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CHARLES C. GILLISPIE

**VOLTERRA, VITO** (*b.* Ancona, Italy, 3 May 1860; *d.* Rome, Italy, 11 October 1940), *mathematics, natural philosophy.*

Volterra was the only child of Abramo Volterra, a cloth merchant, and his wife Angelica Almagià. His ancestors had lived in Bologna, whence at the beginning of the fifteenth century one of them had moved to Volterra, a small city in Tuscany—the origin of the family's present name. In 1459 this ancestor's descendants opened a bank in Florence. Volterras are remembered as fifteenth-century writers and travelers and as collectors of books and ancient codices. In the following centuries branches of the family lived in various Italian cities, including Ancona in the 1700's.

Volterra was two years old when his father died. He and his mother, left amost penniless, were taken into the home of her brother, Alfonso Almagià, an employee of the Banca Nazionale. Later they lived in Turin and in Florence. Volterra spent the greater part of his youth in Florence and considered himself almost a native of that city. He attended the Scuola Tecnica Dante Alighieri and the Istituto Tecnico Galileo Galilei, both of which had excellent teachers, including the physicist Antonio Roiti, who played an important part in Volterra's career.

Volterra was a very precocious child. At the age of eleven he began to study Bertrand's *Traité d'arithmétique* and Legendre's *Éléments de géométrie*. He formulated original problems and tried to solve them. At thirteen he worked on ballistic problems and, after reading Jules Verne's novel *From the Earth to the Moon*, tried to determine the trajectory of a gun's projectile in the combined gravitational field of the earth and the moon—a restricted version of the three-body problem. In his solution the time is partitioned into small intervals, for each of which the force is considered as a constant and the trajectory is given as a succession of small parabolic arcs. Almost forty years later, at the age of fifty-two, Volterra demonstrated this solution in a course of lectures given at the Sorbonne. The idea of studying a natural phenomenon by dividing into small intervals the time in which it occurs, and investigating the phenomenon in each such interval by considering the causes that produce it as invariable, was later applied by Volterra to many other kinds of problems, such as differential linear equations, theory of functionals, and linear substitutions.

Although Volterra was greatly interested in science, his family, which had little money, urged him to follow a commercial career. There followed a struggle between his natural inclination and practical necessity. The family appealed to a distant cousin, Edoardo Almagià, a civil engineer with a doctorate in mathematics, hoping that he would persuade the boy to interrupt his studies and devote himself to business. The cousin, however, who later became Volterra's father-in-law, was so impressed by his mathematical ability that he tried to persuade the family to let the boy pursue his scientific studies. Roiti, having learned that his most able student was being urged to become a bank clerk, immediately nominated him as assistant in the physics laboratory at the University of Florence, an unusual occurrence since Volterra had not enrolled at the university.

Volterra completed high school in 1878 and enrolled in the department of natural sciences at the University of Florence. Two years later he won the competition to become a resident student at the Scuola Normale Superiore in Pisa. At the University of Pisa he enrolled in the mathematics and physics courses given by Betti, Dini, and Riccardo Felici. At first he was very interested in Dini's work in analysis. In one of Volterra's early papers, published while he was still a student, he was the first to present examples of derivable functions the derivatives of which are not reconcilable with Riemann's point of view. This observation was used much later as a starting point for Lebesgue's research on this subject. Volterra was fascinated most by Betti's lectures, and under his influence he devoted his research to mechanics and mathematical physics.

In 1882 Volterra graduated with a doctorate in physics and was immediately appointed Betti's assistant. The following year, at the age of twenty-three, he won the competition for a professorship of mechanics at the University of Pisa. After Betti's death Volterra succeeded him in the chair of mathematical physics. In 1892 Volterra was appointed professor of mechanics at the University of Turin, and in 1900 he succeeded Eugenio Beltrami in the chair of mathematical physics at the University of Rome. In the same year he married Virginia Almagià, who for over forty years was his devoted companion.

In recognition of his scientific achievements, Volterra was made a senator of the kingdom of Italy in 1905. Although he was never attracted by politics, he spoke frequently in the Senate on important issues concerning university organization and problems. He was active in Italian political life during World War I and, later, in the struggle against Fascist oppression.

When World War I broke out, Volterra felt that Italy should join the Allies; and when Italy entered the war, Volterra, although he was fifty-five, enlisted as an officer in the army corps of engineers, joining its air branch. He perfected a new type of airship, studied the possibility of mounting guns in it, and was the first to fire a gun from an airship. He also experimented with airplanes. For these accomplishments he was mentioned in dispatches and decorated with the War Cross.

At the beginning of 1917 Volterra established the Italian Office of War Inventions and became its chairman. He made frequent trips to France and to Great Britain in the process of wartime scientific and technical collaboration among the Allies. He was the first to propose the use of helium as a substitute for hydrogen in airships.

In October 1922 Fascism came to power in Italy. Volterra was one of the few to understand, from the beginning, its threat to the country's democratic institutions. He was one of the principal signatories of the "Intellectuals' Declaration" against Fascism, an action he took while president of the Accademia dei Lincei. When the proposed "laws of national security" were discussed by the Italian Senate, a small group of opposition senators, headed by Volterra and Benedetto Croce, appeared—at great personal risk—at all the Senate's meetings and always voted against Mussolini. By 1930 the parliamentary government created by Cavour in the nineteenth century was abolished, and Volterra never again attended sessions of the Italian Senate.

In 1931, having refused to sign the oath of allegiance imposed upon professors by the Fascist government, Volterra was dismissed from the University of Rome; and in 1932, for the same reason, he was deprived of all his memberships in Italian scientific academies. In 1936, however, on the nomination of Pope Pius XI he was elected to the Pontifical Academy of Sciences.

After 1931 Volterra lectured in Paris at the Sorbonne, in Rumania, in Spain, in Belgium, in Czechoslovakia, and in Switzerland. He spent only short periods in Italy, mainly at his country house at Ariccia, in the Alban Hills south of Rome. From December 1938 he was afflicted by phlebitis, but his mind remained clear and he continued his passionate pursuit of science until his death.

Volterra's scientific work covers the period from 1881, when he published his first papers, to 1940 when his last paper was published in the *Acta* of the Pontifical Academy of Sciences. His most important contributions 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 elastic dislocations of multiconnected bodies, 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.

Volterra received numerous honors, was a member of almost every major scientific academy and was awarded honorary doctorates by many universities. In 1921 he received an honorary knighthood from George V of England.

Scientific research did not, however, occupy all of Volterra's activity. He was an intimate friend of many well-known scientific, political, literary, and artistic men of his time. He has been compared to a typical man of the Italian Renaissance for the variety of his interests and knowledge, his great scientific curiosity, and his sensitivity to art, literature, and music.

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E. VOLTERRA

**VOLTZ, PHILIPPE LOUIS** (*b.* Strasbourg, France, 15 August 1785; *d.* Paris, France, 30 March 1840), *geology*.

Voltz came from a poor family, and his parents had to make great sacrifices for his education. He entered the École Polytechnique in 1803 and the École des Mines in 1806. After serving as a mining engineer in the Belgian provinces, he held the post of chief engineer of the Strasbourg mineralogical district from August 1814 until 1836. In this capacity he advised industrialists in eastern France, made an inventory of the mineral resources of Alsace, and began the surveys needed to establish a geological map of the province. Only the map of the southern region (the Haut-Rhin department) was completed, however; it was published in 1833. Greatly interested in minerals and fossils, Voltz devoted much time to the development of Strasbourg's museum of natural history, which, as a result, soon possessed one of France's largest collections concerning stratigraphic paleontology.

Voltz's publications on the stratigraphy of eastern France, particularly on the Triassic, display his remarkable gifts as an observer. "Aperçu de la topographie minéralogique de l'Alsace" (1828), which appeared simultaneously in German, treats of the stratigraphy and paleontology of the province, as well as of its mineralogy. Paleontology increasingly attracted Voltz, who published several studies of fossil mollusks, notably belemnites and Nerinea.

Because of his fame as a paleontologist, new fossil forms were frequently named after Voltz: for example, Adolphe Brongniart's genus *Voltzia*, a gymnosperm abundant in the Triassic.

Voltz was fluent in German and encouraged contact between scientists on both sides of the Rhine. In December 1828 he and some of his friends founded the Société d'Histoire Naturelle de Strasbourg. He was also a member of the Geological Society of London and a corresponding member of the Société Industrielle de Mulhouse.

In 1830 Voltz began to give a free course of lectures in geognosy at the Strasbourg Faculty of Sciences. Among his students were Jules Thurmann and Amanz Gressly, the latter of whom apparently took up the notion of facies that Voltz had introduced into geology in 1828. Voltz organized and presided at the special meeting of the French Geological Society held at Strasbourg and in the Vosges 6–14 September 1834, which was attended by many French and foreign geologists.

Voltz's activities went far beyond geology. He was a municipal councillor of Strasbourg and *conseiller général* of the Bas-Rhin department. While holding these offices he became concerned about the conditions of the poor, and he seems to have been an enthusiastic supporter of the July Revolution of 1830.

Named inspector-general of mines in December 1836, Voltz moved to Paris, where, besides handling his administrative duties, he enriched the paleontological collection of the École des Mines. His health began to deteriorate, however, and he died four years later.

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JEAN-CLAUDE GALL

**VON NEUMANN, JOHANN** (or **JOHN**) (*b.* Budapest, Hungary, 28 December 1903; *d.* Washington, D.C., 8 February 1957), *mathematics, mathematical physics*.

Von Neumann, the eldest of three sons of Max von Neumann, a well-to-do Jewish banker, was privately educated until he entered the Gymnasium in 1914. His unusual mathematical abilities soon came to the attention of his teachers, who pointed out to his father that teaching him conventional school mathematics would be a waste of time; he was therefore tutored in mathematics under the guidance of university professors, and by