SIPS Congress, the role of Senator Volterra among the protagonists of science policies in Italy was by now consecrated. Summoned to open the SIPS congress, Volterra's address clearly expressed his ideas on science, society and production:

More than thirty years have elapsed since the last congress of Italian scientists was held, in Palermo. Today this noble institution reawakens and salutes the new sun shining before it. Since the last congress, the material and social condition of Italy has undergone profound change, and scientific knowledge has rapidly developed and matured worldwide. The scientific advances appearing in this brief period of time have renewed not just our daily lives but also the general direction of our culture and breeding, strengthening a completely new, modern, original spirit—what I would call a scientific consciousness—that dominates our times just as other intellectual climates dominated earlier times.<sup>21</sup>

His speech closed with a precise programmatic reflection:

. . . The public's attitude toward science is very different today from what it was only fifty years ago. Indeed, the general public, as never before, had witnessed the birth and development of our generation's discoveries in the scientific laboratory, their transfer to the factory floor, and finally their invasion of everyday life.<sup>22</sup>

[. . .] our country does not ask this alone of its nascent institution—not only the satisfaction of intellectual curiosity but also the useful promotion and encouragement of fruitful study and new and vital research. Every day, industrialists, businessmen, and those in the professions turn to science, continually urged by a growing multitude who hope that science will provide a solution to the new, complex, and pressing problems they face and who invoke a science that will prove victorious over ever rising difficulties. [. . .] an open and liberal association like our own, which welcomes men in diverse fields, because even to formulate them requires the cooperation of different disciplines. It will then be up to the laboratories and the scientific institutes to develop and resolve them.<sup>23</sup>

Three essential points emerge from Volterra's institutional activity during that period, which were destined thereafter to play an essential function in shaping his interest for policies of national and international research: (1) his attention to the relationship between scientific community, politics, and economic development; (2) the desire to overcome the limits of hyper-specialization and to promote crossing disciplinary boundaries; and (3) his being involved in the institutional development of disciplinary fields outside mathematics, and especially in three of them, where an important renewal of methods was taking place, i.e., economics, biology and physics.

In the period that ran from 1907 to World War I, the SIPS, substantially headed by Volterra, performed an important role of representation and organization for the scientific community, as well as promoting new research bodies.

The first was the Comitato Talassografico Italiano,<sup>24</sup> launched at the session of the Society on October 15, 1909; not even a year later, it was transformed by special law into a state organ with autonomous financial resources. Volterra became vice-president (by statute, the president was the Minister of the Navy). From a strictly scientific viewpoint, it marked a considerable revival of oceanographic studies in Italy; from the political viewpoint, it had an important international repercussion with the birth in 1911 of the International Commission for the Study of the Adriatic, which in 1914 became the International Commission for the Scientific Exploration of the Mediterranean, headed by Prince Albert of Monaco and later, from 1924 and 1929, by Volterra himself.<sup>25</sup>

The Committee's range of activity was quite extensive and also included studies in meteorology and on the upper atmosphere, successively leading to the onset of important initiatives in aeronautics which, after the onset of World War I, Volterra attended to directly for military reasons.

In these initiatives, he availed himself of the support of economist Bonaldo Stringher, director of the Banca d'Italia and a prominent personality of the technocratic milieu, with whom he developed a productive collaboration.<sup>26</sup>

Both the creation of SIPS and the institution of the Comitato Talassografico showed Volterra's need to fill the gap between pure and applied research, a gap that Volterra, along with many other scientists, considered a stumbling block in the modernization of post-unification Italy. Let us say that he felt the need for a large national laboratory like the one in Teddington, the British laboratory founded in 1899 near London, which Volterra had seen on the occasion of a visit to the University of Cambridge in 1900.

#### INSTITUTIONALIZING THE INVISIBLE COLLEGE: TOWARDS THE INTERNATIONAL RESEARCH COUNCIL

In 1909, Volterra sailed for his first journey to the United States. He had been invited (with Ernest Rutherford, Robert W. Wood and Carl Barus) by Arthur G. Webster to lecture during the celebration of the twentieth anniversary of Clark University, near Boston. A few months before leaving Italy, he had met George Ellery Hale<sup>27</sup> in Brussels, and then in Rome, where Hale had been invited to lecture on his recent research on sunspots and where he was introduced by Volterra in person. Between 1907 and 1920, Hale was a leader in the American scientific community in several areas: he was involved in the origins of Caltech, in the renewal and strengthening of the National Academy of Sciences (NAS), and during World War I in the establishment of the National Research Council (NRC).<sup>28</sup>

In 1911, precisely on Hale's initiative, Volterra was called to become a member of the National Academy of Sciences in Washington.

During his first American visit, however, Volterra was not able to visit the Mount Wilson Observatory, of which the American astronomer was both founder and director; the observatory and Hale's residence were important legs of his two later trips in 1912 and 1919. The two men indeed got along well and shared ideas and outlooks on various subjects. Each in his own country was confronting analogous problems, with the objective of creating an institutional environment favorable to cooperation between the scientific community, politics and industry. There were, of course, great differences between a country with an already strong industrial structure, though not yet oriented towards growth through research, and the Italy of industrial development where part of the ruling class had a clear picture of the need to develop production in conjunction with the progress of scientific research.

Volterra was attracted by the development then underway in the United States, where the cooperation between research and industry was not assured (as it was in Germany) by strong state control, but was instead favored and made inevitable by a context in which there was strong interpenetration between industrial management and the world of research and advanced education.

The relaunching of science in service to the country coincided in Hale's case with the scientific-technological preparation that he sought to bring about in view of a possible intervention in World War I: in this framework, he promoted creating the NRC.<sup>29</sup>

On being confirmed secretary of foreign affairs (a post he held as of 1910) of the NAS, instituted soon after American independence, towards this end Hale requested the Academy utmost freedom of action and initiative in the technical and military field. In his diary, he scribbled in pencil: "National Service Research Foundation—Object: The promotion of scientific research in the broadest and most liberal manner, for the increase of knowledge and the advancement of the National Security and welfare." Soon he was writing to his friend Scherer: "I really believe this is the greatest chance we ever had to advance research in America."<sup>30</sup>

In 1916, the NRC was launched and Hale became its chairman. Meanwhile, he sailed for Europe where he traveled through England and France.

The creation of the NRC was an important step for an increasingly powerful force in American life. Previously, organizations like the NAS, the American Association for the Advancement of Science, and the American Philosophical Society had never concerned themselves with the general advancement of science and the national welfare. Now, under Hale's leadership, American scientists would have the chance to develop cooperative research on an unparalleled scale, first for war and later, as he had hoped and planned.

On April 6, 1917, war was declared. On May 29<sup>th</sup> a Franco-British commission landed in New York. It included the great British physicist Ernest Rutherford, a commander in the Royal Navy named Bridge, Charles Fabry from Marseilles, and Henri Abraham from the University of Paris. The problems that had to be solved were manifold. They ranged from the treatment of disease to the manufacture of optical glass for gun sights, rangefinders, and periscopes, from chemicals needed for high explosive to the "scores of other products developed in Germany after long years of investigation,"<sup>31</sup> and now suddenly rendered inaccessible. It was also necessary on this level to organize an operations network with the Allied countries and then agree upon a precise technical-military strategy with them.

Meanwhile, Hale was trying to reach an even more fundamental goal—the establishment of the NRC on a permanent basis. If it was of value in war, its role in the life of the nation should be even greater in peacetime. The bearing of its activities, as Hale was to write, "reaches down to the very foundations of national welfare. The problems of peace are inextricably entangled with those of war, and if scientific methods and the aid of scientific research are needed to

overcome the menace of the enemy, they will be no less urgently needed during the turmoil of reconstruction and the future competitions of peace.”<sup>32</sup> So, he began to ask the NAS to perpetuate the NRC, whose work “in organizing research and in securing cooperation of military and civilian agencies in the solution of military problems has demonstrated its capacity for larger service.”<sup>33</sup> Then followed a list of the council’s functions, with the first and most important being the stimulation of “research in the mathematical, physical and biological sciences, and in the application of these sciences to engineering, agriculture, medicine and other useful arts, with the object of increasing knowledge, strengthening the national defence, and contributing in other ways to the public welfare.”<sup>34</sup>

At this point, he renewed cooperation with foreign scientists. He dreamed of establishing an international organization that would first include the Allies and might later be extended to include all the nations of the world.<sup>35</sup> In April 1918, he had written of his dream to the British physicist Arthur Schuster,<sup>36</sup> secretary of the Royal Society. Hale was sure of his sympathy and enthusiastic support: they had met at meetings of the International Association of Academies (IAA) in Vienna in 1907, in Paris in 1910, and at St. Petersburg in 1913.<sup>37</sup>

Both were well aware that the future of an international organization of science after the war would involve the total cancellation of the IAA, a representative body of a generally cultural character that had been instituted in 1899, but whose control had always been in the hands of the academies of the Central Powers (Berlin, Göttingen, Leipzig, Munich, and Vienna).

Taking the NRC as a model, he suggested to Schuster that the proposed “Inter-Allied Research Council” devote itself to “large undertakings requiring the concerted efforts of scientists of different nations working in diverse scientific fields.”<sup>38</sup> He suggested, too, that it be led by the great national academies—the Royal Society of London, the Paris Academy of Sciences, the Accademia dei Lincei in Italy, and the National Academy in the United States.

Under the parent organization, Hale proposed the formation of international unions representing the various branches of science and technology.

Again Hale stressed that the council’s primary purpose should be “to promote international cooperation in scientific research rather than to hold congresses for the reading of papers, though it may combine both functions.”<sup>39</sup> To promote such cooperation, it was agreed that a group of international unions, dealing with various branches of science, should be formed.

The International Council would become the chief representative of its various unions, including Astronomy, Geodesy and Geophysics, Chemistry, Mathematics, Physics, Scientific Radio, Geography, and the Biological Sciences. As a result, its name would eventually be changed to the International Council of Scientific Unions.

Though he had expressed a negative stance towards the War in Libya in 1911, Volterra, too, had actively participated in the political debate in his country and especially on the stance Italy should have assumed in the war in Europe.

Contrary to the neutrality proclaimed by the Italian government in 1914, he fought for intervention alongside France and Great Britain, according to Whitaker's biographical notes,<sup>40</sup> organizing an active propaganda campaign in agreement with Gabriele D'Annunzio, Leonida Bissolati, and Salvatore Barzilai. He definitely participated in the gathering promoted by poet-fighter D'Annunzio in Rome in 1915, of which he wrote to his wife: "the celebration of this morning went very well, and it was very beautiful."<sup>41</sup>

In collaboration with mathematicians Borel, Painlevé, and Picard, with whom he had long-standing scientific relations that he now resumed in wartime, Volterra founded the Association for Intellectual Cooperation between the allied and friendly countries. As the title itself indicates, it undertook initiatives in the domain of national education and intellectual questions. It offered and asked allied countries for mutual collaboration to serve the people's best interests. The ties of mutual friendship that benefit all peoples should be further strengthened by implementing the temporary exchange of lecturers, professors, and students who should receive the mutual recognition of diplomas and certificates issued by the allied countries. The Association had a wide following, which was also parliamentary, and published a journal *L'Intesa intellettuale* that was issued until 1919.<sup>42</sup>

When Italy declared war on Austria on May 24, 1915, the by now fifty-five-year-old mathematician voluntarily enlisted with the Aeronautical Engineers, immediately becoming a protagonist of inter-allied cooperation in the scientific and technological field. His position in the Italian scientific community and his vast and capillary network of international relations indeed made him a natural point of reference for the military and government authorities in this field.

He was thus soon on the battlefields. For more than two years he lived in the Italian skies, perfecting a new type of airship and studying the possibility of mounting guns on it. At last he inaugurated the system of firing from an airship, in spite of the general opinion that the airship would be set on fire or explode at the first shot. He also published some mathematical works relating to aerial warfare, and experimented with aeroplanes. At the end of these dangerous enterprises, he was mentioned in dispatches and decorated with the War Cross.

When in 1917 some political parties—especially the Socialists—wanted a separate peace for Italy, he strenuously opposed their proposal. After the disaster of Caporetto, he and Sonnino helped to create the parliamentary bloc that was resolved to carry on the war to ultimate victory.<sup>43</sup>

That same year, Volterra was appointed director of the Inventions and Research Office of the Ministry for Weapons and Munitions: an office analogous to those created in other allied countries, which covered a wide range of research activities for the Navy, the Engineers Corps, the Artillery and the Air Force.<sup>44</sup> The project of the Italian Office of War Inventions came in the wake of an invitation by Émile Borel. In his capacity as head of the French Ministry of Inventions, Borel got in touch with the Italian Ministry and Volterra and

invited them to set up a ministerial body that would pool scientists, manage the resources of the various experimental research institutes, and guide the military technical offices so as to ensure a better and targeted defence of the country.

The project Volterra outlined in 1917 envisioned a single central office entrusted with assessing and organizing the inventions of the various scientific bodies and setting up an archive that would gather and statistically classify all the inventions.

As for the United States, relations had grown even closer, thanks to the liaison function performed between Rome, Paris and the American military commands by two young scholars in uniform: Griffith C. Evans and Giorgio Abetti. Sent to Europe as a liaison officer with the American air force, after receiving a brilliant degree in mathematics at Harvard in 1910, Evans had specialized in Italy under Volterra. Giorgio Abetti was the son of the Florentine astronomer Antonio, a friend and colleague of Hale and Volterra. During the war, he had a long period of research training at the Mount Wilson Observatory, thus finding himself playing an important role in the communications between Volterra and Hale, both during the war period and in the years that followed, when his relationships were useful for the development of solar physics research at the Arcetri Observatory.

A year later, in 1918, the office Volterra had promoted was renamed the Office of Inventions and Research<sup>45</sup> and became the scientific and technical advisory group of a number of ministries (War, Navy, Industry, Trade, Agriculture, Education, and Foreign Affairs). It soon broadened its scope and came to cover a wide range of scientific disciplines, such as mathematics, physics, mineralogy, radiotelegraphy, mechanics, electrotechnics, physiology, etc. Closer links were established through ad hoc working groups with universities, polytechnic schools, colleges, experimental laboratories, and industries.

The Italian Office boasted permanent delegates in Paris, London and Washington. Between October 1917 and March 1918, the Italian representative in London, chemist Umberto Sborgi, who was later assigned a chair at the University of Milan, sent to Rome as many as 180 letters reporting findings from military, scientific and technological research activities that were in progress in England. For his part, Volterra traveled several times to the battlefields in France (a wonderful photograph depicts him with Madame Curie),<sup>46</sup> and also met with British allies in the course of trips to Manchester, Glasgow, Edinburgh and Oxford (where he gave passionate speeches that survive).<sup>47</sup>

In light of the aforesaid, it should come as no surprise that in the biennium 1918–1919, along with the Englishman Schuster,<sup>48</sup> the Frenchman Picard, and the Belgian Georges Lecoq, Volterra became one of Hale's European interlocutors when the latter began to promote the creation of the International Research Council (IRC), forerunner of today's International Council of Scientific Unions (ICSU).<sup>49</sup> Hale's objective was twofold: at home, to project the National Research Council into an international dimension in order to make its activity permanent following the war; abroad, to export its model to favor the

birth of a stable organization of the international scientific community, whose founding core would be formed by new organs tied to the academies of the winning powers, and extended to the neutral countries, but with the exclusion of Austria and Germany (at least in the early phase), capable of including all disciplines and, at the same time, an expression, for the first time in the scientific field, of an American capability of initiative. The experiences that were invested in this circumstance were, on the one hand, that of the intellectual and scientific-technological cooperation between the allied countries; on the other hand, that of international collaboration in the field of disciplinary research, starting from the sector of astrophysics where, as we know, Hale had played a particularly important role not only for his scientific contributions, but also for his organizing capabilities. This institutional proposal was to prove extremely innovative in the field of a nascent research system, as the future international body provided that the national divisions, disciplinary councils and committees should be directly financed by their respective governments.

The first meeting called by the Royal Society, and held at Burlington House, was presided over by the noted physicist J. J. Thomson. There were delegates from Belgium, France, Great Britain, Italy, Japan, Serbia and, of course, the United States. In the course of the meeting, a compromise was reached at length: the scientific community's mistrust of government interference was compounded by the dissent of the neutral countries. These did not intend to accept the exclusion of the Germans but eventually backed down, faced with the violent Franco-Belgian reaction.

A second meeting was summoned for November of the same year in Paris; it was organized by an inter-allied provisional committee of which Hale was president and Volterra, vice-president.<sup>51</sup> When the complex diplomatic procedure to form the IRC was over, also thanks to the offices of the nascent League of Nations,<sup>52</sup> after the inter-allied conference of Brussels of July 1919 and the meetings held in London and Paris, Émile Picard was appointed president of the new body, of which Volterra became vice-president. He was to hold this office until 1928.<sup>53</sup>

The objectives of the IRC were simple and realistic: to coordinate international efforts in the different branches of science and its applications; to initiate the formation of international Associations or Unions deemed to be useful to the progress of science, in accordance with Article 2 of the resolution adopted at the Conference of London, October 1918; to direct international scientific activity in subjects that did not fall within the purview of any existing international associations; and to enter through the proper channels into relations with the governments of the countries adhering to the IRC in order to promote investigations falling within the competence of the Council.

On completion, the undertaking gave rise to reservations in the international community (even among the allies) and, in the course of time, roused lively discussions in the historiographic sphere as to national science policies and their legitimacy. Richard Gregory, director of the journal *Nature*, who had

followed the entire affair, often hosting both favorable and critical interventions in the journal,<sup>54</sup> wrote a comment entitled *The Promotion of Science*,<sup>55</sup> which still has a topical ring today. He, first of all, took pleasure in the fact that the value of scientific research had finally been recognized as a decisive factor in national development. And yet, he hastened to say, while on the one hand, it was a good thing to abandon the *laissez-faire* politics with respect to research, pursued even by Gladstone in his time for fear of “disturbing” the individual creativity of scientists, it was necessary, on the other hand, to take steps to avoid science becoming subservient to either industry or government. Science is, of course, never a routine work—he concluded—making an appeal to a paradoxical figure of Newton as a functionary of state science—but this could not question the success attained by the IRC in gaining official recognition of the principle of national responsibility toward protecting and boosting research activity, a principle that totally responded to the institutional spirit that had animated the politics of science of Hale and Volterra. Volterra, like Hale, saw the IRC as an opportunity to renew scientific alliances and a way to avoid Italy losing her scientific achievements, now that she had entered the category of great nations. As for the system of national research, he was finally in a position to form a central research organism which, on the one hand, would have strengthened the Accademia Nazionale dei Lincei, while on the other, would have permitted him to give a solid basis to a large experimental laboratory. Volterra had long cherished the dream of establishing a central research laboratory, unrestrained by didactic purposes and the pettiness of small university laboratories. He had succeeded in setting up the “floating laboratories” of the Oceanographic Committee, the Biological Station in Messina, but not a truly national laboratory like the one in Teddington.

At the London conference, Volterra, with the strong support of the French delegation, indeed advanced the proposal to create large, private and national experimental science laboratories that were totally lacking in Italy, unlike the United States and Great Britain.

The following is the address Volterra drafted as Italy’s representative to the London meeting:

Many of us, whom a lengthy work had confined to a rather restricted scientific field, have had to unveil newer and broader horizons, but we have felt heartened by our fellow colleagues from those countries fighting for freedom and justice who have expressed solidarity. Broader horizons have opened up also for science which has linked up more closely with industry and war, out of necessity. New fields have been explored, new applications have been developed. Whole scientific chapters have been written.

Organizing the war has been deemed morally and intellectually unavoidable, and the groundwork has been laid for an organization which is set to become a new weapon against the common enemy. The

past four years of war have deeply changed our perception of the world, but they have not deprived us of the devotion to science, nor of the longing for its progress.<sup>56</sup>

He went on to show farsightedness as to the possible abuse of research and its policies:

Make no mistake. Do not say that science is harmful because, in the hands of our foes, it has yielded unspeakable results. Science is a delicate tool and . . . it can prove beneficial if it is inspired by ethics and civilization. Give a scalpel into the hands of a talented surgeon and he shall work wonders, give a scalpel into the hands of a felon and crimes and deaths shall ensue. The same holds true for science.

He then concluded,

We should foster collaborative research [. . .]. Academies and Universities should join forces and co-operate in geographical, geodesic, astronomical and oceanographic studies, all the fields which stretch from the sky, through the land, to water.<sup>57</sup>

In November 1919, Volterra sailed again to the United States, this time to lecture in Berkeley. On the way back, he again visited Pasadena and Houston, to meet Hale and Evans, and to participate in some social events organized by Evans and Lovett. Before leaving for Europe, he also found time to give a talk at Cornell University, which had invited him when they learned he was in the States. This was Volterra's last visit to the USA; archival research shows that he was planning at least three further visits, in 1923, 1926 and 1937, but that he failed to leave for different reasons.

After the war, Volterra's institutional career peaked: in 1920, he was elected president of the Società dei XL, a position he abandoned a few months later after being elected vice-president of the Accademia dei Lincei, of which he became president in 1923.<sup>58</sup> Also in 1923, after four years of frustrated attempts, the Consiglio Nazionale delle Ricerche (NRC) was instituted, and the great mathematician who had been its promoter was made president.<sup>59</sup> This was the last victory for Volterra, the politician of Italian science.

In 1924, he began to play a second important international role. After serving as president of the Bureau International des Poids et Mesures (1921–1940),<sup>60</sup> he became the point of reference for Europe in the field of physics and mathematical disciplines of the International Education Board, the body that managed the scholarships and other international educational activities of the Rockefeller Foundation, an instrument of the strategy to strengthen the National Research Council promoted by Hale. Its expansion on an international scale, as with other Rockefeller activities, took on concrete form in major

interventions in various countries of Europe, and also in Italy in the 1920s and 1930s.<sup>61</sup> Volterra's opinion was decisive when it came to the Foundation supporting the educational and research experiences abroad of various European mathematicians (mainly Frenchmen), financing the reinforcement of the Bureau International des Poids et Mesures, and creating the Institut Poincaré of Paris.

The Rockefeller scholarships proposed by Volterra, who since the beginning had encouraged the school of theoretical physics in Rome, were for the young physicists of Via Panisperna: in 1924, for Enrico Fermi, who went to Leyden to study with Lorentz; in 1925, for Enrico Persico, who went to Cambridge to Rutherford's laboratory; in 1928–29 for Franco Rasetti, who went to Pasadena, at Caltech.

### VOLTERRA AND THE ITALIAN RESEARCH COUNCIL

The Consiglio Nazionale delle Ricerche was instituted with a decree dated November 18, 1923, and signed by Mussolini who, at that time, was Minister of Foreign Affairs and Prime Minister.<sup>62</sup> While, on the one hand, its concrete origin derived from the Inventions Office conceived and coordinated by Volterra, on the other hand it perfectly assumed the principal characteristics of Hale's NRC: its national structure, the development of pure research and its technical-industrial applications, and its function in war and peacetime.

Placed under the auspices of the Accademia dei Lincei, Volterra stated on June 1, 1924, the NRC "is destined not only to form relationships with the international scientific unions, but also to organize national Committees of the various sciences and distribute financial means to them. Its effective benefits will be felt even more when it will be completed, as in England, France and America, by Institutes of a practical and experimental nature."<sup>63</sup> Indeed, the Accademie, both old and new, "not only rapidly give circulation to discoveries and original ideas, they also become interpreters of scientific public opinion; they found modern institutions under their auspices and administer them, such as national laboratories, and promote fertile and useful undertakings of an international character. The Accademia dei Lincei has also taken this route, promoting agreements with other countries and foreign academies, giving life to new institutions like the national Unions and Committees, encouraging special research,"<sup>64</sup> as well as providing "an environment in which the new scholars of scientific disciplines can train from an early age. There is an urgent need in our country to give the greatest boost to existing means and to procure new ones."<sup>65</sup>

On January 12, 1924, Accademia headquarters hosted the first plenary meeting of the NRC disciplinary committees, in the course of which Volterra, as the Lincei delegate, was elected president by unanimous vote. The Commit-

tees present were those for geodesy, geophysics, astronomy, mathematics, geography, radiotelegraphy, and chemistry, which were joined by the two ministerial representatives.

At that time, the International Astronomical Union (1922) and the National Geodesic Union, of which Volterra had been appointed President in 1921, had already been formed, precisely due to Volterra's initiative.<sup>66</sup>

The responsibility of the NRC was, first of all, to "coordinate Italy's scientific activity for the study of all matters pertaining to the sciences and their practical applications, the solution of which was interesting and useful for the country,"<sup>67</sup> as well as to set up a research laboratory which, for the President, should be like the one at Teddington, namely unique and central, capable of embracing the problems of pure research, as well as technical and industrial applications. The aim of its creation was to establish a new structure, of a quality higher than that of university institutes and, in any event, totally different from them, as they were traditionally troubled by serious economic problems and an "absolute lack of coordination and interconnection."<sup>68</sup>

Many, many years after the Unification of Italy, the question of the university laboratories was proposed once again, but this time with the difference that thanks to Volterra, a specific institution exclusively devoted to research was the point of reference instead of state bodies. Important scientists had fought for this institution both inside and outside of Parliament and within the scientific community, including, for example, Raffaello Nasini, the Lincei delegate in Paris along with Volterra and his active assistant at the Inventions Office, who was also a member of the National Radio Commission, and protagonist of the birth of the International Chemistry Union in Brussels; Umberto Sborgi and Giorgio Abetti, his assistants during the war; physicist Orso Mario Corbino, Minister of Public Education (1921–22) and the Budget (1923–24), and senator Emanuele Paternò, the distinguished chemistry professor at Palermo.

The laboratory was divided into a sector for analytical research (radio analysis, crystallography, optics, etc.), one for "physical chemistry studies (mechanics, pneumatics, heat, cold, light, electricity, magnetism, X-rays and derivations, etc.)," another "for synthetic research (catalysis, etc.)," and yet another "for the transfer to immediate industrial application."<sup>69</sup> The laboratory was to operate under the direction of the NRC, maintain strong ties with the other research institutions under the control of the universities and other administrations of the State and, at the same time, secure essential connections with the great industrial realities of the country that was requested to contribute financially to its development.

All these general requisites formed the necessary premises so that the national laboratory could effectively perform the functions entrusted to it: to promote and guide scientific-industrial research; assist companies in experimental investigations; provide entrepreneurs and companies with the indications, criteria and orientations to transform engineering practices conducted inside

factories into research of industrial interest. The principal task of coordinating and disciplining scientific research was joined by the commitment to recruit and train a new generation of researchers.

The priority of the national laboratory was forcefully sanctioned by the committees assembly in 1925, in conformity with the provisions of the executive committee, which declared the matter of setting up the laboratory mature enough to be subjected to the attention of the government. According to President Volterra, the nation and not only the experts was beginning "to clearly understand all the importance of scientific research for the solution of its greatest economic problems and for the problems which concerned its very existence, like those of national defence."<sup>70</sup>

The memorandum for the national laboratory was delivered to Mussolini and was "obtaining an excellent reception. He approved the idea on the whole and requested news as to the necessary means and time, but the matter can be considered as accepted. We now need to study the modalities"<sup>71</sup> wrote NRC secretary Giovanni Magrini to Volterra.

Despite the Duce's "excellent reception," the institution ran aground, but this time due to serious political reasons.

Volterra had never liked the Mussolini government. Since the end of 1922, in correspondence with Bureau secretary, Charles Guillaume, he had expressed worry about the developments of the Italian political situation.<sup>72</sup> Nonetheless, like many other figures of the liberal ruling class, in the beginning he had adapted to cohabiting with the Fascist government, awaiting changes in the political sphere, finding himself, among other things, president of the Accademia dei Lincei and of the NRC in 1923. In the same year, he joined with a handful of other senators and university professors in voicing strong objections to the new rules that his Minister of Public Education, Giovanni Gentile, had imposed on the field of education.

Shortly thereafter, between 1924 and 1925, Volterra realized that Fascism was changing into a dictatorial regime. Following the murder of the Socialist member of parliament Giacomo Matteotti, he joined the Union of Liberal and Democratic Forces, promoted in October 1924 by Giovanni Amendola and, in 1925, was among the signatories of the "Manifesto of Anti-Fascist Intellectuals," drawn up by Benedetto Croce, with which he found himself in the small group of opposition senators, thus becoming an official enemy of Mussolini.<sup>73</sup>

While the so-called "fascistissime" laws from 1925 to 1929 defined Fascism as a dictatorship, with the eradication of parliamentary prerogatives and all powers placed in the hands of the executive branch of government, guided by Mussolini, the regime began a phase of "political normalization" in the world of culture in general and, in particular, in the scientific community. Thus began a veritable persecution against Volterra to deprive him of his institutional positions and abolish his presence from public life. The first part of this operation was carried through between 1926 and 1928, with the dismissal of the great

mathematician from the presidencies of the Accademia dei Lincei and the NRC, from the International Commission for the Scientific Exploration of the Mediterranean, and from the vice-presidency of the International Research Council. In 1927, Guglielmo Marconi was summoned by Mussolini to take up the presidency of a reformed NRC, which became a body at the service of the Fascist state.

In 1931, the Mussolini government imposed on university teachers an oath of loyalty to the Fascist regime. Only twelve university teachers, as we know, refused to swear.<sup>74</sup> Volterra was one of them and was, for this reason, deprived of his university chair. "I swear to be loyal to the King, his royal successors and to the Fascist Regime . . . and to discharge all academic duties with the aim of shaping hard-working, upright citizens, dedicated to the Country and to the Fascist Regime." To this wording of the oath, Volterra replied to the rector of the University of Rome as follows: "my political ideas are well known, though they appear solely from my parliamentary conduct, which is however unquestionable on the strength of art. 51 of the Fundamental Statute of the Kingdom. Your Excellency will therefore understand how I cannot in conscience adhere to your invitation expressed in the letter dated the 18<sup>th</sup> of this month concerning the oath of professors."<sup>75</sup> Volterra wrote after refusing to sign:

I am now unemployed in Italy because the Fascist government dismissed me from the position as professor that I carried out for half a century, because for my principles and my conscience I refused to take an oath of loyalty to the Fascist regime. Such an oath would have moreover limited my political liberty as Senator that was guaranteed to me by the statute of the kingdom. In short, today I am no longer a member of the Italian university.<sup>76</sup>

In 1934, an analogous oath was imposed on the members of academies and cultural institutions, and Volterra was declared debarred from all Italian academies, including the Accademia dei Lincei.

Upon learning the news, Hale sent him a letter of support: "I wish I could also tell you personally of . . . my admiration of your attitude and courage," he wrote. In his answer, Volterra, by now all but banished from public view, made it clear that he harbored no illusions. "If you no longer see my name among the membership of the Accademia dei Lincei," he wrote to Hale in 1932, "do not think I am dead."<sup>77</sup> Vito Volterra had become an invisible man.

Despite the fact that he continued to be a senator, Volterra was placed under close police surveillance by direct order of Mussolini. This is proven by traces of exchanges between the Duce and the chief of police, and notes written by Mussolini and signed with his characteristic "M."

The enactment of the racial laws in 1938 oppressed the by now eighty-year-old scholar. The dictatorship grew stronger and so did the grip of Fascist politics on the life of the country.<sup>78</sup>

Volterra reacted to political persecution by devoting himself to his scientific work with renewed intensity; to this phase of his life belong the fundamental contributions he made to biomathematics. Despite the aforementioned difficulties, his trips abroad became more frequent as well, the fruit of the numerous invitations he received. He spent a good deal of time in Paris holding courses and conferences, and retaining the post of president of the Bureau International des Poids et Mesures. He also maintained relations with his American colleagues, indeed increasing the number of contacts, corresponding with scholars interested in his new contributions to the field of biology. It appears he never seriously considered the possibility of emigrating, though opportunities were not lacking. He continued to devote assiduous care to his extraordinary library of ancient and modern mathematical and scientific works which, with the legacy of other nineteenth-century collections, became one of the most important in the world.

He died at the age of 80, commemorated only abroad, a few months after Italy entered World War II.<sup>79</sup> It was only in 1946 that mathematician Guido Castelnuovo, who had become president of the Accademia dei Lincei after a year spent as commissioner of a renewed NRC, solemnly evoked the figure and work of Volterra at the beginning of the general assembly that marked the “re-birth” of the Accademia, after the “appalling catastrophe” of the dictatorship and the war. “He was one of the greatest mathematicians that Italy every had. Known throughout the world . . . for more than half a century, he upheld the glory of the Italian school among all civilized peoples.” But scientific research—continued Castelnuovo—“was insufficient to absorb the activity and fervor of Vito Volterra. For the first 25 years of this century, he was the moving spirit and organizer of Italian science. We can say that in this period, no important scientific institution was born in our Country that he did not either found or promote.”<sup>80</sup>

Volterra’s library is today kept in the United States. After many years in Boston, first at Brandeis University and then at Dibner Institute, it was transferred to the Huntington Library of San Marino near Pasadena, California, alongside that of his American friend and colleague, George E. Hale, with whom Volterra had shared the love for science, the ideals of justice, and the most extraordinary institutional spirit at the service of research and its development.

## NOTES

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  42. Following a first round of contacts and after drafting a provisional statute, the constituent assembly of the Association was held July 8, 1916, in Rome at the Università "La Sapienza." On that occasion, Antonio De Viti De Marco proposed the name definitively adopted. President was Volterra, Vice-Presidents were De Viti De Marco and Maggiorino Ferraris; director was Banca d'Italia director Bonaldo Stringher. See the Association for Intellectual Cooperation between the Allied and Friendly Countries, Minutes of the session of July 8, 1916, Vito Volterra Collection, file XV, Accademia Nazionale dei Lincei, Roma. For the projects of intellectual leagues, see Giovanni Paoloni, *Vito Volterra e il suo tempo 1860–1940*, cit., pp. 96–98; the Vito Volterra/Antonio De Viti De Marco and Vito Volterra/Carlo Somigliana correspondences, Vito Volterra Collection, Correspondence, Accademia Nazionale dei Lincei, Roma.
  43. According to a statement by Ferdinando Martini (Gabriele De Rosa, ed., *Diario 1914–1918*, Milano: Mondadori, 1966), p. 1087, Volterra was one of the most authoritative members of the parliamentary group for national defence.

44. On technical organization in allied countries during the war and on the theme of internationalism in science, see "Historique de la Direction des recherches scientifiques et industrielles et des inventions," *Bulletin Officiel de la Direction des recherches industrielles et des inventions*, 1, (November 1919); M. Pattinson, "Scientists, Government and Invention: The Experience of the Invention Boards 1915–1918," in *Home Fires and Foreign Field. British Social and Military Experience in the First World War*, ed. Peter H. Liddle (London-Washington, D.C.: Brassey's Defence Publishers, 1985), pp. 83–100; Roy and Kay MacLeod, "The Social Relations of Science and Technology 1914–1939," in *Fontana Economic History of Europe*, Carlo M. Cipolla, ed. (London: Collins, 1976), Vol. 5, pp. 301–63; Donald S.L. Cardwell, *The Organization of Science in England* (Melbourne: Heinemann, 1957); Eric Hutchinson, "Scientists and Civil Servants: the Struggle over the National Physical Laboratory in 1918," *Minerva*, VII, 3 (1969): 373–398; Ian Varcoe, "Scientists, Government and Organized Research: the Early History of the DSIR, 1914–16," *Minerva*, 8 (1970): 192–217; Roy MacLeod and Kay Andrews, "Scientific Advice in the War at Sea, 1915–17: the Board of Invention and Research," *Journal of Contemporary History*, 6, 2 (1971): 3–40; Jean-François Picard and Elisabeth Pradoura, "La longue marche vers le CNRS (1901–1945), *Papiers pour l'Histoire du CNRS 1939–1989* (Paris: Ed. du CNRS, 1988), pp. 7–40.
45. Vito Volterra, Report to H.E. Under-Secretary of State. Summary of Office activity in the October 1917–March 1918 semester, Vito Volterra Collection, Inventions Office Correspondence, Accademia Nazionale dei Lincei, Roma. See also Luigi Venturini, "L'Ufficio Invenzioni e Ricerche e la mobilitazione scientifica dell'Italia durante la Grande Guerra: fonti e documenti," *Ricerche Storiche*, XXI, 3, (1991): 803–835; Luigi Tomassini, *Le origini*, in *Per una storia del Consiglio Nazionale delle Ricerche*, cit., vol. I, pp. 5–71.
46. A copy of the photo is found in Rome in the Volterra Room on the first floor of the NRC.
47. Oxford speech, 1918 (draft); Edinburgh speech, 1918 (draft); Glasgow speech, 1918 (draft); Cambridge speech, 1918 (draft); Manchester speech, 1918 (draft), Vito Volterra Collection, scatola 23, Accademia Nazionale dei Lincei, Roma.
48. See the Vito Volterra/Arthur Schuster correspondence, Vito Volterra Collection, Correspondence, Accademia Nazionale dei Lincei, Roma.
49. International Council of Scientific Unions, ed., *Description of the International Council of Scientific Unions: a description of the council, of its commissions, and of its affiliated scientific unions and commissions with some account of their history and scientific activities* (Cambridge, 1950); Jean J. Salomon, *Organisations scientifiques internationales* (Paris: OCDE, 1965); Frank Greenaway, *Science International. A History of the International Council of Scientific Unions* (Cambridge: Cambridge University Press, 1996). See also Brigitte Schroeder-Gudehus, *Les scientifiques et la paix. La communauté scientifique internationale au cours des années 20* (Montréal: Les Presses de l'Université de Montréal, 1978); A.G. Cock, "Chauvinism and Internationalism in Science: the International Research Council, 1919–1926," *Notes and Records of the Royal Society*, 37, no. 2 (1983): 249–288.
50. Georges Lecoq, "Les relations internationales d'après guerre," *Bulletin de la classe des sciences, Académie Royale de Belgique* (1919): 37–47; Émile Picard, *Discours et mélanges* (Paris: Gauthier-Villars, 1922); Paul Painlevé, *Paroles et écrits* (Paris: Les éd. Rieder, 1936); Harry W. Paul, *The Sorcerer's Apprentice: The French Scientist's*

- Image of German Science, 1840–1919* (Gainesville: University of Florida Press, 1972).
51. According to Volterra, preparatory meetings were held in the spring of 1918 in London with the participation of Volterra and Raffaello Nasini for Italy (that is, the UIR), the Secretary's Office of the Academy of Sciences of Paris and the President's Office of the Royal Society. Then, in the summer, Hale (who was also a foreign member of the Accademia dei Lincei) sent a letter specifically proposing collaboration to Volterra and Elia Millosevich (secretary of the Lincei), explicitly suggesting the participation of the UIR ("The Inter-allied Conference on Science Organisation," *L'Intesa Intellettuale*, 1, no. 4 (1918), p. 219). The Italian delegation at the Brussels conference was quite large, with 15 delegates out of the total 225 (that is, the fifth delegation, according to this criterion, after the hosts, the French, the American—which, however, did not include Hale—and the British). The Italian delegates present were only 6, however, as the others could not participate for various reasons (Vito Volterra, "La Terza Conferenza del Consiglio Internazionale di Ricerche, tenuta a Bruxelles dal 18 al 28 luglio 1919," *L'Intesa Intellettuale*, 2, no. 3–4 (1919), p. 132).
  52. Paul Otlet, *Les problèmes internationaux et la guerre* (Paris-Geneve: Rossem Kundig, 1916); Leonard Woolf, *International Government: two reports* (London: Fabian Society, G. Allen, 1916); Alvin Leroy Bennet, *The Development of Intellectual Cooperation under the League of Nations* (Urbana: University of Illinois, Ph. D. dissertation, 1950).
  53. The Executive Committee of the International Research Council was presided over by É. Picard; vice-presidents were Volterra, G. Lecointe, G.E. Hale, secretary A. Schuster.
  54. See the critical articles by Wentworth D'Arcy Thompson, "International Relations in Science," *Nature*, 104 (October 23, 1919): p. 72; Edwin R. Lankester, "International Relations in Science," *ibidem*, 104 (October 30, 1919): p. 154; Norman R. Campbell, "Letter to the Editor," *ibidem*, 104 (September 4, 1919): 72–73 as well as the reports "Science and the State," *Nature*, 94 (October 29, 1914): 221–222; "Science and Industry," *ibidem*, 95 (March 18, 1915): 57–59; "Science in National Affairs," *ibidem*, 96 (October 21, 1915): 195–197; "Inter-allied Conference on International Organizations in Science," *ibidem*, 102 (December 26, 1918): 325–327; "International Organisation of Science," *ibidem*, 102 (January 2, 1919): 341–342; "Meeting Brussels," *ibidem*, 103 (August 7, 1919): 449; "The Organisation of Research," *ibidem*, 104 (September 4, 1919): 6–7.
  55. Richard Gregory, "The Promotion of Science," *Nature*, 105 (November 6, 1919): 259–261.
  56. Speech prepared for London 1918 (draft), Vito Volterra Collection, scatola 23, Accademia Nazionale dei Lincei, Roma. See also Vito Volterra, Speech on the need for the science organization after the War at the II Inter-allied Conference on Science Organisation, Paris 1918, Vito Volterra Collection, scatola 23, Accademia Nazionale dei Lincei, Roma.
  57. *Ibidem*.
  58. Giovanni Paoloni and Raffaella Simili, eds., *I Lincei nell'Italia Unita. Mostra storico documentaria* (Roma: Giorgio Bretschneider Editore, 2004).
  59. Raffaella Simili, "La presidenza Volterra," in *Per una storia del Consiglio Nazionale delle Ricerche*, cit., vol. I, pp. 72–127.

60. BIPM, ed., *Le Bureau International des Poids et Mesures, 1875–1975* (Paris: B.i.p.m., 1975), English translation by Chester H. Page and Paul Vigoureux, eds., *The International Bureau of Weights and Measures 1875–1975* (Washington: U.S. Department of Commerce-National Bureau of Standards, 1975); Vito Volterra, “Sur l’Histoire du Bureau International Des Poids et Mesures,” *Comptes Rendus des séances de la septième conférence des Poids et Mesures* (1927): 16–20; also in Vito Volterra, *Opere matematiche. Memorie e note*, 5 vols. (Roma: Accademia Nazionale dei Lincei, 1954–1962), vol. V, pp. 125–129; Bureau International des Poids et Mesures, Vito Volterra Collection, cartella VII–XI, Accademia Nazionale dei Lincei, Roma.
61. Concerning the relations between the Rockefeller Foundation and Italy: Giovanni Paoloni, “Public Health and Research: the Istituto di sanità pubblica between support from the Rockefeller Foundation and the Italian authorities,” in *American Foundations and Large-scale Research: Construction and Transfer of Knowledge*, ed. Giuliana Gemelli (Bologna: Clueb, 2001), pp. 115–128; *Id.*, “Sanità, ricerca e amministrazione: I primi quindici anni dell’Istituto superiore di sanità tra Fondazione Rockefeller e autorità italiane,” *Isole senza arcipelago*, eds. Giuliana Gemelli et al. (Bari: Palomar, 2003), pp. 27–54; Gianfranco Donelli and Enrica Serinaldi, *Dalla lotta alla malaria alla nascita dell’Istituto di sanità pubblica: il ruolo della Rockefeller Foundation in Italia: 1922–1934* (Roma: Laterza, 2003).
62. For the NRC decree, see *Decreto istitutivo e statuti del Consiglio e dei Comitati Nazionali* (Venezia: Ferrari, 1924). See also Giovanni Paoloni, “Organizzazione e risorse di un ente in formazione,” in *Per una storia del Consiglio Nazionale delle Ricerche*, cit., Vol. 1, pp. 201–223; Margherita Martelli, “Documenti,” *ibidem*, pp. 600–639.
63. Vito Volterra, “Discorso Presidenziale del 1924,” *Rendiconti delle sedute solenni della R. Accademia dei Lincei*, III, (1916–1928): 517–522; also in Vito Volterra, *Opere matematiche. Memorie e note*, cit., vol. IV, p. 523.
64. *Ibidem*, p. 524.
65. *Ibidem*, p. 125.
66. Vito Volterra, “Discorso inaugurale della International Astronomical Union,” *Transactions of the International Astronomical Union*, 1, (1922): 127–131; also in Vito Volterra, *Opere matematiche. Memorie e note*, cit., Vol. 4, pp. 496–502.
67. “Relazione della presidenza,” Seduta plenaria del 9 giugno 1925, Presidenza del Consiglio dei Ministri, Consiglio nazionale delle ricerche (hereafter, NRC), II versamento, b. 231/1, Archivio Centrale dello Stato Roma (hereafter, ACS). See also Minuta di verbale della seduta plenaria del Consiglio Nazionale delle Ricerche 9 giugno 1925 in *Per una storia del Consiglio Nazionale delle Ricerche*, cit., pp. 609–615.
68. Verbale della seduta del Comitato esecutivo del Consiglio nazionale di ricerche, 7 aprile 1925, (NRC), II versamento, b. 231/1, (ACS).
69. *Ibidem*.
70. “Relazione della presidenza,” Seduta plenaria del 9 giugno 1925, cit.
71. Giovanni Magrini to Vito Volterra, April 18, 1925, Vito Volterra Collection, Correspondence, Accademia Nazionale dei Lincei, Roma, published in Giovanni Paoloni, ed., *Vito Volterra e il suo tempo, 1860–1940*, cit., p. 142 and in Raffaella Simili, “La presidenza Volterra,” cit., p.105.

72. See the Volterra/Guillaume correspondence, Vito Volterra Collection, Correspondence, Accademia Nazionale dei Lincei, Roma.
73. Emilio R. Papa, *Storia di due manifesti* (Milano: Feltrinelli, 1958); Angelo Guerraggio and Pietro Nastasi, eds., *Gentile e i matematici italiani. Lettere 1907–1943* (Torino: Bollati Boringhieri, 1993); Pietro Nastasi, “La matematica italiana nel cinquantennio 1890–1940,” in *Una difficile modernità. Tradizioni di ricerca e comunità scientifiche in Italia 1890–1940*, Antonio Casella et al. (Pavia: Università degli studi di Pavia, 2000), pp. 133–176.
74. Helmut Goetz, *Der freie Geist und seine Widersacher* (Frankfurt am Main: Haag and Herchen Verlag GmbH, 1993); Giorgio Boatti, *Preferirei di no. Le storie dei dodici professori che si opposero a Mussolini* (Torino: Einaudi, 2001). The professors who did not swear allegiance were Giorgio Levi della Vida (Rome), Gaetano de Sanctis (Rome), Vito Volterra (Rome), Edoardo Ruffini Avondo (Perugia), Bartolo Nigrisoli (Bologna), Mario Carrara (Turin), Francesco Ruffini (Turin), Lionello Venturi (Turin), Giorgio Errera (Pavia), Fabio Luzzatto (Scuola superiore di agricoltura, Milan), Piero Martinetti (Milan), and Ernesto Bonaiuti (Rome). Albert Einstein intervened against the oath of allegiance to the Fascist regime to help his Italian colleagues, sending a letter to the Minister of Justice Alfredo Rocco, which had no effect (A. Einstein to Minister Rocco, Berlin, November 16, 1931, The Albert Einstein Archives, The Jewish National & University Library, The Hebrew University of Jerusalem). The letter was published several times: see Carl Seelig, ed., *Mein Weltbild* (Amsterdam: Querido, 1934); Otto Nathan and Heinz Norden, *Einstein on Peace* (New York: Simon and Schuster, 1960), Leandro Polverini, “Albert Einstein e il giuramento fascista del 1931,” *Rivista storica italiana*, 103, no. 1 (1991), pp. 268–280 (pp. 274–275); Helmut Goetz, *Der freie Geist und seine Widersacher*, cit.; Sandra Linguerrri and Raffaella Simili, *Einstein parla italiano. Itinerari e polemiche* (Bologna: Pendragon, 2008).
75. Letter by Vito Volterra to the rector of the University of Rome in which he refuses to take the oath, November 18, 1931 (Vito Volterra Collection, s.3, fasc. XVII/4, Accademia Nazionale dei Lincei, Roma), published in *I Lincei nell’Italia Unita*, cit., pp. 154.
76. Vito Volterra to Griffith Evans, January 7, 1932, Box 1, Evans Papers, UC Berkeley quoted in Judith R. Goodstein, *The Volterra Chronicles. The Life and Times of an Extraordinary Mathematician 1860–1940*, cit., p. 197.
77. George E. Hale to Vito Volterra, June 30, 1932, and Vito Volterra to George E. Hale, December 24, 1934, G.E. Hale Papers, Box 41, Archives, California Institute of Technology quoted in Raffaella Simili, “Introduzione,” in Vito Volterra, ed., *Saggi scientifici*, cit., pp. XIV–XV and in Judith R. Goodstein, *The Volterra Chronicles. The Life and Times of an Extraordinary Mathematician 1860–1940*, cit., pp. 3–4.
78. We limit ourselves to mentioning the books that deal with the Italian situation, by Giorgio Israel and Pietro Nastasi, *Scienza e razza nell’Italia fascista* (Bologna: Il Mulino, 1998); Roberto Maiocchi, *Scienza italiana e razzismo fascista* (Firenze: La Nuova Italia, 1999); *Id.*, *Gli scienziati del Duce. Il ruolo dei ricercatori e del CNR nella politica autarchica del fascismo* (Roma: Carocci, 2003); *Id.*, *Scienza e fascismo* (Roma: Carocci, 2004); Angelo Guerraggio and Pietro Nastasi, *Matematica in camiscia nera. Il regime e gli scienziati* (Torino: Bruno Mondatori, 2005).

79. Phonogram from the Police Department in Rome announcing the death of Vito Volterra, October 11, 1940 (ACS, Ministry of the Interior, Police Headquarters, cat. A1, 1940): "Senator Volterra, Vito, son of Abramo, of the Jewish race, died this morning at 4:30 at his home on Via Lucina, no. 17. Signed Palma."
80. Guido Castelnuovo, "Discorso," (October 17, 1945), Accademia Nazionale dei Lincei, Rendiconto dell'adunanza solenne, (1947): 5–9; also in Vito Volterra, *Opere matematiche. Memorie e note*, cit., vol. I, p. XIII.