Sofia Vasilyevna Kovalevskaya

Born: 15 Jan 1850 in Moscow, Russia
Died: 10 Feb 1891 in Stockholm, Sweden

Sofia Kovalevskaya was the middle child of Vasily Korvin-Krukovsky, an artillery general, and Yelizaveta Shubert, both well-educated members of the Russian nobility. Sofia was educated by tutors and governesses, lived first at Palabino, the Krukovsky country estate, then in St. Petersburg, and joined her family's social circle which included the author Dostoevsky.

Sofia was attracted to mathematics at a very young age. Her uncle Pyotr Vasilievich Krukovsky, who had a great respect for mathematics, spoke about the subject. Sofia wrote in her autobiography:-

The meaning of these concepts I naturally could not yet grasp, but they acted on my imagination, instilling in me a reverence for mathematics as an exalted and mysterious science which opens up to its initiates a new world of wonders, inaccessible to ordinary mortals.

When Sofia was 11 years old, the walls of her nursery were papered with pages of Ostrogradski's lecture notes on differential and integral analysis. She noticed that certain things on the sheets she had heard mentioned by her uncle. Studying the wallpaper was Sofia's introduction to calculus.

It was under the family's tutor, Y I Malevich, that Sofia undertook her first proper study of mathematics, and she says that it was as his pupil that

I began to feel an attraction for my mathematics so intense that I started to neglect my other studies.

Sofia 's father decided to put a stop to her mathematics lessons but she borrowed a copy of Bourdeu's *Algebra* which she read at night when the rest of the household was asleep.

A year later a neighbour, Professor Tyrtov, presented her family with a physics textbook which he had written, and Sofia attempted to read it. She did not understand the trigonometric formulas and attempted to explain them herself. Tyrtov realised that in her working with the concept of *sine*, she had used the same method by which it had developed historically. Tyrtov argued with Sofia's father that she should be encouraged to study mathematics further but it was several years later that he permitted Sofia to take private lessons.

Sofia was forced to marry so that she could go abroad to enter higher education. Her father would not allow her to leave home to study at a university, and women in Russia could not live apart from their families without the written permission of their father or husband. At the age of eighteen, she entered a nominal marriage with Vladimir Kovalevski, a young palaeontologist. This marriage caused problems for Sofia and, throughout its fifteen years, it was a source of intermittent sorrow, exasperation and tension and her concentration was broken by her frequent quarrels and misunderstandings with her husband .

In 1869 Sofia travelled to Heidelberg to study mathematics and the natural sciences, only to discover that women could not matriculate at the university. Eventually she persuaded the university authorities to allow her to attend lectures unofficially, provided that she obtain the permission of each of her lecturers. Sofia studied there successfully for three semesters and, according to the memoirs of a fellow student, she

immediately attracted the attention of her teachers with her uncommon mathematical ability. Professor Königsberger, the eminent chemist Kirchhoff, ... and all of the other professors were ecstatic over their gifted student and spoke about her as an extraordinary phenomenon .

In 1871 Kovalevskaya moved to Berlin to study with Weierstrass, Königsberger's teacher. Despite the efforts of Weierstrass and his colleagues the senate refused to permit her to attend courses at the university. Ironically this actually helped her since over the next four years Weierstrass tutored her privately.

By the spring of 1874, Kovalevskaya had completed three papers. Weierstrass deemed each of these worthy of a doctorate. The three papers were on Partial differential equations, Abelian integrals and Saturn's Rings. The first of these is a remarkable contribution which was published in Crelle's *Journal* in 1875. The paper on the reduction of abelian integrals to simpler elliptic integrals is of less importance but it consisted of a skilled series of manipulations which showed her complete command of Weierstrass's theory.

In 1874 Kovalevskaya was granted her doctorate, summa cum laude, from Göttingen University. Despite this doctorate and letters of strong recommendation from Weierstrass, Kovalevskaya was unable to obtain an academic position. This was for a combination of reasons, but her sex was a major handicap. Her rejections resulted in a six year period during which time she neither undertook research nor replied to Weierstrass's letters. She was bitter to discover that the best job she was offered was teaching arithmetic to elementary classes of school girls, and remarked

I was unfortunately weak in the multiplication table .

In 1878, Kovalevskaya gave birth to a daughter, but from 1880 increasingly returned to her study of mathematics. In 1882 she began work on the refraction of light, and wrote three articles on the topic. In 1916, Volterra discovered that Kovalevskaya had made the same mistake as Lamé, on whose work these papers were based, though she had pointed out several others which he had made in his presentation of the problem. The first of these three articles was still a valuable paper however, because it contained an exposition of Weierstrass's theory for integrating certain partial differential equations.

In the spring of 1883, Vladimir, from whom Sofia had been separated for two years, committed suicide. After the initial shock, Kovalevskaya immersed herself in mathematical work in an attempt to rid herself of feelings of guilt. Mittag-Leffler managed to overcome opposition to Kovalevskaya in Stockholm, and obtained for her a position as *privat docent*. She began to lecture there in early 1884, was appointed to a five year *extraordinary professorship* in June of that year, and in June 1889 became the first woman since the physicist Laura Bassi and Maria Gaetana Agnesi to hold a chair at a European university.

During Kovalevskaya's years at Stockholm, she carried out what many consider her most important research She taught courses on the latest topics in analysis and became an editor of the new journal *Acta Mathematica*. She took over the task of liaison with the mathematicians of Paris and Berlin and took part in the organisation of international conferences. Her status brought her attention from society, and she began again to write reminiscences and dramas that she had enjoyed doing when young.

The topic of the Prix Bordin of the French Academy of Sciences was announced in 1886. Entries were to be significant contributions to the problem of the study of a rigid body. Kovalevskaya entered and, in 1886, was awarded the Prix Bordin for her paper *Mémoire sur un cas particulier du problème de le rotation d'un corps pesant autour d'un point fixe, où l'intégration s'effectue à l'aide des fonctions ultraelliptiques du temps*. In recognition of the brilliance of this work the prize money was raised from 3,000 to 5,000 francs.

Kovalevskaya's further research on this subject won a prize from the Swedish Academy of Sciences in 1889, and in the same year, on the initiative of Chebyshev, Kovalevskaya was elected a corresponding member of the Imperial Academy of Sciences. Although the Tsarist government had repeatedly refused her a university position in her own country, the rules at the Imperial Academy were changed to allow the election of a woman.

Kovalevskaya's last published work was a short article *Sur un théorème de M. Bruns* in which she gave a new, simpler proof of Bruns' theorem on a property of the potential function of a homogeneous body. In early 1891, at the height of her mathematical powers and reputation, Kovalevskaya died of influenza complicated by pneumonia.

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