VITO VOLTERRA (May 3, 1860 – October 11, 1940)

by Heinz Klaus Strick, Germany

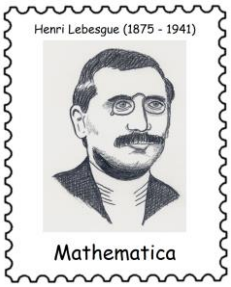
VITO VOLTERRA was born in Ancona, the son of a Jewish textile merchant. When VITO was two years old, his father died and his penniless mother ANGELICA was forced to move with the boy to her brother ALFONSO ALMAGIÀ. IN 1865 ALMAGIÀ moved to a position at the National Bank in Florence, where VITO also went to school.

His particular interest in mathematics became apparent early on: at the age of 11, he began working through JOSEPH BERTRAND's *Traité d'Arithmétique* and ADRIEN-MARIE LEGENDRE's *Éléments de Géometrie*. At the age of 13 – after reading JULES VERNE's book *De la Terre à la Lune* – he worked on the ballistic problem of shooting a projectile from the earth to the moon by dividing the process into short time intervals and determining the effects of the gravitational forces of the moon and earth on the projectile – which were assumed to be constant in the intervals – in order to approximately determine the parabolic trajectory. Incidentally, he reported on this episode forty years later as part of a guest lecture at the Sorbonne, thereby demonstrating a way in which complex processes could be grasped mathematically.

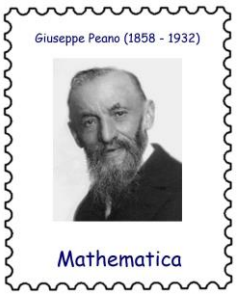
Because of the family's difficult financial situation, ALFONSO ALMAGIÀ urged his nephew to stop attending school and to begin an apprenticeship in banking. EDOARDO ALMAGIÀ , a distant relative, an engineer and mathematician, was supposed to help persuade the boy to pursue vocational training. However, when he noticed VITO'S mathematical abilities, he backed him and supported him continuing to attend school. And when VITO's physics teacher heard about the planned termination of his school education, he made things happen: He got the highly gifted student a job as an assistant at the physics laboratory at the University of Florence, and VITO was able to continue attending school at the same time.

VITO VOLTERRA enrolled in the science faculty of the University of Florence. In 1880 he successfully took part in a competition at the university in Pisa and received a full scholarship to the *Scuola Normale Superiore.*

In Pisa he received special support from the two internationally renowned professors ENRICO BETTI and ULISSE DINI. While still a student, VOLTERRA published several papers, including one on pointwise discontinuous functions, which inspired HENRI LEBESGUE to carry out further research.



After VOLTERRA's doctorate in 1882 on a topic in hydrodynamics, his career took off: immediately after his doctoral examination he was hired as BETTI's assistant, and the following year he was successful in his application for a professorship in mechanics at the University of Pisa. In 1887 the Italian *Accademia Nazionale delle Scienze* honoured him with a gold medal, and the *Accademia dei Lincei* appointed him a corresponding member.



As BETTI's successor to his chair of mathematical physics, VOLTERRA also became dean of the faculty in 1890 and took over the editorship of the specialist journal *Nuovo Cimento* from BETTI.

In 1892 he was headhunted by the University of Turin, where GIUSEPPE PEANO also taught. The always friendly and courteous scientist got into an unpleasant priority dispute with PEANO, but he survived unscathed.

In 1900 VOLTERRA succeeded EUGENIO BELTRAMI in Rome. In his inaugural lecture *Sui tentativi di applicazione delle matematiche alle scienze biologiche e sociali* he discussed the application of mathematical methods to biological and social science topics.

Also in 1900, he married VIRGINA ALMAGIÁ , a second cousin, daughter of EDOARDO ALMAGIÀ.
Six children were born into the happy marriage, two of whom died shortly after birth.

VOLTERRA was rarely at home as he was repeatedly invited to give guest lectures at European and American universities and showered with honours everywhere. To date, he is the only mathematician to have been invited four times to give a keynote lecture at an International Congress of Mathematicians (Paris 1900, Rome 1908, Strasbourg 1920, Bologna 1928).

In recognition of his services, the Italian king appointed VOLTERRA a member of the Senate. There he kept a low profile on general political issues, but was actively involved when it came to university matters. This changed with the outbreak of World War I. He took sides in favour of the termination of the alliance with Germany and Austria-Hungary and in favour of Italy's participation on the side of the allies France and Great Britain. Although he was already 55 years old, he joined an army group of engineers as an officer who was involved in the use of airships and aircraft at the front. He was one of the first to suggest using helium instead of hydrogen to fill airships. VOLTERRA itself tested the possibility of equipping the airships with guns. In 1917 he took over the management of the *Office for Weapons and Ammunition*.

When MUSSOLINI's fascists took power in October 1922, the staunch royalist VOLTERRA recognised the danger to democratic institutions. In his role as president of the *Accademia dei Lincei*, he signed a declaration against fascism, and when the national security laws introduced by the fascists were discussed in the Senate, he was one of the few opposition senators who even showed up at the meeting and voted against the Laws.

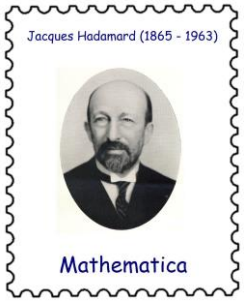
From 1928 onwards he was monitored as a “political suspect”. In 1931 he was dismissed from the university when he refused to take the government oath (only twelve university professors in all of Italy behaved like him). All institutions in Italy were forced to remove him from their membership lists. The only bright spot: In 1936, at the instigation of Pope PIUS XI, VOLTERRA was accepted as a member of the papal academy, the *Pontificia Academia Scientiarum*, where he was also able to publish his future scientific contributions.

VOLTERRA spent most of the 1930s in other European countries – thanks to numerous invitations to give lectures. After the racial laws came into force, because of his Jewish origins his Italian citizenship was revoked in 1938. Two of his sons, who worked at universities, emigrated in time.

At the end of 1938, for health reasons, VOLTERRA was no longer able to accept an invitation to a special honour at *St Andrews University* in Scotland. He died in October 1940 at his home in Rome.

The news of his death was spread only through the Papal Academy. His tombstone bears the following motto he chose: *Muoiono gli imperi, ma i teoremi di Euclide conservano eterna giovinezza* (Empires may fade, but EUCLID's theorems retain eternal youth).

VOLTERRA was – together with the Polish mathematician STEFAN BANACH – one of the founders of so-called *functional analysis*, which deals with functional spaces and their properties (investigation of transformations, partial differential and integral equations); the term was coined by JACQUES HADAMARD.



VOLTERRA also became known outside of mathematics through the so-called LOTKA-VOLTERRA rules , which he, and almost simultaneously the Austrian-American chemist ALFRED JAMES LOTKA, discovered, which are also known as *the predator-prey equations*. This is a pair of non-linear differential equations that can describe the changes in the population sizes x, y by

$$\frac{dx}{dt} = \alpha x - \beta xy \text{ and } \frac{dy}{dt} = \delta xy - \gamma y .$$

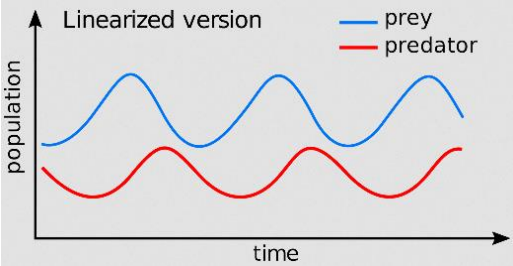
Example

x = number of rabbits, y = number of foxes, $\frac{dx}{dt}, \frac{dy}{dt}$ = instantaneous rates of change,

Model assumptions: no changes in conditions due to the environment;
Rabbits: unlimited food supply, exponential reproduction;
Foxes: unlimited appetite, reduction in the number of foxes due to death or change of territory.

The reduction in the number of rabbits or the increase in the number of foxes is proportional to x, y, each reduced by the number of "encounters" $x \cdot y$.

VOLTERRA had discovered these rules while analysing the results of his son-in-law, the marine biologist UMBERTO D'ANCONA. He found that due to the reduced fishing during the First World War, the proportion of sharks caught in fishing increased, and then decreased again when fishing intensified after the war (see the following Wikipedia model drawing).



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