ÉMILE BOREL (07.01.1871 – 03.02.1956)

by HEINZ KLAUS STRICK, Germany

FÉLIX EDOUARD JUSTIN ÉMILE BOREL was born the third child of
HONORÉ BOREL and his wife ÉMILIE in Saint Affrique (Aveyron,
southern France). He received his first lessons from his father,
a pastor who ran a private school for children from Protestant
families. At the age of eleven, ÉMILE, who already had the
reputation of a child prodigy, went to the Lycée in Montauban
(Tarn-et-Garonne) and there he lived with the family of his
sister, who was 14 years older than him.

As a scholarship holder at the *Collège Sainte-Barbe* in Paris,
the oldest college in France, he took courses at the *Lycée Louis-
le-Grand* to prepare for the entrance examinations to the *École
Polytechnique* and the *École Normale Supérieure*. He passed both exams at the top of his class in
1889 and he also won first prize at the nationwide *Concours Général.*

He was urged from all sides to study at the more prestigious *École Polytechnique* as a degree from
this university would have secured him a well-paid job in commerce or industry.

ÉMILE, however, had other plans. During his time at the *Lycée Louis-le-Grand* he had become
friends with JEAN-GASTON DARBOUX, the son of a mathematics professor at the Sorbonne, and
through his family he had also met other mathematicians, including ÉMILE PICARD. So he decided –
with the support of his father – to study mathematics at the *École Normale Supérieure* (*ENS*)*.

Shortly after beginning his studies in 1889, ÉMILE BOREL published his first mathematical papers.
Although he had to interrupt his studies because of compulsory military service (in an engineering
battalion), he was still able to complete his degree in 1892. He won the national competition to
recruit mathematics teachers to teach at high schools or universities (*agrégation de
mathématiques*).

The following year he received his doctorate under GASTON DARBOUX with his thesis *Sur quelques
points de la théorie des fonctions* (On some points of the theory of functions). Before the doctoral
process had even ended, the 22-year-old received an offer to teach as a lecturer (*Maître de
Conférence*) *at the University of Lille.*

During his time in Lille, BOREL published over 20 papers – not only the number but also the quality
of his contributions caused a stir in professional circles. Academic careers in France still usually
started at a university in the provinces and then – if the appropriate evidence of achievement was
provided – gradually worked their way up to the elite universities in the capital with further
intermediate stations.

BOREL returned to Paris as early as 1897 as a lecturer at the *École Normale Supérieure*. In August of
that year he took on one of the leading roles in organizing the 1st International Congress of
Mathematicians in Zurich.

In the next few years, BOREL also taught at the *Collège de France* and was appointed examiner at
the *École Navale*. In 1898 he received the *Grand Prix* of the *Académie des Sciences*, in 1901 the
Prix Poncelet, and other awards followed. In 1905, at the age of 34, he was elected president of
the *Société Mathématique de France*. In 1909, the Sorbonne set up a chair for function theory
especially for him. In 1910, he also took on the position of deputy director of the ENS for 10 years.
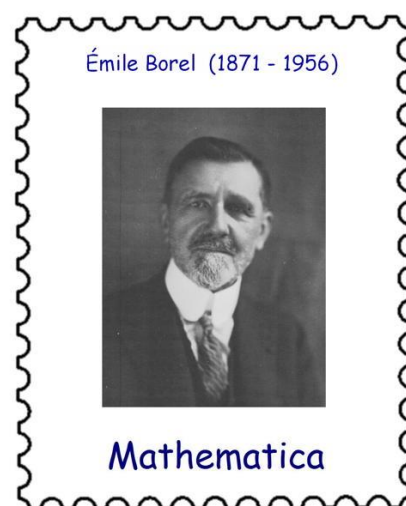
BOREL married MARGUERITE APPELL, who was only 17 years old and the daughter of the mathematician PAUL APPELL, professor at the *École Centrale Paris*. When the marriage remained childless, the couple adopted FERNAND LEBEAU, the son of BOREL's older sister, after his parents died early.

MARGUERITE BOREL became a respected writer. She published a series of novels under the pseudonym MARBO and in 1913 she was awarded the *Prix Femina*. With the help of her husband's prize money, she started the monthly literary and scientific magazine *La revue du mois* though the magazine had to be closed down during the economic crisis of 1920.

After the outbreak of the war in 1914, BOREL initially commanded a battalion, then, at the request of the Minister of War PAUL PAINLEVÉ (who was a friend of his), he took over the management of the technical office in the ministry; this office was tasked with supporting the soldiers at the front with "inventions in the service of national defence."
MARGUERITE BOREL ran a military hospital during the war.

BOREL found himself emotionally unable to continue his work at his previous place of work: half of his students at the *École Normale* had died in the war. His adopted son FERNAND had also died in 1915 while serving at the front.

So he ended his work at the ENS and instead accepted a position as chair of probability theory and mathematical physics at the *Université de Paris.* The *Institut de Statistique* (ISUP), which he initiated, was tasked with training statisticians who would support the scientific work of the other faculties (law, literature, medicine, natural sciences).

In 1921, BOREL was elected a member of the *Académie des Sciences* and in 1933/34 he was vice president and president of this institution. With financial support from the *ROCKEFELLER* and *ROTHSCHILD Foundations*, he founded the Institute of Physics in 1928. Together with JACQUES HADAMARD, ÉMILE PICARD and GEORGE DAVID BIRKHOFF he established the *Institut HENRI POINCARÉ* in Paris, which BOREL then headed for the next 30 years. The institute's facilities today include the *Centre ÉMILE BOREL* and one of the world's largest mathematical libraries.

Jacques Hadamard (1865 - 1963)
Mathematica
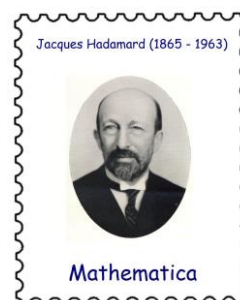
In parallel with his academic activities, BOREL began a political career. He joined the Republican Socialist Party of ARISTIDE BRIAND (who received the Nobel Peace Prize in 1926 together with GUSTAV STRESEMANN) and was a directly elected member of the French Chamber of Deputies from 1924 to 1936. He even served as Minister of the Navy for a few months in 1925.

After the occupation of parts of France by German troops in 1940, BOREL WAS temporarily arrested, and then joined the Resistance. For a time he took over the office of mayor in his hometown of Saint Affrique.

The fact that he was able to do all this without having to limit his mathematical activities is due to his exceptional intelligence and impressive drive. BOREL was always willing to devote time and energy to a cause he considered important. However, as the years went by, he became increasingly impatient and occasionally seemed almost rude when he felt that someone was being too wasteful with the time he had made available to him.

ÉMILE BOREL, who was active until the end, died in Paris at the age of 85 – he had never recovered from the effects of a fall he suffered on his ship's return from a conference in Brazil.

The mathematician, who was honoured many times around the world, was buried in the cemetery of his hometown.

In his doctoral thesis, BOREL dealt with the generalization of the method of the analytic continuation of a complex-valued function. In a subordinate theorem, he showed that every countable covering of a closed interval by open sets can be done with a finite number of sets. This led to the *HEINE-BOREL theorem,* named after him (and the German mathematician EDUARD HEINE):

- *A subset of $\mathbb{R}^n$ is closed and bounded if and only if every covering by open sets already has a finite subcover.*

In measure theory, a number of terms (e.g. the concept of the *BOREL measurable set*) are reminiscent of his fundamental work from 1898 and these were further developed by his doctoral student HENRI LEBESGUE, among others.

BOREL increasingly worked on probability theory. In total he published more than 50 articles in this field. He was less interested in the axiomatics than in the concrete applications in other fields.
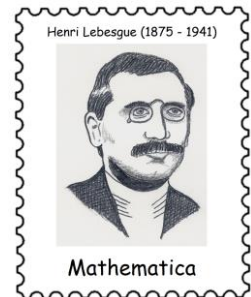
In 1909, BOREL proved a version of the so-called *Strong Law of Large Numbers*: the mean of a sequence of independent, binomially distributed random variables with parameter p ($0 < p < 1$) converges *almost certainly* to this parameter.

Borel also wrote *Le paradoxe du singe savant (Infinite monkey theorem)*, a thought experiment which states that a monkey which randomly hits keys on a typewriter an infinite number of times can almost certainly write any text it wants. However, the chance of this happening in a period of time on the order of the age of the universe is tiny, although not zero.

In the 1920s he worked (independently of and earlier than JOHN VON NEUMANN) on the fundamentals of game theory and investigated optimal strategies for simple games.