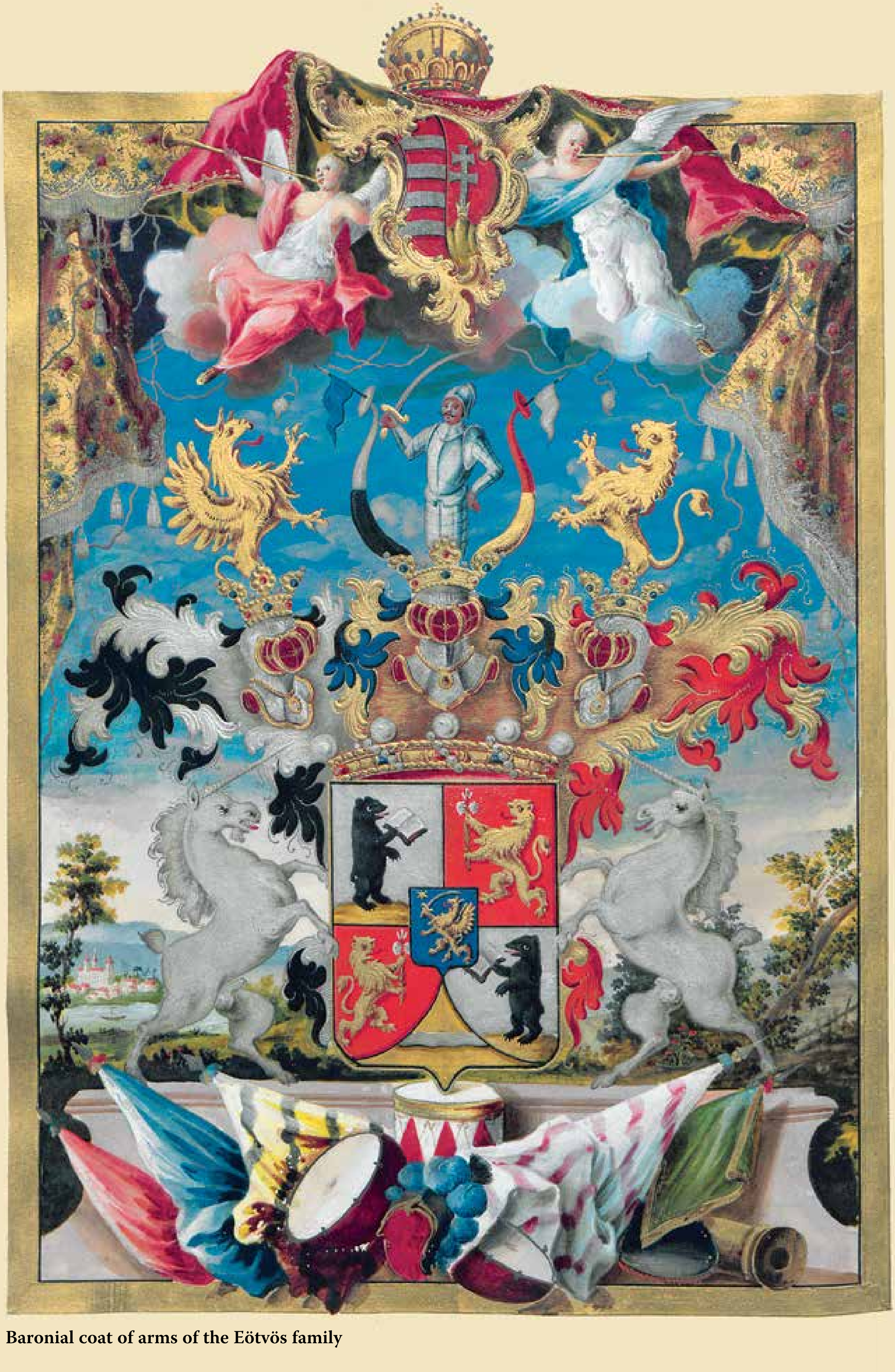
ROLAND EÖTVÖS

Memorial Album



Baronial coat of arms of the Eötvös family

ROLAND EÖTVÖS

Memorial Album

under the auspices of

EÖTVÖS LORÁND UNIVERSITY

and the

HUNGARIAN ACADEMY OF SCIENCES

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KOSSUTH PUBLISHING

With the support of

National Research, Development and Innovation Office
Hungary

PROGRAM FINANCED FROM THE NRDI FUND

within the centenary commemorations

1EÖTVÖS

ISBN 978-963-09-9929-8

Lectori salutem!

LÁSZLÓ LOVÁSZ, PRESIDENT OF THE HUNGARIAN ACADEMY OF SCIENCES

There are those whose true worth and greatness are acknowledged and appreciated by their contemporaries. Their achievements and resilience in the face of hardship continue to set an example for decades, even centuries, to come.

There are also those – although fewer in number – whose names are inextricably linked to the tangible results of their genius and their powers of innovation and perseverance. Regardless of the particular political or pedagogical system in place, the study of their lives continues to be part of the school curriculum. Prestigious institutions are named after them in recognition, and those who work and study there are conscious of their reputation and the attendant expectations.

Baron Roland Eötvös de Vásárosnamény is one such figure in Hungarian history and science. He was a world-renowned natural scientist whose academic achievements continue to inspire, as well as a statesmanlike figure in the field of Hungarian education and research.

The 100th anniversary of his death provides a unique opportunity for the research community to pay tribute to one of Hungary's greatest scientists, with, among other things, the publication of a collection of essays in honour of Eötvös's work.

The scale of the editorial task was well-nigh overwhelming. Even compiling a list of keywords to summarise his extremely rich life's work is a lengthy undertaking. Without aiming to be exhaustive, we can highlight the following from among Eötvös's achievements: his measurements confirmed the validity of the first hypothesis of Albert Einstein's general theory of relativity, the equivalence principle. The Eötvös rule describes the temperature dependence of the surface tension of a liquid, while the Eötvös effect explains the weight difference in eastbound or westbound bodies as a result of the Earth's rotation. With the foundation and culmination of the above, as an experimental physicist, he created a torsion balance, the Eötvös balance, which demonstrated the equivalence of gravitational and inertial mass.

In his role as chair of a ceremonial meeting of the Hungarian Academy of Sciences on 12 May 1901, he presented the essence of his invention as follows: "This instrument is merely a simple, straight bar, specially charged at each end, and insulated in a metal case to protect it from changes in the air and changes in temperature. Each individual mass, whether near or far, exerts an orienting force on this bar; however, the wire from which it is suspended resists, and while it resists it twists, and the degree of the twist indicates the exact magnitude of the forces that are acting upon the bar. It is a Coulomb's balance, and that's all there is to it. It is simple, like Hamlet's pipe – you merely have to know how to play it; just like a musician who can delight with wonderful variations, so with this balance the physicist, with no less wonder, can determine the subtlest variations in gravity. Thus we are able to gaze into the Earth's crust to a depth that neither our eyes nor our longest drills could ever reach." Through his achievements, as well as through the clarity of his thinking and the eloquence of his expression, he proved himself to be the worthy intellectual heir of his father, the third president of the Hungarian Academy of Sciences, writer, poet and lawyer Baron József Eötvös, a prominent Reform

Era politician who was minister of religion and public education.

He was also the respected intellectual successor to and a follower of Count István Széchenyi, the founder of the Hungarian Academy of Sciences. In the words of Eötvös, "Academies are not just scientific, but also national institutions. They are national institutions indeed, insofar as the subjects of their research are the language and literature, history, economics, social and natural conditions of our nation, and likewise they are considered as national institutions in that they express through their endeavours the scientific aspirations of a nation and enter the world's scientific arena under its banner." More than a century ago, well before the scientific and technological revolution, he made it abundantly clear that science is an international pursuit, but that, within the cross-border field of science, Hungarian researchers were obliged to accommodate themselves to the Hungarian Academy of Sciences: "The Hungarian Academy of Sciences represents the Hungarian port in the world ocean of sciences; the lighthouse keeper must ensure that the light remains in one place, but is always shining brightly so that it can be seen in good and bad weather alike by all, but above all by the Hungarian sailor."

He was a national liberal in the noblest sense of the word. His sensitivity to social issues predestined him to assume a political role, although he was not a born politician. While serving as a minister, he expanded the network of public schools and introduced the law on the emancipation of the community of the Jewish faith to the Upper House, concluding the reforms initiated by his father, József Eötvös.

As researchers, we often mention how excellence should be the only standard in the field of science. The current Excellence Programmes run by the Hungarian Academy of Sciences are supporting dedicated young scientists to follow in the footsteps of today's leading researchers. In the early 21st century, if we are looking for historical examples of the nurturing of talent, one of the most important is the frequently cited institute originally known as the Baron Eötvös József Collegium, established by Roland Eötvös, an intellectual workshop of international reputation that has been cultivating Hungarian talent for more than 120 years, and where "the intellect is free to serve". Launched in 2016, the Academy's Content Pedagogy Research Programme draws on Eötvös's concept of the "scholar teacher". As president of the Hungarian Academy of Sciences, Roland Eötvös successfully encouraged wealthy individuals to set up scholarships to support the research activities of teachers. His successors at the Academy today are likewise encouraging cooperation between teachers and researchers in order to promote new scientific achievements and even the introduction of new disciplines in the public education system.

The writer honours Roland Eötvös not only as a scientist and university professor who achieved international acclaim, but also as the president of the Academy, who, seizing the opportunity offered by the improvement in the Academy's operating conditions following the Compromise of 1867, strove to make Hungarian scientific life part of the international scientific world, which was bringing to light historically significant findings at the turn of the 19th and 20th centuries. "Let us strive to make our nation Hungarian, and not only Hungarian but also educated, and, as such, to stand tall among the larger, more powerful European nations", he appealed; with the strengthening of the sciences in Hungary, under his leadership the Academy successfully established multilateral ties with the international scientific community, becoming a founding member of the International Association of Academies in 1900. Eötvös's reputation, as well as the international recognition of Hungarian science, are also clearly demonstrated by the fact that the torsion balance was presented at the World Exposition in Paris that same year, where it won an award.

I wrote above of the overwhelming task facing the editors responsible for compiling the present volume. Besides the editors, more than a dozen foreign and Hungarian authors, including academics, have committed themselves to providing the public with a comprehensive and entertaining portrait of Roland Eötvös, scientist and scientific organiser, the father of instrumental geophysical research, public figure, intellectual aristocrat and citizen of the modernising Hungary of the fin de siècle. At its session in November 2017, the General Assembly of UNESCO adopted a resolution to commemorate the 100th anniversary of the death of Roland Eötvös together with the people of Hungary. This memorial volume has therefore been published in English as well as Hungarian.

"… our work will never be complete in the field of science", Eötvös said in his inaugural address to the Academy. Even as I hold this memorial volume in my hand, we should not deceive ourselves into thinking there is no longer any point writing new articles or books about this physicist who died one hundred years ago. Nevertheless, we can be certain that this is the most complete and attractive publication to date, by means of which the present-day admirers of Roland Eötvös are commemorating this exceptional scientist.

Lectori salutem!

LÁSZLÓ BORHY, RECTOR OF EÖTVÖS LORÁND UNIVERSITY

One of the defining characteristics of the permanent passage of time is that, whatever challenge is posed by the eternal necessity of embracing change, each precious and memorable moment is filled with at least as much ardour. Although, like most calendar years, 2019 marks the anniversary of many past events, as rector of the Eötvös Loránd University, I can assure you that one of these events is particularly special. Anyone with an interest in the world of science, politics or education knows that 2019 is the centenary of the death of Roland Eötvös.

On the occasion of this landmark anniversary, organisations closely associated with his name and work have announced a year-long series of commemorative events (including the publication of this memorial volume) to honour and celebrate his merits and achievements. The aim of this volume is none other than to present the extremely diverse undertakings associated with this great scholar, politician, university professor and academician, as well as to offer readers a portrait of his remarkable career in its entirety.

Roland Eötvös was born on 27 July 1848, in an era when individuals faced exactly the same challenges as would soon put the entire world to the test at the time of his death in 1919, and at the beginning of the 20th century. His life was framed by major events in both Hungarian and world history, which, far from auguring well, were rather characterised by the ever-changing nature of power relations. Among these circumstances, it was his family that proved to be a solid base and inspiration for him throughout his life. His father, Baron József Eötvös, was an exemplary figure.

Baron József Eötvös was a lawyer, writer and politician, as well as the minister of religion and public education in the Batthyány Government and later in the Andrássy Government. He stood as an example for his son not only in terms of his principles and political role, but also in Hungarian scientific life, being president of the Hungarian Academy of Sciences between 1866 and 1871. Education was an issue that was particularly dear to his heart, as it would be later for his son. As soon as he had an opportunity, he embarked on educational reforms that included the adoption of a law on elementary education in public schools.

Although, inspired by his father, Roland Eötvös initially studied law, his interests gradually shifted towards science in the course of his parallel studies.

His father can be commended – and in hindsight we can be grateful to him – for heeding his son's wishes and allowing him to continue his studies in Heidelberg, where he attended lectures given by great contemporary scientists.

After obtaining an excellent doctoral degree with *summa cum laude* distinction from the University of Heidelberg, he returned home to continue his research in physics and become a university lecturer. His dedication to teaching is clearly illustrated by the fact that he was entirely untroubled by the general public's surprise that he, holding the rank of a baron, pursued academic ambitions. In 1883, a decade after being elected as a corresponding member of the Hungarian Academy of Sciences at an extremely young age, he became a full member of the Academy, and was elected its president a few years later, in 1889. In this capacity, he regarded as his most important tasks the nurturing and dissemination of science and literature in the Hungarian language, as well as the promotion of greater respect for scholars and universities.

Universities were particularly important to him, as he considered them to be the repositories of independent thought. It was no coincidence that, between 1891 and 1892, he held the position of rector of the Budapest University, which is known today as Eötvös Loránd University. Following in his father's footsteps, he became minister of religion and public education, which gave him an opportunity to express his views in a political role between June 1894 and January 1895. During his brief time in office, he established several new public elementary schools and increased remuneration for teachers. He handled nationality issues with extreme sensitivity, and was likewise sensitive to the fates of poor but talented young people. The Baron Eötvös József Collegium was founded for their benefit, again at the initiative of Roland Eötvös.

After retiring as president of the Academy in 1905, he devoted the rest of his life to teaching and research in the field of physics. It is an interesting coincidence that 8 April, the day of his death in 1919, was the same day on which István Széchenyi ("the Greatest Hungarian") had died 59 years earlier.

A brief survey of his life shows Roland Eötvös to have been a truly versatile and talented individual, who endeavoured to serve others through his own undertakings at all times. He was a dedicated scholar, researcher and educator. As a minister, he was committed to the good of the people. As the president of the Hungarian Academy of Sciences, he devoted himself to enhancing respect for science and education. When rector of the Budapest University, he was as committed to the values entrusted to him, as he was to the pursuit of individual sporting activities that contributed to individual development. Few people are aware that the establishment of the Budapest University Athletics Club (BEAC) is linked with his name, and that he was the first president of the Hungarian Tourist Association.

His passion for mountaineering and hiking is commemorated today by the Baron Roland Eötvös Hikers' Lodge.

However, while success and achievements are clearly visible with hindsight, we reach them only by making difficult and responsible decisions, the final outcome of which remains shrouded in the mists of the future. In this context, our own values are our only guide, along with the experiences accumulated and passed on to us by our predecessors throughout their lives. After all, growing up in the everyday sense of the word is a mere biological process that takes place independently of our will, but rising to the challenges that face us is an entirely different matter. It demands a voluntary commitment to a journey on which we are able to surpass our former selves, and, based on the knowledge available, fight our own battles in a way that our achievements and experience enrich those who come after us. That is why it is important to take stock of our achievements from time to time and to be aware of what is worth preserving. We should at the same time demonstrate our respect towards the original and true owners of knowledge.

As rector of Eötvös Loránd University, I am proud that our university bears not only the name of Roland Eötvös, but also shares his values and preserves his legacy. As the Latin proverb says: *Nomen est omen*. It is an obligation that we are delighted to fulfil, especially because his thinking has stood fast through the storms of time. For, if the problems facing what was in his time regarded as the accelerated world of the 19th century could be remedied by a comprehensive intellectual grounding, the individual of today should not remain unarmed for the struggle, because rapid intellectual adaptation to change is now an essential aspect of life. At the same time, it is in the fundamental interest of us all that constant innovations based on our common traditions become an integral part of our lives, and thus evolve into genuine values in the long term.

Surveying the legacy of Roland Eötvös as a whole, I believe that this volume, with its richly illustrated and scientifically invaluable studies, is a worthy contribution to the series of centenary-related commemorations, the events that present specific aspects of Eötvös's life, together with the commemorative stamps and medals.

I would like to express my gratitude and appreciation to the organisers of the commemorations and those responsible for compiling the present volume for their outstanding professionalism. However, special thanks go to you, the readers of this book, for being among the most important participants in bringing to life the past of Roland Eötvös and contributing to the joint commemorations by browsing these pages.

I sincerely hope you will find this volume both useful and entertaining.

Introduction

MIKLÓS RÉTHELYI, CHAIRPERSON OF THE HUNGARIAN NATIONAL COMMISSION FOR UNESCO

ROLAND EÖTVÖS
27 JULY 1848 – 8 APRIL 1919

Roland Eötvös can be described as extremely talented, multifaceted, goal oriented, meticulous and methodical. After high school graduation he went to Germany for three years and, in contrast to the expectations of his father, chose to study science instead of law at the world-renowned German universities. In spite of this disagreement, their correspondence, which was widely quoted by Izidor Fröchlich in his talk *The Memory of Baron Lorand Eötvös* at the general meeting of the Hungarian Academy of Sciences, reveals a warm and harmonious relationship between father and son. The correspondence shows a beloved son beginning to live his own life, asking for his father's help and accepting his father's decisions, sometimes even when they go against his own wishes. He asks his father to summon him home from Königsberg earlier than planned in order to give a legitimate excuse for his premature departure – "I don't have enough patience to wait for the end of the semester: I wouldn't want to make it public here", he wrote home. His father disagreed, because he could not believe that the "teachers' lectures would be worthless, and even in this case that his son would be unable to learn from them." Thus he persuaded Roland to stay, which he did. It turned out later that his father's advice was valuable and Roland left Königsberg at the end of the semester with positive memories. Driven by his insatiable thirst for knowledge, Roland had serious plans to participate in an Arctic expedition – and again he requested his father's consent. The answer was discouraging: it would cause his mother unbearable anxiety, as she would imagine her son to be in constant danger. An additional argument against the expedition was that he would "miss at least a year of study, even if he returned in good health, which was far from certain." "Stay at home this time: you can always go by yourself later," his father wrote.

Between 1867 and 1870, attending the lectures of distinguished professors and participating in their laboratory work carried out in German universities, Roland Eötvös formulated his intellectual and scientific objectives. His regular correspondence with his father played a key role in this process. The chosen career involves the kind of activities "that make one's heart beat faster" (and) "we must remain faithful to it, even in the face of hardship" – wrote the young Roland Eötvös, continuing:

"Since each individual is forced to act for the benefit of humankind to the best of his or her abilities," he wanted to do something for humanity in his own country; his most important task being to contribute to the erudition of the country, by which he meant intellectual refinement and the dissemination of science.

The memory of Roland Eötvös has been enriched by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in two respects:

On the one hand, *Three documents related to the two most outstanding results of the work of Roland*

Eötvös were included in the UNESCO *Memory of the World Register* in 2015. The goal of the Memory of the World programme is to record and protect the most valuable elements of the world's documentary heritage.

On the other hand, following the joint celebrations with UNESCO of the anniversaries of János Szentágothai, György Solti, Robert Capa, Miklós Ybl, Ödön Lechner, Ignác Semmelweis, Flóris Rómer, Bishop Saint Martin and Zoltán Kodály, in 2019 Hungary is commemorating the centenaries of the deaths of the physicist, geophysicist and innovator of higher education Roland Eötvös (1848–1919) and the painter Tivadar Csontváry Kosztka (1853–1919) together with UNESCO and its 193 Member States.

Mathematician and university professor Lajos Dávid (1881–1962) published an article in praise of Roland Eötvös in the 1919/7 issue of the literary magazine *Nyugat,* which he ended with the following lines:

"And how spontaneously he is able to communicate his thoughts, taking apart the tangled threads of reality. Only at the end does his audience become aware of how difficult the road has been, and of the depths over which he has led them to incredible heights. When this happens, we can only agree how right he is to expect greater things from our universities, first and foremost when there are active scientists teaching there who are thinking creatively rather than merely remembering accurately."

UNESCO

United Nations
Educational, Scientific and
Cultural Organization

100th anniversary of Roland Eötvös (1848-1919), physicist, geophysicist, and innovator of higher education

Commemorated in association with UNESCO

GYULA RADNAI

Roland Eötvös, natural scientist

SCIENTIFIC LEANINGS, AMBITIONS AND MOTIVATION

József Eötvös (1813–1871)

"Father, to whom I owe my life on Earth!
Who raised me and shaped my intellect,
I sacrifice it to the country of my birth,
To those who deem it worthy of respect."[1]

Childhood and adolescence

Roland Eötvös (in Hungarian his first name is Loránd) was born on 27 July 1848 in Buda. His father, the writer and politician József (Joseph) Eötvös, recalled the day in a letter written to his son on his 20th birthday:

"The day you were born was one of the most painful days in my life. After giving birth, your mother's life was in danger. In the city, the mighty people were in revolt, and, as I sat by my wife's bedside in hope and despair, the alarm bells were ringing out from the towers of Pest-Buda, filling the silence of the night, and a steady stream of messages arrived summoning me to a meeting of the Cabinet. I had never known such suffering as during those hours, until, at around dawn, Dr. Balassa informed me that your mother was no longer in danger, and I kissed her and hastened to the city. Now it seems that, through grace, fate is to make up for what I suffered at that time by so ordering that it should be you, who unconsciously inflicted my torment, who now brings me the greatest pleasures in my life. May Heaven grant you a long life, healthy in mind and body, and bring you a sense of self-fulfilment. I am unable to wish you more, convinced as I am that you are more demanding of yourself than I could ever be."

At the time this letter was sent to his son in Heidelberg, József Eötvös was 55 years old, and once again serving as minister of religion and education, as he had been 20 years earlier. Although the demanding work that came with this role affected his health – who could know then that he had only three more years to live? – this doting father, who raised his children with such concern and devotion, remained a role model for his son throughout his life.

The first two years of Roland's life were spent in Bavaria, living near József Eötvös's sister Julia, where – after the killing of the minister of war Latour by the mob in the Vienna uprising and the stabbing of the Austrian field-marshal Lamberg in Hungary – the family had fled via Vienna with their daughters, aged 1 and 2, and the infant Roland in October 1848. Ágoston Trefort and his wife, József Eötvös's sister, accompanied them in their flight. They did not return to Hungary until the end of November 1850. In 1854, Trefort's only son was born, and a second son was born to the Eötvös family, although he died very soon from diphtheria. Six-year-old Roland took it very badly, and his parents were so worried about him that they kept him at home at the slightest suspicion of illness or infection. He was thirteen when József Eötvös asked his friend, Tivadar Pauler, to recommend one of his law students as a tutor for his son, who was attending the Piarist Grammar School in Pest. Pauler recommended two students, and Eötvös accepted both of them. This is how 27-year-old Gusztáv Keleti and 22-year-old Tamás Vécsey became Roland's teachers. Gusztáv Keleti later abandoned the legal profession to become a painter, and he endeavoured to develop Roland Eötvös's skills in the fine arts and drawing, with some success. Following in his father's footsteps, as an adolescent Roland Eötvös wrote poems and kept a diary, in which he made sketches during his excursions. He was a keen walker. Not only did he enjoy reading books, he also took pleasure in observing and studying the natural world.

His father noticed Roland's special interests and obtained relevant books for him. He hired

Ágnes Rosty, wife of József Eötvös (1825–1913)

"Butterfly, flower, each living thing,
Oh mother dear your blessings sing,
While one who owes you all, alone
Is lost for words: your son."[2]

mineralogist József Krenner, who was the same age as Tamás Vécsey, as a tutor, and introduced his son to the chemist Károly Than, who was the same age as Gusztáv Keleti, and who immediately took Roland under his wing, allowing him to carry out experiments and make measurements in his university laboratory. (Mór Than, the brother of Károly Than, also painted Roland's mother. A close relationship developed between the Than and Eötvös families.)

In 1865, Roland Eötvös successfully passed the baccalaureate exam at the Piarist Grammar School and, just as expected, enrolled in the Faculty of Law at the University of Pest. He completed his first academic year in 1865/66 and made friendships, although the lectures and subjects on offer failed to satisfy his interests. In the meantime, he studied mathematics with Ottó Petzval, mineralogy with József Krenner, and astronomy with Gusztáv Kondor at the university. At the end of March 1866, towards the end of his first year, the 18-year-old wrote to his father: "I am compelled by ambition and a sense of duty that binds me not only to a privileged nation, but towards all of humankind; to satisfy these two passions, and to satisfy them while maintaining my independence as an individual, is my purpose in life, and I find that I can best fulfil them by pursing a scientific career… Through the books you have given me, you yourself have contributed to my advancement. But can I study from them on my own? I am studying mineralogy, but I do not know any minerals; I am studying geology but the simplest formations puzzle me; I am studying zoology with no animals and botany with no plants – in short, the natural sciences with no nature. I believe that this problem could be resolved at a foreign university, under the guidance of good teachers…"

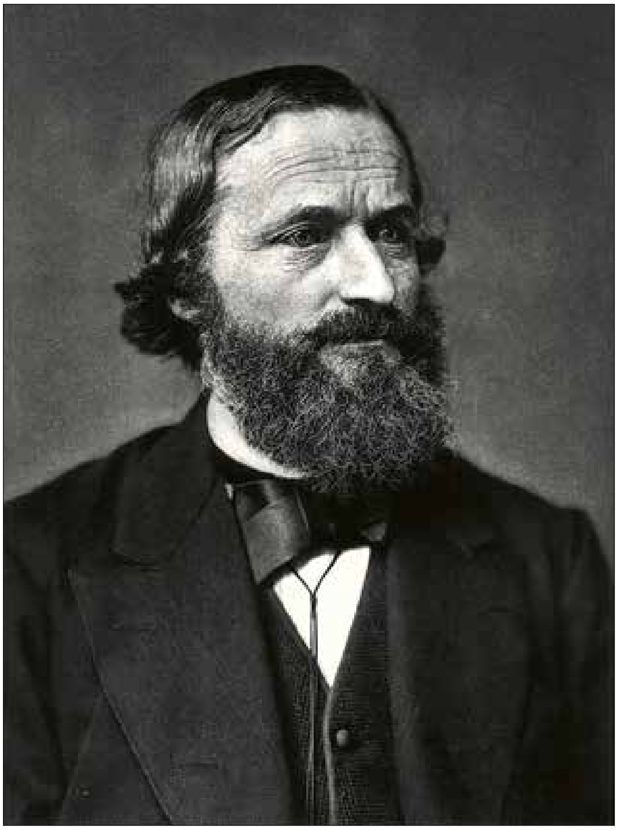
Károly Than recommended that Roland should attend university in Heidelberg, where his former teacher, Robert Bunsen, was professor of chemistry. Bunsen was only two years older than József Eötvös, and they knew one another. However, in 1867, the year of the Austro-Hungarian Compromise, when József Eötvös was reappointed as minister in the Austro-Hungarian Monarchy, it was not an easy decision to allow his son to attend a foreign university, bypassing Vienna…

Károly Than (1834–1908)

Chemist, member of the Academy of Sciences, and distinguished public lecturer at the University of Pest from 1862. In 1858, he was made doctor of chemistry at the University of Vienna. From there, he won a scholarship to Heidelberg, where he continued his studies in Bunsen's laboratory. Roland Eötvös's first lectures were delivered in the small hall at the Institute of Chemistry, which had been constructed according to his plans.

The Heidelberg years

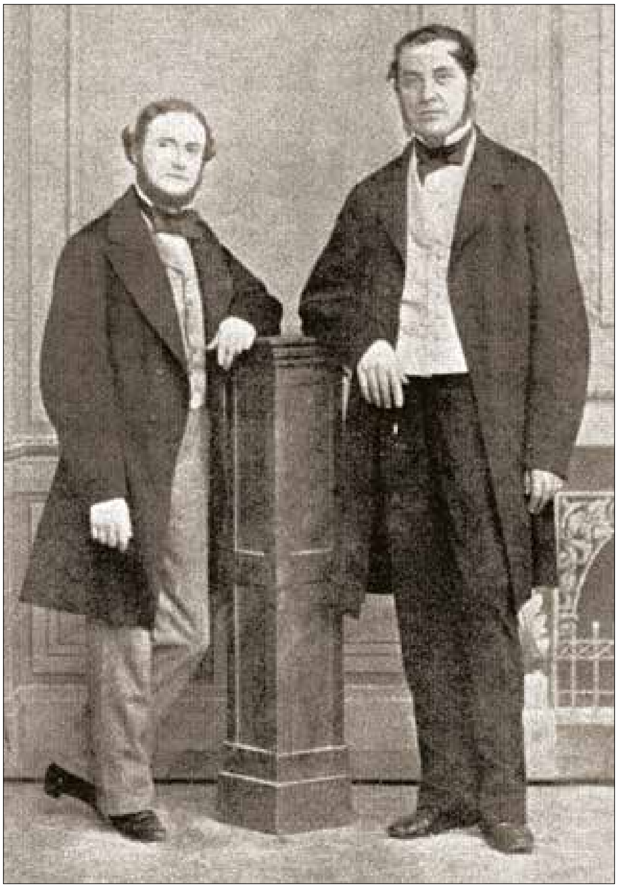
"I will never forget the moment my train arrived in Heidelberg station along the Neckar Valley. I was happy just being able to breathe the same air as those erudite men whose fame had brought me here… And how did we study in Heidelberg? We enrolled for no more than 20 or 25 hours of lectures per week, but we did actually attend the lectures we'd chosen. We weren't content to merely listen, we also made notes on what our teachers said, and, based on these notes, made more or less extensive lecture notes for ourselves at home… In Germany, there is no requirement that a university professor write a textbook that he then reads out at his lectures…" wrote Roland Eötvös in an open letter to the minister of religion and education Ágoston Trefort, which was published in the journal *Budapesti Szemle* in 1887.



Most of the notes that Roland Eötvös made in Heidelberg have been held in the Manuscript Library of the Hungarian Academy of Sciences since 1972 and are freely accessible. At that time, the German universities did not have autumn and spring semesters, but rather winter and summer semesters. In the winter semester of 1867/68, Roland Eötvös had four hours a week of algebra and five hours of experimental physics in the mornings, while he also had lectures in the afternoons, including one on meteorology. He attended seminars on Saturdays. After the summer semester of 1868, he decided to choose physics under Kirchhoff as his main subject, rather than chemistry under Bunsen during the third semester. The slightly old-fashioned Bunsen had less of a hold on him than Kirchhoff, a more dynamic lecturer in his early forties. Eötvös particularly enjoyed Kirchhoff's laboratory, where the professor evaluated his work according to the accuracy of his measurements. To achieve top marks, he had to produce more accurate measurements than Kirchhoff.

Gustav Robert Kirchhoff (1824–1887)

He completed his university studies in his hometown of Königsberg, before obtaining his doctorate in Berlin. His dissertation focused on the laws related to the electric circuits that he had worked on during his years at university. This makes the name of Kirchhoff familiar today to high school students throughout the world. He went to Breslau (now Wrocław, Poland) with the support of Robert Wilhelm Bunsen (1811–1899), with whom he then went to Heidelberg. The topical questions of light and thermal radiation were among Kirchhoff's favourite research subjects. Kirchhoff's law of thermal radiation is part of the university curriculum today, while Kirchhoff's diffraction formula for modelling the propagation of light features even now only in specialised university lectures. In 1875, the Department of Theoretical Physics was established specifically for Kirchhoff at the University of Berlin. It is worth noting that a similar department had been established at the University of Pest four years earlier, for Roland Eötvös.



Kirchhoff and Bunsen in Heidelberg

In Heidelberg, Bunsen and Kirchhoff worked on the development of spectral analysis, the most exciting physico-chemical method of material analysis in the 19th century. They also identified two previously unknown chemical elements: rubidium and caesium.

He managed to do this on several occasions, thus winning the confidence of his teacher. The professor, who was of relatively short stature and often suffered pain in his legs, had no ambitions as a mountaineer, rather impressing Eötvös with the superiority of his intellect.

Gustav Robert Kirchhoff was born in Königsberg, where he attended university. He studied physics under Franz Neumann, who, along with Wilhelm Weber who was at that time working with Gauss in Göttingen, was regarded as one of the leading physicists in Germany. His mathematics tutor was Friedrich Richelot, whose daughter Kirchhoff later married. On 30 June 1868, Eötvös visited him to congratulate them on the birth of their fifth child. Kirchhoff advised him to spend a semester in Königsberg, under Professor Neumann.

View of Heidelberg

Just as Than had done, Kirchhoff directed Roland Eötvös toward his own favourite professor. Accordingly, Eötvös spent his fourth semester, the summer of 1869, in Königsberg. However, it was a decision that almost brought an end to his scientific ambitions. He was unable to understand the mathematics that was used in the lectures at Königsberg, and his love of the natural world was pulling him in an entirely different direction: he wanted to join an expedition to the North Pole. To do so, he needed to contribute a certain sum of money, which Roland hoped his father would provide. As a concerned father, and with excellent pedagogical reasoning, József Eötvös advised his son against this venture, persuading Roland to continue his university studies back in Heidelberg, where, with his prodigious stamina, within the space of a year he had worked his way up to be among the very best. Meanwhile, during Roland Eötvös's time in Königsberg, Kirchhoff's wife contracted tuberculosis and died. The way in which Kirchhoff managed to adjust to this change in his circumstances must have provided something of a role model for Eötvös. He took care of his children and continued to give his lectures, merely taking a temporary break from writing publications. When Eötvös applied to take his doctoral examination at the end of the sixth semester, his favourite professor invited Bunsen and the new professor of mathematics, Königsberger, to be his fellow examiners. He passed with flying colours: in July 1870, Roland Eötvös obtained his doctorate *summa cum laude* from the Ruperto Carola University in Heidelberg.

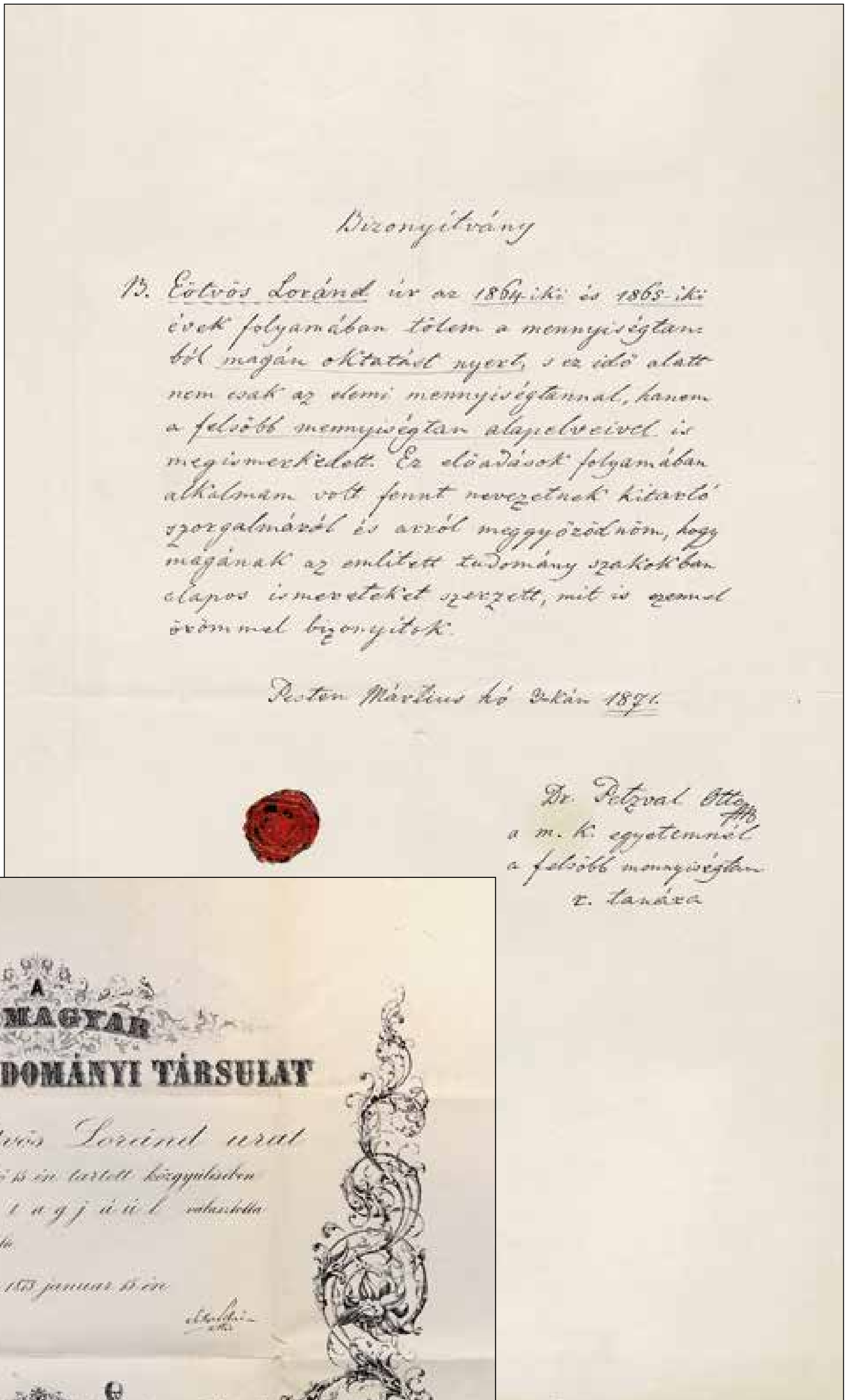
Early career in Hungary

Roland had only six more months to benefit from his father's presence: József Eötvös died on 2 February 1871. The young 23-year-old, aware of the responsibilities that now fell to him, took the sad news as a mature adult. He behaved just as his father would have expected: he remained strong and did everything he could to establish his scientific career. He drew on some authoritative figures for support: Károly Than, Ottó Petzval and Ányos Jedlik helped him on his path. A month after his father's death, he applied to the Faculty of Arts for an associate professorship in mathematical natural sciences – known today as theoretical physics. And why this particular discipline? Because the Department of Natural and Power Engineering (that is, experimental physics)

Ányos Jedlik (1800–1895), Benedictine university professor

Between the ages of 40 and 78, Ányos Jedlik was a professor in the Department of Natural and Power Engineering (i.e. experimental physics and mechanics). In 1848, the year of the Revolution, he was dean of the Faculty of Humanities in Pest, and in 1864/65 he became rector of the university. In 1850, he wrote the first Hungarian university textbook on physics, introducing a number of Hungarian technical terms, and he gave his wholehearted support to the professorial appointment of 23-year-old Roland Eötvös.

“Certificate” awarded by Ottó Petzval (1809–1883), confirming that Roland Eötvös, while preparing for his baccalaureate, successfully mastered the principles of higher mathematics during private lessons.



Bizonyítvány

B. Eötvös Loránd úr az 1864-iki és 1865-iki évek folyamában tőlem a mennyiségtanból magán oktatást nyert, s ez idő alatt nem csak az elemi mennyiségtannal, hanem a felsőbb mennyiségtan alapelveivel is megismerkedett. Ez előadások folyamában alkalmam volt fennt nevezettnek kitartó szorgalmáról és arról meggyőződnöm, hogy magának az említett tudomány szakokban alapos ismereteket szerzett, mit is nemcsak örömmel bizonyítok.

Pesten Márczius hó 9-kén 1871.

Dr. Petzval Ottó
a m. k. egyetemnél
a felsőbb mennyiségtan
r. tanára

Artistic confirmation that Roland Eötvös became a supporting member of the Hungarian Royal Society of Natural Sciences in 1873. Signed by: Károly Than and Kálmán Szily (1838–1924), then general secretary of the society and editor-in-chief of the journal *Természettudományi Közlöny* (Communications in Natural Sciences).

A KIR. MAGYAR
TERMÉSZETTUDOMÁNYI TÁRSULAT

Mélt. Báró Eötvös Loránd urat
1873 ik évi januar hó 15 én tartott közgyülésben
pártoló tagjául választotta
s ezen oklevelet kiadni rendelte
Kelt Budapesten 1873 januar 15 én

was headed by Ányos Jedlik, and he wished to do things in his own way.

Less than two weeks later, he was associate professor of "the higher natural sciences", and barely a year later became a corresponding member of the Hungarian Academy of Sciences. In 1880, in his inaugural lecture, he recalled the beginnings of his career as follows:

"I endeavoured to enter the field of scientific undertakings in Hungary as a young man with keen ambition but with no personal merit, and I discovered that every door opened before me, as if by some magic word, and I found helping hands on every side, offering to support my first steps. This magic word was the name of my late father, my most valuable inheritance, a constant reminder that I must live up to it through my work. I had never been so keenly aware of this as when the prestigious Academy admitted me as a corresponding member. To earn this honour, and to prove myself worthy of it, will be one of the greatest ambitions of my life."

And prove it he did. In terms of scholarly endeavours, his role model was Gustav Kirchhoff. Initially, he continued to pursue the topics in which he had been involved in Heidelberg: he gave lectures at the university in theoretical physics on the subject of physical optics, delivered the paper "On the Law of the Action-at-a-Distance as Deducted from Vibration Theory" at a session of the Academy, and lectured on the theory of capillarity at the Society of Natural Sciences, presumably on the basis of Franz Neumann's lectures in Königsberg.

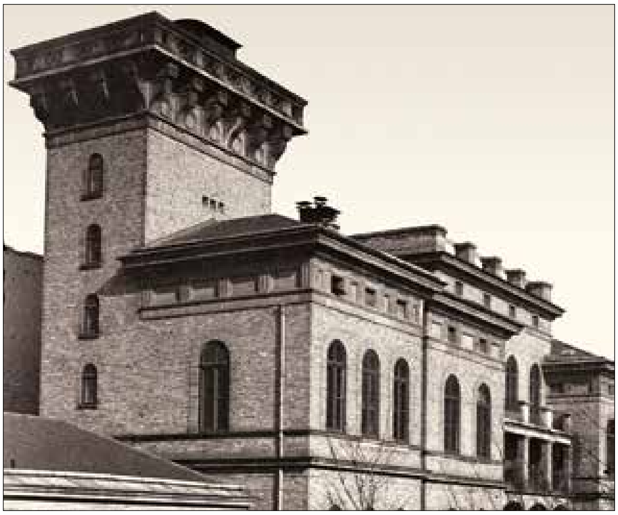
His was no easy task, as he had learned all the physical terminology in German and had to translate it into Hungarian. While working in Neumann's laboratory, he had developed a precise, original method for measuring the surface tension of liquids, which had earned him praise from the renowned professor. He soon began to work on this research topic at his home institute by himself. His young teaching assistants, who included Jenő Klupathy and Géza Bartoniek, assisted him with the measurements.

Marriage, teaching, institutional management

Encouraged by his mother, he began to think more and more about starting a family. He met Gizella Horváth, five years his junior, while skating one winter. As a "young lady from a good family", the match was acceptable for his mother: Gizella's father was Boldizsár Horváth, minister of justice in the first post-Compromise government. The young couple quickly fell in love.

They became engaged in May 1875, and in July, the day after Roland Eötvös's 27th birthday, they were married. Although the wedding took place in Marienbad (now Mariánské Lázně, near the Czech-German border), rather than in Hungary, a Catholic priest from Hungary officiated at the ceremony, which followed Hungarian tradition. They travelled to France for their honeymoon.

One year earlier, in 1874, Roland Eötvös had already won the right to lecture on experimental physics at the university, and for this purpose he was authorised to use Jedlik's laboratory. However, in order to distinguish his course of lectures from those given by Jedlik, he advertised it as "General



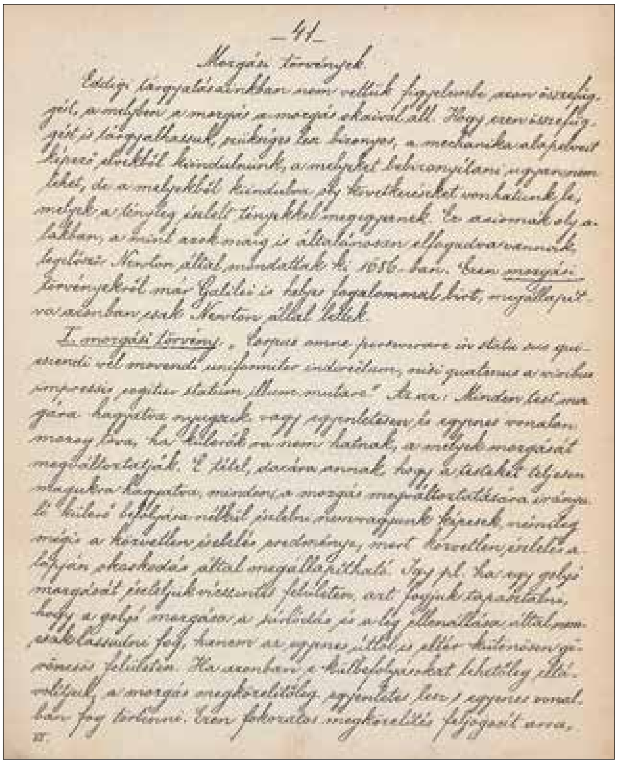
Building D, constructed in 1886, where Roland Eötvös lived, taught and carried out his experiments, is now a historic site of European physics

The series of measurements by Eötvös, Pekár and Fekete, which they submitted for the Beneke Prize, were undertaken here using the Eötvös balance. In 2018, a commemorative plaque was commissioned by the European Physical Society and the Eötvös Loránd Physical Society.

Experimental Science", taught for five hours per week. A handwritten lithograph of notes from this lecture has recently come to light, in which the influence of his German university studies is clear. However, it must have been his own decision to teach the laws of Newton in their original form, also in Latin (Newton himself never saw the English version of his book…). Interestingly, Eötvös finished the academic year with lectures on sound and light, two subjects to which he may have been attracted through the lectures of Helmholtz, whose popular scientific presentations he translated from the German with Jenő Jendrassik in 1874. Eötvös's views on physics at that time are also reflected by his reading of "On the Question of Action-at-a Distance", given at the General Assembly of the Academy in 1877 and published in the 1877 Yearbook of the Hungarian Academy of Sciences.

Gustav Kirchhoff, whose concepts regarding research in physics were adopted by Roland Eötvös, moved from Heidelberg to Berlin in 1875, to the department of "mathematical physics", which was established specially for him. It is interesting in itself that the University of Pest had a department of theoretical physics before Berlin…

In 1878, Ányos Jedlik retired at the age of 78. From that time on, Roland Eötvös, both as a father and as the head of the institute of experimental physics, had to live up to his own strict standards. In 1881, he attended the International Electrical Congress in Paris, as a representative of Hungary. Károly Than went with him to the Congress, while Gustav Kirchhoff participated as a representative of the German Empire. They must have met there, although no document of the meeting has survived. Understandably, even in Paris Eötvös was thinking more about his own small daughters (Rolanda, who was born in 1878, and Ilona who was born in 1880) than details of the latest inventions in electricity, which were anyway difficult to follow. "There are an awful lot of frauds," he wrote to his wife back home. In 1882, he purchased a villa surrounded by many acres of park in Szentlőrinc, where he was able to spend the summer months with his family, and in 1883 construction work began on a new physics building near Károly Than's Institute of Chemistry. The designers consulted Eötvös, and, as was customary at that time, created a director's apartment for him in Building D. For Eötvös, the time had come to publish the theoretical and experimental results of his capillary-related research in a foreign language, and this happened in 1886, the year in which Building D was completed. (For more details, see the contribution to this volume by József Cserti and András Patkós.)



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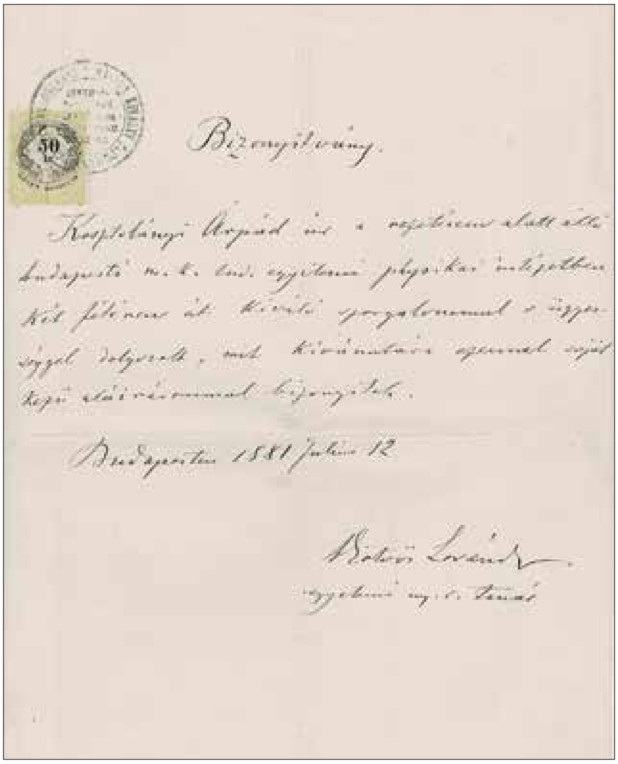
Mozgás törvényei

Roland Eötvös considered Newton's laws of motion to be of such importance that he taught them in Latin, in the original wording.

Newton's famous work "Principia …" was published in 1687 in Latin, the language of science at that time. Eötvös had the volume in his library. Lithographed notes on his lecture (not in Eötvös's handwriting) are held in the University Library and are freely accessible.



Bizonyítvány.

Budapesten 1881 július 12

Eötvös Loránd

"Certificate" issued by Roland Eötvös confirming that Árpád Kosztolányi (father of the poet and novelist Dezső Kosztolányi) was an excellent student of physics at the university.

On the path to world renown

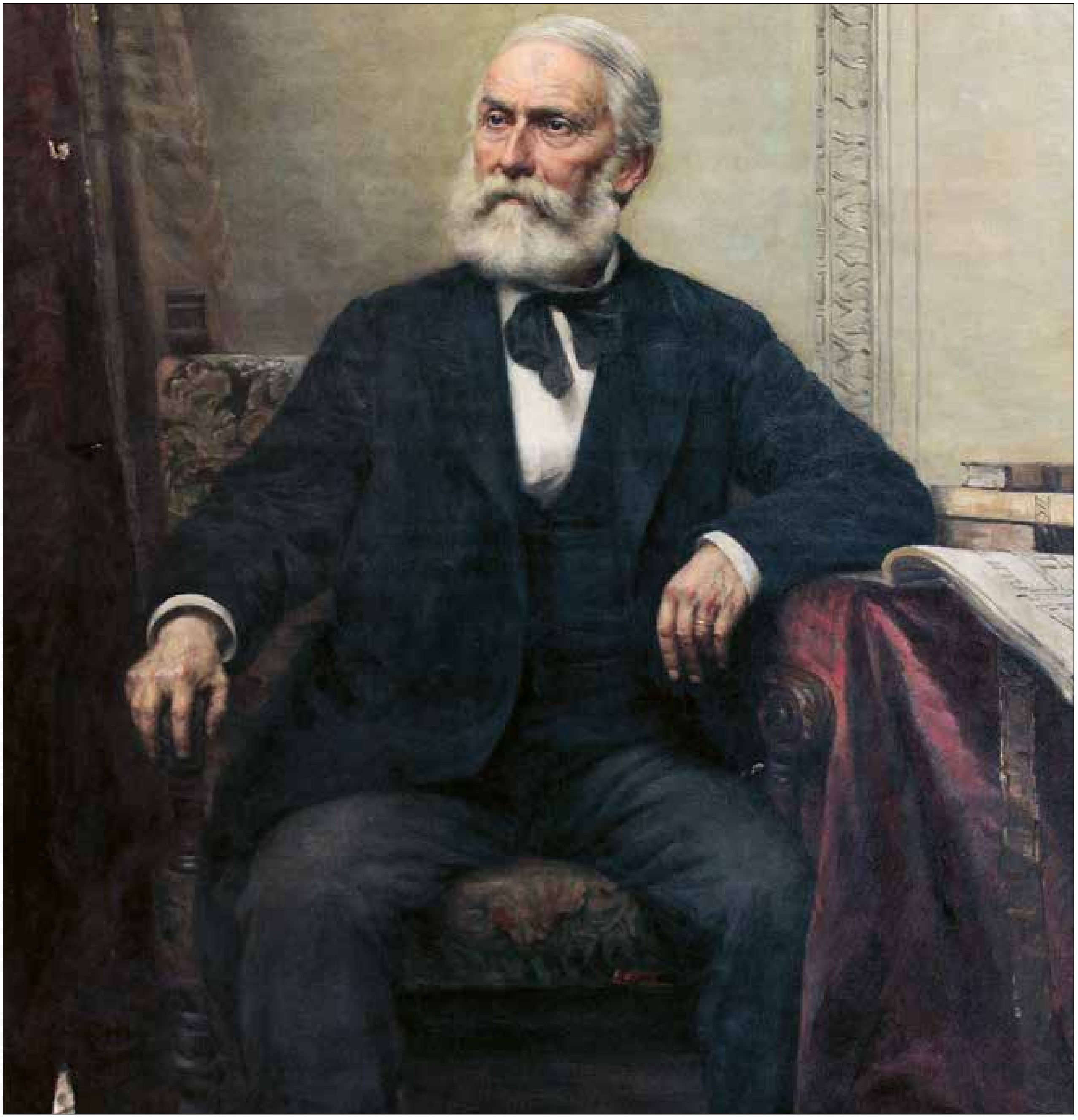
Building D included a physics lecture hall that could seat several hundred people, with a connected laboratory and preparation room. Eötvös had hoped to entertain his audiences with spectacular, new experiments, but his audience did not appreciate the work he had invested. The professor was frustrated by his students' lack of interest and their inability to appreciate the efforts he had made on their behalf. Recalling his own university experience, in 1887 he wrote a desperate, open letter to Ágoston Trefort, the then minister of education, a good friend of his father: "Anyone walking through the teaching rooms at the University of Budapest, expecting to find large audiences but seeing just how few students bother to listen properly to the lectures, may well ask if it is

The building of the Hungarian Academy of Sciences in Pest (built in 1865)

even possible to educate young people in the sciences, if the majority of them aren't even there", he pointed out in his long letter in *Budapesti Szemle.*

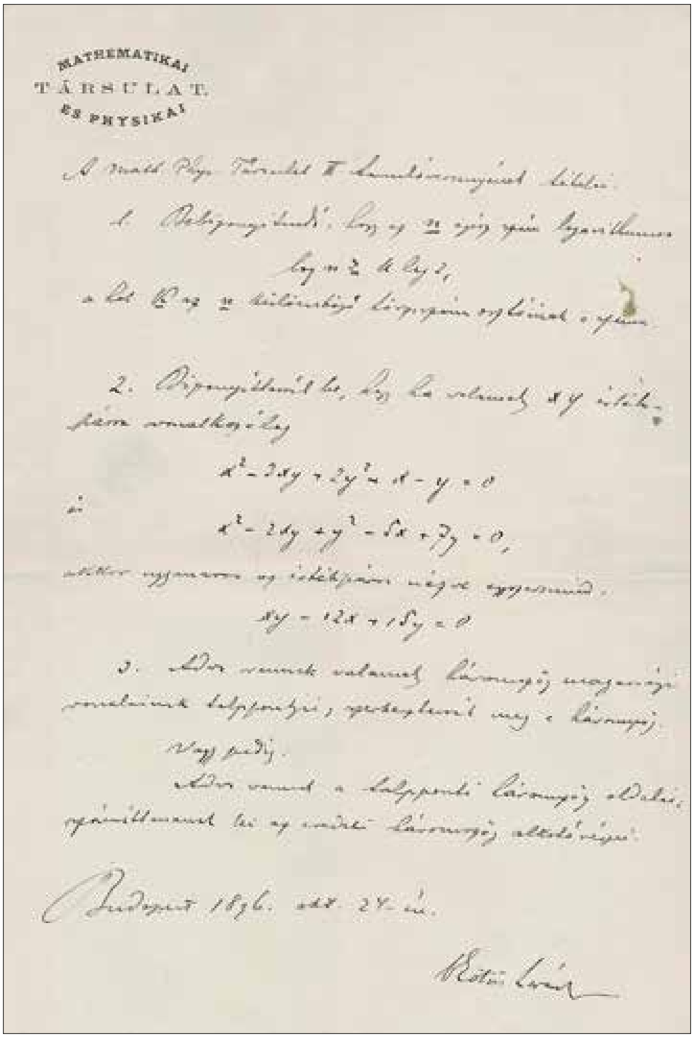
In November 1887, his disillusion was exacerbated by news from Berlin: Gustav Robert Kirchhoff, his beloved teacher from Heidelberg and his role model, had died. Eötvös took refuge in his studies, although at the same time he hoped to find a competent, or at least interested, environment – if not among the young, then among the older generation. At the initiative of Béla Lengyel, a professor of chemistry whom he had first met in Heidelberg, and being motivated also as vice president of the Society of Natural Sciences, he announced a 10-week series of scientific lectures on "the current state of physics and its research methodologies" in the great lecture hall of Building D. The lectures took place in the first months of 1888, and the series was a resounding success. One of the experiments that Eötvös presented in January was described in the journal *Vasárnapi Ujság* a year later: "… in a heated lecture hall, glowing in the lamplight, he demonstrated to an audience of over 300 people how it takes a few kilograms of mercury to attract a piece of lead weighing less than 100 grams…".

However, a minor accident occurred in February, when a glass tube that had been prepared for a lecture on the thermodynamic critical state exploded during the experiment. Eötvös's face was grazed by splinters of glass, and he was fortunate that his eyes were not damaged… At that point, he abandoned his research on critical capillarity. He sought a new subject, investigating, for example, the temperature dependence of the optical refractive index of liquids and developing a new method for its measurement. He made a huge number of measurements, although he was unwilling to publish them until he had found the appropriate theoretical background to explain the fascinating data. In the end the method was published not by him, but by



Ágoston Trefort (1817–1888)

He was twenty when he met József Eötvös, four years his elder, with whom he established a lifelong friendship. At the age of 30, he married the younger sister of Ágnes Rosty. They were godparents to Roland Eötvös. After the death of József Eötvös, from 1872 until the end of his life he was minister of religion and education, and from 1885 he was president of the Hungarian Academy of Sciences. By constructing new buildings, establishing new sections, increasing the number of laboratories and modernising their equipment, he raised the standard of higher education, especially in the field of medicine. It was during this period that the buildings of the Technical University on Museum Boulevard, the University Library, the Faculty of Medicine, and the "Clinics Quarter" on Üllői Street were completed. He spoke several languages, and in this respect also served as a role model for Roland Eötvös.



MATHEMATIKAI ÉS PHYSIKAI TÁRSULAT

$$x^2-3xy+2y^2+x-y=0$$

$$x^2-2xy+y^2-5x+7y=0,$$

$$xy-12x+15y=0$$

Budapest 1896. okt. 24-én.

Eötvös Loránd

The predecessor of today's Eötvös Competition, the Student Competition for graduates was launched by the Mathematical and Physical Society on the occasion of the appointment of Roland Eötvös as minister in 1894.

Initially, Eötvös was involved even in setting the problems to be solved, later he took part only in the award ceremony, handing over the prizes that were named after him to the two winning competitors. In 1896, the first competition was won by Aladár Visnya (1878–1959), with Győző Zemplén (1879–1916) in second place.

the Russian scientist Boris Galitzin, who had worked on the same topic independently.

In the autumn of 1888, Eötvös's uncle and godfather Ágoston Trefort, who was then not only minister of religion and education but also president of the Hungarian Academy of Sciences, died unexpectedly. It suddenly became essential for Eötvös to work on something of major scientific importance, having been elected as a full member of the Academy in 1883.

An exploration of the Earth's gravity and magnetic field seemed an appropriate challenge. Although he had already begun the research in as early as 1888 (but certainly no earlier, contrary to what many historians of science thought and continue to think today), he remained consistent in terms of his cautious publication practice.

In 1890, at a session of Section III of the Hungarian Academy of Sciences, he reported that he had significantly improved on the accuracy of Bessel, and he even published his findings in the journal *Mathematische and Naturwissenschaftliche Berichte aus Ungarn* in 1891, although it was several years before he published a scholarly study on his experiments and research on gravity. This research topic proved to be of wider significance, as demonstrated in the spring of 1889, when the Academy elected 41-year-old Roland Eötvös as its president, in place of the late Ágoston Trefort.

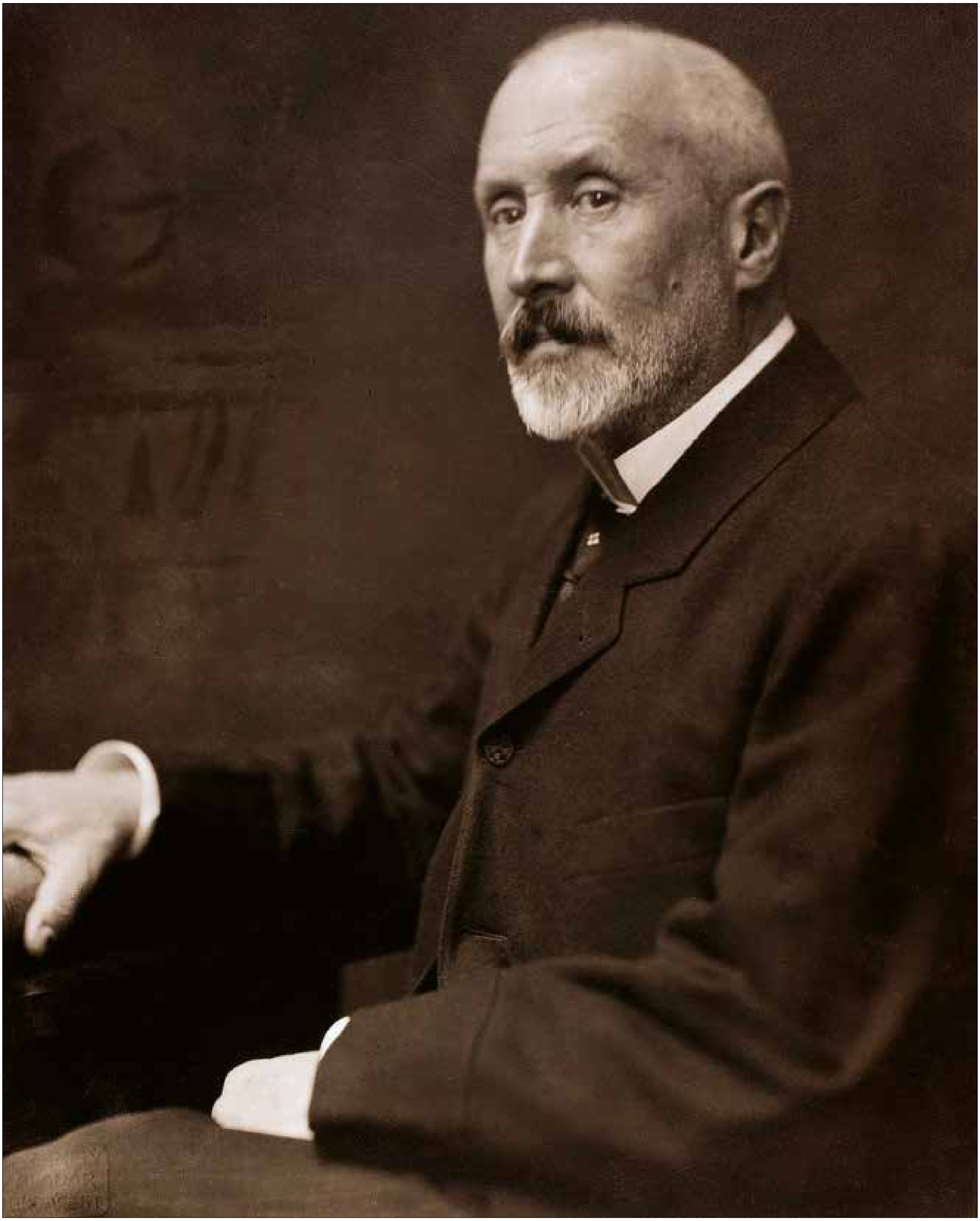
Science until death

For the remainder of his life he continued his research on gravity, as described in several of the fascinating articles in the present volume. He invited Kálmán Szily, who had earlier convinced him to join the Society of Natural Sciences, to become secretary general of the Academy, which proved to be an excellent move. In 1891, he established the Mathematical and Physical Society in order to expand his professional base in Hungary, and, following in the footsteps of his father, he accepted the post of minister of religion and education in 1894. It was during this time that his long-standing plans were approved for the establishment of a teachers' training institute of high scientific standards, dedicated to, and later named after, his father. At the 1896 Millennium Exhibition, an X-ray tube made in the glass workshop at the Institute of Experimental Physics was exhibited in the public education pavilion, even attracting praise from the visiting Emperor Franz Joseph. Nándor Süss was invited from Kolozsvár (Cluj-Napoca) to Budapest, where, under the guidance of Eötvös and with suggestions from Eötvös's colleagues, former students of his Dezső Pekár and István Rybár, he produced more and more innovative torsion balances in the workshop that would become the Hungarian Optical Works a few decades later.

The introduction of the Eötvös balance at the World Exposition in Paris in 1900, and Eötvös's French-language presentation at the surveyors congress, attracted the attention of the scientific world. In 1906, at the request of the chair of the conference session, he repeated in French the presentation he had delivered in German at the Budapest Conference of the International Federaton of Surveyors, after which he demonstrated the measurement process so successfully to the foreign scientists who were visiting the measurement site that they appealed to the Hungarian Government for special funding for Eötvös's research. The funding was granted, and in 1909 the then 61-year-old Eötvös, together with 36-year-old Dezső Pekár and Jenő Fekete, who was just 29, jointly won the Beneke Prize, awarded by the University of Göttingen, with their anonymous application. The application was the result of several years of joint research and is still regarded today as one of the


Mathematikai és Physikai Társulat.
1894. 26. sz.
TAGSÁGI JEGY
Báró Eötvös Loránd
rendes tag részére.
Budapest, 1894 június 1én
pénztárnok.
(Tagsági díj: 5 frt)

Baron Roland Eötvös's membership card confirming payment of his membership fees to the Mathematical and Physical Society for the year 1894. It is typical of Eötvös's consistently precise and honest personality that, despite being president of the society, he paid his membership fee just like anyone else, and even retained the receipt…



Roland Eötvös in a photo taken by Aladár Székely in 1913

An X-ray image of Roland Eötvös's hand, taken in December 1895 just a few days after Röntgen discovered the mysterious X-ray and published his findings.

The source of radiation was an X-ray tube, probably made in the glass workshop at the Institute of Experimental Physics, a so-called Puluj lamp, which was operated by the physicist Jenő Klupathy (1861–1931), who obtained his doctorate under Eötvös. The recording was made by his young teaching assistant Dezső Pekár (1873–1953).

decisive experimental proofs of Einstein's general theory of relativity, as described in the above-mentioned study by József Cserti and András Patkós in the present volume.

His love for the natural world never left him, and on his climbing trips in the Dolomites, after the turn of the century, he took along his daughters, who were then in their twenties. His attitude to technological innovations was also interesting. He loved horse riding, although when the bicycle became fashionable he purchased one for himself and one for each of his daughters, and they cycled as far as Schluderbach (South Tyrol) in just a few weeks.

In his youth, he had enjoyed drawing the landscape wherever he went, although as soon as the camera reached maturity he became addicted to stereoscopic photography.

His last major scientific endeavour was his critical revision of the measurements made by the Potsdam professor Oskar Hecker on ships sailing on the various oceans of the world. When evaluating his data, the professor had failed to take into account the Coriolis force that acts on bodies in motion on the rotating Earth.

In order to convince the sceptics, he devised and created a "rotating seesaw", with which he demonstrated this effect convincingly, using the resonance method. Oskar Hecker then re-evaluated the measurements he had made on the Black Sea in the light of Roland Eötvös's criticism, and, acknowledging its validity, he named this tiny change in the weight of moving bodies the "Eötvös effect."

In 1919, then terminally ill, Roland Eötvös dictated the study that contained a persuasive discussion of the above problem to his daughters, before his death on 8 April. He died only a few days after his beloved wife had passed away, after 44 years of marriage.

In 2019, the 100th anniversary of their deaths was deservedly commemorated by the Hungarian Academy of Sciences in the framework of the "Eötvös 100" series of celebrations – which include the present article.

JÓZSEF CSERTI
ANDRÁS PATKÓS

From the Eötvös Rule to the Eötvös Effect via the Eötvös Balance

THREE OUTSTANDING DISCOVERIES IN THE FIELD OF PHYSICS BY ROLAND EÖTVÖS

In the 19th century, physicists explored in parallel the natural laws of matter that are independent of microstructure, and phenomena that contain indirect information on the – at that time hypothetical – atomic and molecular constituents. Eötvös made important contributions to both these areas of research. He began his career with the experimental exploration of the role of microscopic interactions in certain macroscopic properties of matter, which eventually led him to establish a general rule that is valid independent of the type of matter. In the following, longer, period of his life, he designed and carried out extremely accurate gravitational measurements, as a result of which his name is enshrined in the history of science.

In the memorial volume published on the 10th anniversary of Eötvös's death, Sándor Mikola wrote the following: "The discoveries of Baron Roland Eötvös regarding gravitational force and capillary effect will remain valid for the next millennium, even if our notions of gravitational force or the most elementary constituents of matter become meaningless."

The goal of this chapter is to present the most important scientific achievements of Roland Eötvös in a way that is accessible to all readers of the present volume.

The Eötvös Rule

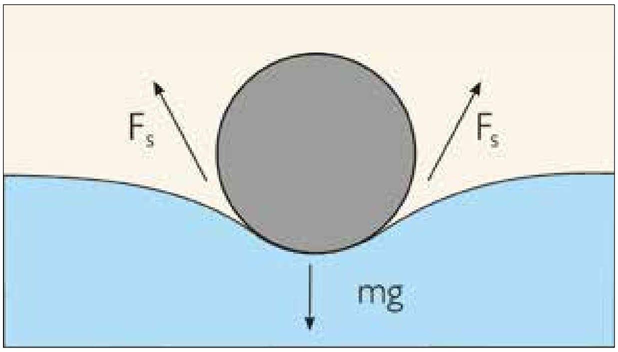
The secret of the swimming spider

In the summer months, the airy motion of certain insects on the calm surface of the water is a captivating sight. It is not Archimedes' principle that stops them from sinking: they are not submerged in the water at all. Their legs skim the surface without breaking it, their weight merely making an indentation in the water.

The forces that act tangentially on their legs along the indented water surface prevent the swimming spider, pond skater, and similar insects from sinking.

These surface forces originate from the attractive forces between the molecules in a fluid, which prevent the molecules from leaving the fluid. To overcome this attraction, an input of energy is required. The surface energy increases proportionally with the increase in the surface. The specific energy per unit of surface area is known as the *capillary constant.* The general principle – that is, the process by which the energy of all closed systems tends to decrease – determines the surface geometry of a liquid droplet.

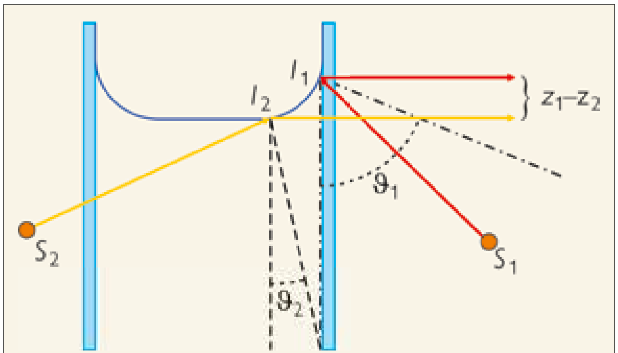
The surface of the water beneath the pond skater (top) and swimming spider (above) bends but does not break.



The force (F) holding together the surface and acting tangentially on the body placed on top of it is called the capillary constant or surface tension. The sum of the capillary forces counterbalances the gravity (mg) that would otherwise cause the insects to be submerged.

Eötvös's experimental method for measuring the capillary constant

In 1869, Eötvös attended the lectures given by Franz Neumann in Königsberg, which included presentations of his theory of capillarity. A liquid wets and "climbs up" the walls of a container. The height



A droplet of fluid (depicted in blue) wets the side walls and adheres to them with a convex curved surface. A ray of light is directed to two distinct points on the surface of the fluid at an angle that ensures that the reflected ray arrives exactly horizontally to the measuring telescope. The theodolite measures the difference in height between the horizontal branches of the rays, shown in yellow and red. The angles between the vertical direction and the normal vector also need to be measured with respect to the points of reflection on the surface of the fluid. Using a simple mathematical formula, it is then possible to accurately determine the capillary constant. (The original theodolite in the photo belongs to the Eötvös Memorial Collection, Budapest)

of a point on the surface measured in relation to the horizontal surface of the liquid at a distance from the wall is related to the angle between the tangential and horizontal directions at this point by means of a simple functional formula containing the capillary constant. As a student, Eötvös was praised by his professor for proposing a method for measuring the capillary constant by determining the height difference between the two surface points and the corresponding angles.

On his return home, he presented his method to the Hungarian Academy of Sciences and published it as the first paper to appear in the newly founded *Communications of the Technical University of Budapest (Műegyetemi Lapok)* in 1876.

The birth of the Eötvös Rule

Having worked out a very accurate method of measurement, Eötvös looked for a rule that would be generally valid for surface tension independent of the composition of the liquid. Based on its hypothetical molecular structure, he assumed that each separate molecule on the surface of the liquid covers a well-defined unit of surface area. Here one can introduce the notion of molar surface as the surface of a cube containing one mol of the substance. Eötvös asked how the capillary energy per unit of surface changes as the temperature changes by one degree Celsius. Based on certain theoretical arguments, he proposed the following relationship:

$$\frac{\text{change in product (capillary constant)}\times\text{(molar surface)}}{\text{change in temperature}} = \text{universal constant}$$

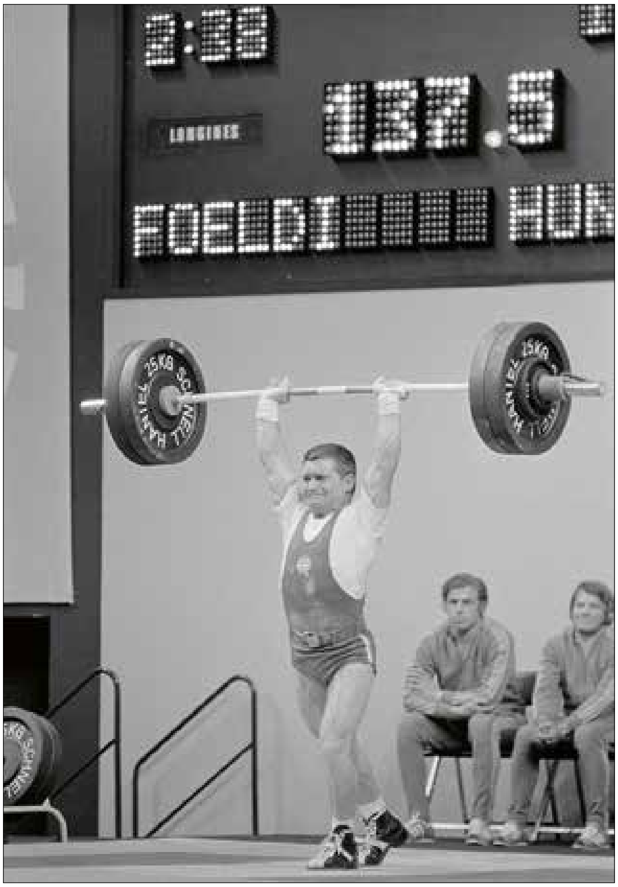
A former student of Eötvös, Professor Károly Tangl, wrote in 1930: "Whenever a theoretical result was formulated, fevered laboratory work began in order to verify the rule. The windows of the old physics building at the university were frequently alight late into the night. The measurements yielded a considerable surprise: it turned out that the ratio is independent even of the initial temperature value. Roland Eötvös presented his findings at a session of the Academy of Sciences in 1885: 'The molecular surface energy of all simple composite liquids changes to the same extent with a change in temperature of one degree.'" This universal value is known today as the *Eötvös constant* in the physicochemical literature.

Extremely accurate verification of the proportionality of gravitational and inertial mass

The mass of a body obtained unambiguously from Newton's law of gravitation is known as its *gravitational mass*. It is not at all obvious that the acceleration of a body falling due to gravitational force is independent both of its quantity and material quality. Acceleration due to the action of a given force is determined by the *inertial mass* of the body.

Falling body experiments in the 16th and 20th centuries

The velocity of falling bodies was explored in the 16th century by means of increasingly extensive experimentation. Benedetto Varchi (1544), followed by Giuseppe Moletti (1576), reported findings that contradicted the previously undisputed statement



Imre Földi (1972 Olympic champion weightlifter) works against gravitational mass (left), Gyula Zsivótzky (1968 Olympic champion hammer thrower) accelerates the hammer against its inertial mass (right)

by Aristotle that heavier bodies fall faster. In 1586, Simon Stevin and Jan de Groot dropped lead balls of different weights from a height of 30 feet. On observing that the sound made by the balls as they hit the ground was emitted at the same time, they concluded that the final velocity of the balls is identical.

In 1634, in his book *Discorsi e Demonstrazioni Matematiche interno a due nuovo scienze,* Galilei published the first mathematical treatment of gravitational free fall. He emphasised that, ignoring the phenomenon of drag, this law is independent of the constitution of the material. He was the first to point out that the upward motion of a feather is related to drag. Galilei's thought experiment was actually performed by Apollo 15 astronaut Dave Scott, who dropped a feather and a hammer on the Moon. In the video of the experiment, no difference can be observed in the moment that the two objects hit the surface of the Moon.[3]

The pendulum experiments of Newton and Bessel

In his most important work, the *Mathematical Principles of Natural Philosophy,* Isaac Newton writes in Definition I: *"The quantity of matter is the measure of the same, arising from its density and bulk conjointly."* In the interpretative part, he adds: *"It is this quantity that I mean hereafter everywhere under the name of body or mass. And the same is known by the weight of each body; for it is proportional* *to the weight, as I have found by experiments on pendulums, very accurately made…"*

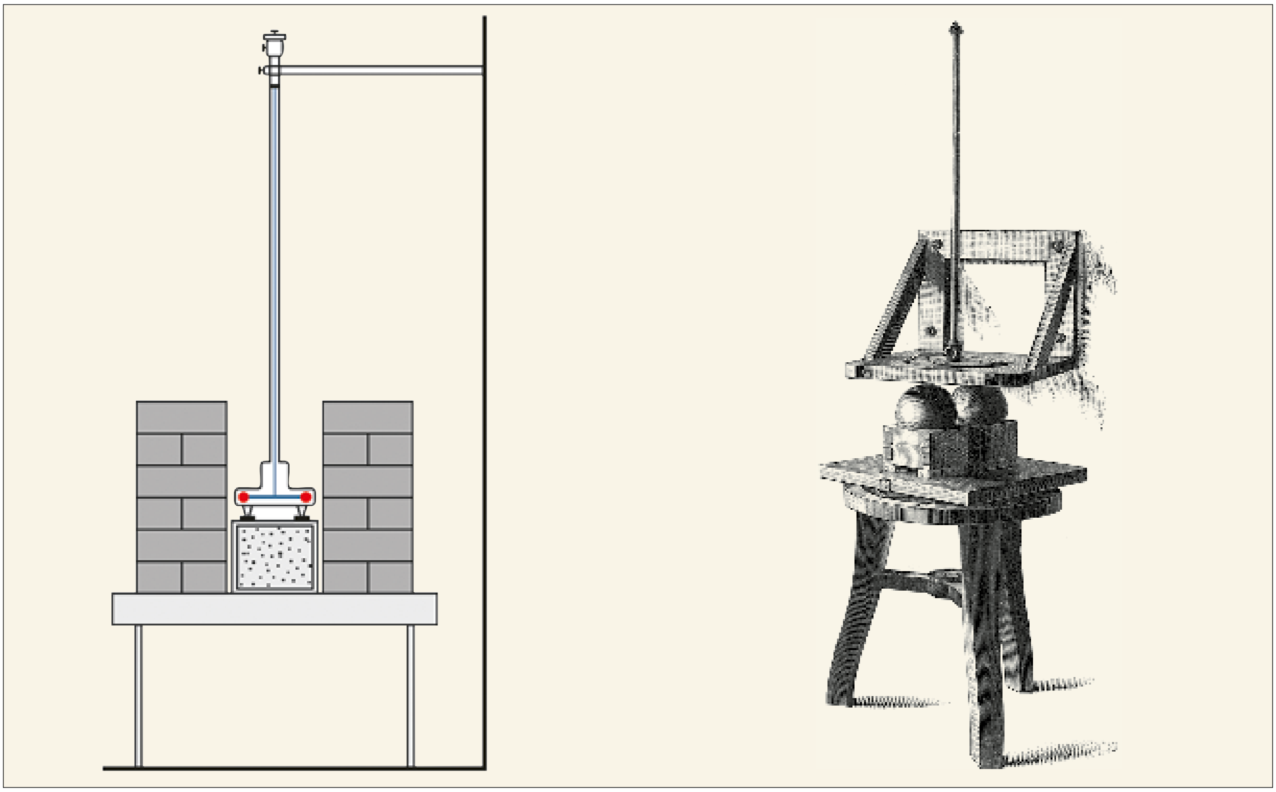
In 1830, the astronomer and mathematician Friedrich Bessel was able to improve on the one part in 1,000 precision of Newton's experiments. Eötvös summarised the results he obtained from the swinging of samples of gold, silver, lead, iron, tin, copper, marble, clay, quartz and meteorites, such that the maximum deviation in their gravitational acceleration was no greater than one part in 50,000. He praised Bessel as follows: "Bessel was correct in stating that it will always be of interest to check the results of this experiment with the accuracy allowed by the improved experimental tools of the future."

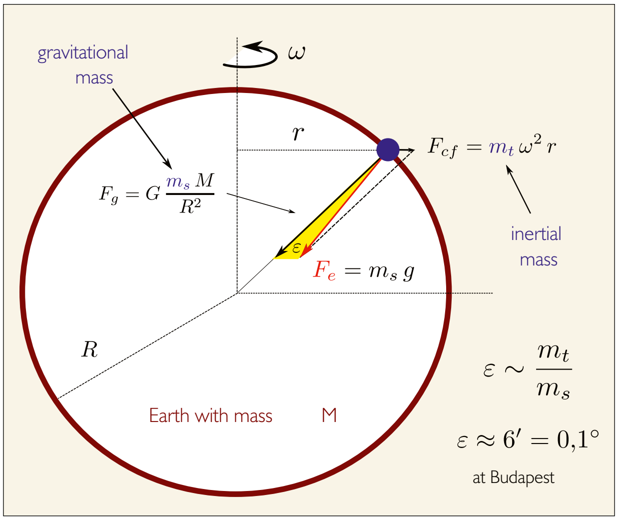
Eötvös takes his place in the history of science

Eötvös quickly understood that he would be unable to achieve the one part in a million accuracy that he aimed at with any pendulum experiment, thus he did not attempt to create any better-quality pendulum than his predecessors.

The weight of all the bodies on the Earth is the sum of Newton's gravitational force and the centrifugal force due to the Earth's rotation. The former is proportional to the gravitational mass, and the latter to the inertial mass. In Budapest, the angle between the gravitational force and the resulting weight is 356 arc seconds (nearly 6 arc minutes), if one assumes that the two types of mass are identical.

The image on the left shows the torsion balance swinging between two lead walls. The swinging period of the balance depends on whether it is performing small amplitude oscillations starting with the weights aligned in parallel or orthogonally to the walls. By measuring the difference in this period, Eötvös was able to find the gravitational constant of Newton with an accuracy of two parts in 1,000. On the right of the figure is a Coulomb balance. The balance was kept in a box attached to the wall, and below the box there are two lead balls weighing 25 kg. When the two balls are moved into an orthogonal position, the torsion balance is twisted.



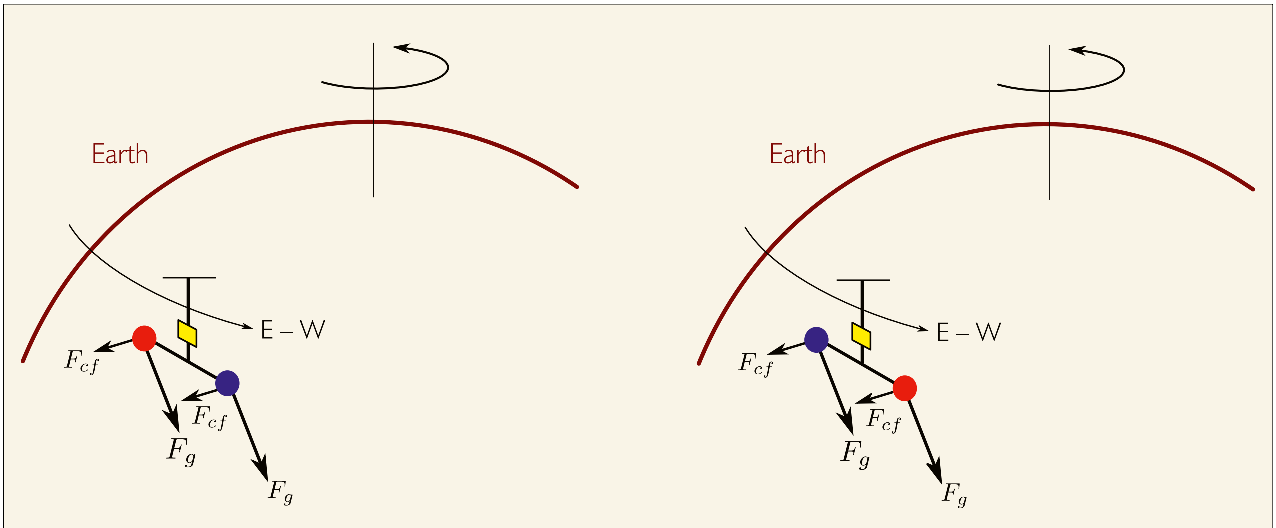


The balance "senses" the weight vector denoted by a red arrow, which is the resultant of the gravitational (F_g) and centrifugal (F_{cf}) forces. The angle ε between the resultant and the gravitational forces would change if the ratio of the inertial mass to the gravitational mass depended on the kind of matter.

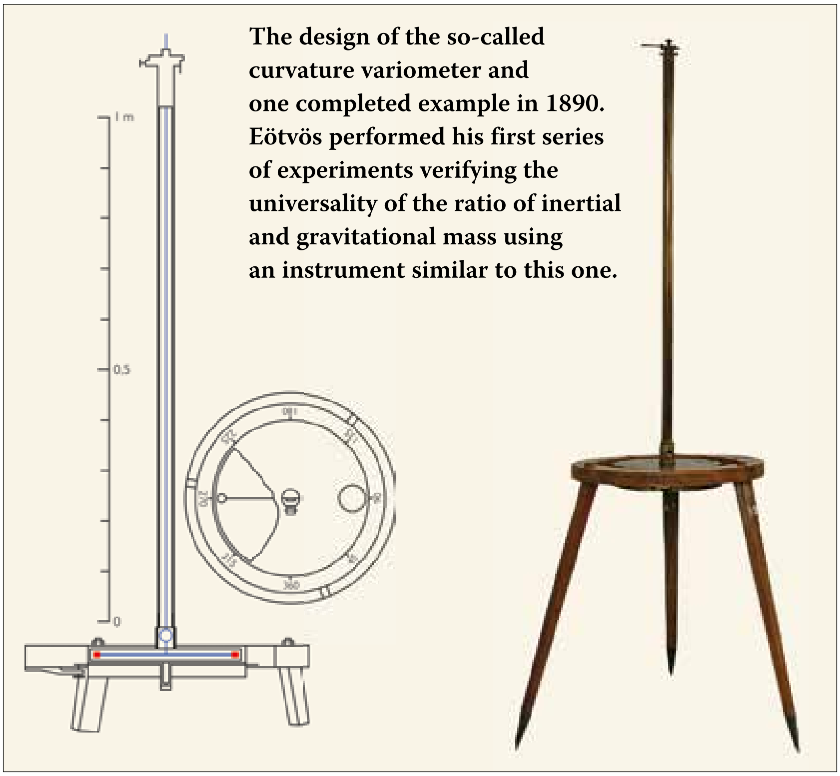
If the ratio of the inertial mass to the gravitational mass is different for two bodies, then the directions of the resulting forces acting on the bodies will be slightly different. In order to detect a one part in a million deviation, a difference of 356"/1,000,000 must be observed in the angle of the resulting force relative to the gravitational force. Eötvös realised that with pendulum experiments, this is not possible.

For his successful measurements, Eötvös used the so-called Coulomb balance, the torsion balance used by Coulomb to define the law of electrostatic force. Eötvös installed the torsion balance between two parallel walls constructed from lead blocks. He began swinging the balance first around an equilibrium position parallel to the walls, then orthogonal to the walls. The difference between the oscillation period in the two cases was 219 seconds, as a consequence of the different torque resulting from the sum of the Earth's gravitation and the additional gravitational force exerted by the walls on the swinging samples. From the time difference the gravitational constant could be deduced.

The Coulomb balance made it possible to measure also the potential tiny difference in the direction of the gravitational acceleration of the two samples



The weights placed on the two ends of the beam in the Coulomb balance exert an opposite torque on the hanging fibre. After the swings are damped, the light reflected from the mirror attached to the fibre points in a direction characterising the equilibrium position. When the instrument is turned 180 degrees, any change in this direction would signal a difference in the ratio of the inertial and gravitational masses of the two sample materials. Eötvös succeeded in giving a limit for the angle of the change in the orientation that was approximately 400 times lower than previously.



The design of the so-called curvature variometer and one completed example in 1890. Eötvös performed his first series of experiments verifying the universality of the ratio of inertial and gravitational mass using an instrument similar to this one.

placed at the two ends of a rod hanging from the platinum fibre of the torsion balance. His balance proved to be several thousand times more sensitive than the method based on measuring the oscillation period of each sample separately with a pendulum.

In 1887, Michelson and Morley exploited a somewhat similar idea in their attempt to identify a difference in the speed of light, in one case with light moving in parallel to the Earth's motion, and in the other moving orthogonally to the Earth's motion. They devised an interferometric method directly sensitive to the difference in velocity in the two directions, if any such difference existed.

The Coulomb balance experiment was performed with the help of Károly Tangl between 1888 and 1890. Eötvös succeeded in improving the upper limits of any deviation from the universal proportionality of inertial and gravitational masses by a factor of around 400. His instrument may have been similar to the so-called curvature variometer designed according to his own plans in 1890 for performing outdoor field measurements.

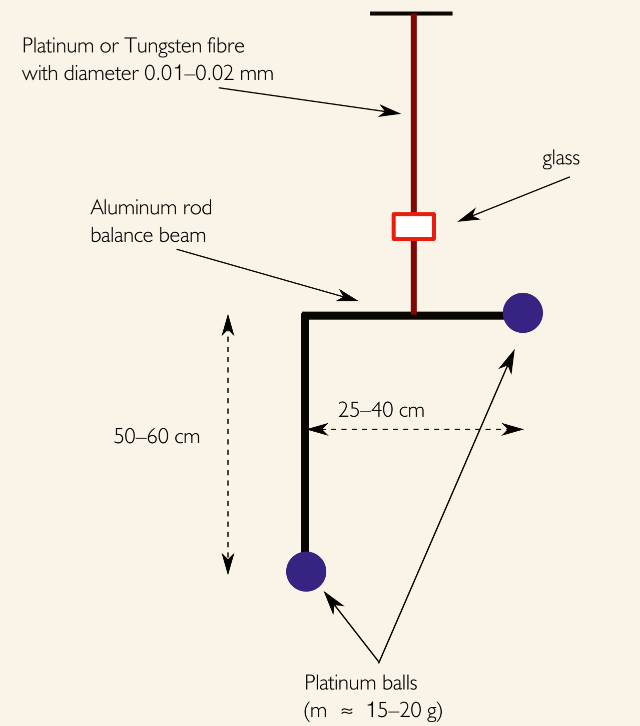
The Eötvös-Fekete-Pekár experiment

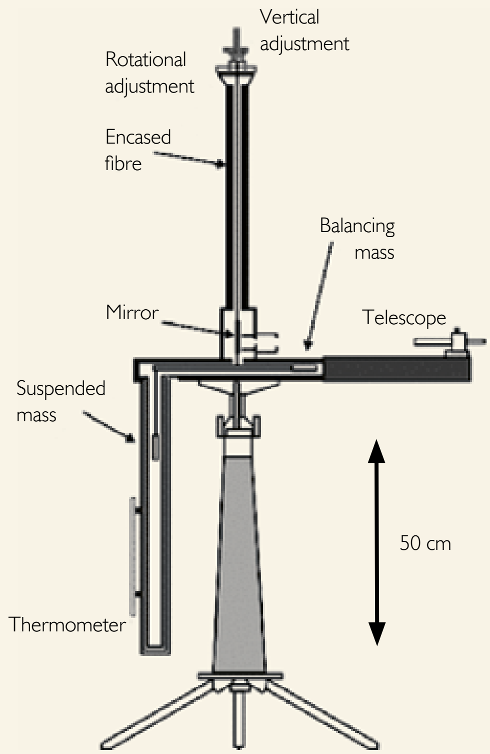
Eötvös's first publication on his experiments did not attract international attention. It was his report to the Congress of the International Federation of Surveyors, held in Paris in 1900, that generated significant interest. In this report, he focused mainly on the geophysical applications of his apparatus, although he also briefly summarised the results of the measurements performed earlier, in 1888–90. It was doubtless these results that prompted a call by the Beneke Prize Foundation in 1906 for new research into the relationship between inertial and gravitational mass:

"Eötvös has designed a very clever method for comparing the measurements of the inertia and gravity of matter. With this in mind, and taking into consideration the latest developments in electrodynamics and the discovery of radioactive materials, it would be desirable to make further progress in analysing the proportionality of inertial and gravitational masses according to Newton's theory."

This call was a direct challenge to Eötvös to repeat his measurements with even greater accuracy. The announcement was instinctively very forward looking. At present, the energy of electromagnetic and weak interactions (the latter interaction that can explain radioactivity) is known to represent a certain mass. With sufficiently accurate measurements, it would be possible to decide whether the binding energy of an atom resulting from electromagnetic interaction experiences the same gravitational force as that of the nucleus or cloud of electrons.

For the new series of measurements, which ultimately took about 4,000 hours, Roland Eötvös and his two assistants, Dezső Pekár and Jenő Fekete, used two newly constructed Eötvös bal-





The design of the simple horizontal variometer and a sketchy explanation of its working principle (above), and an advanced double variometer in which two simple variometers of opposite orientation work in parallel (right).

ances, the so-called *simple gravitational variometer* and *the double gravitational variometer.* With these instruments, they were able to measure the variation in the gravitational field due to the objects near the apparatus. For this, however, they had to determine the equilibrium position of the balance in more than just two positions.

If their findings are described in terms of the weight dropping experiments, it can be stated that the relative difference in velocity of two bodies dropped from the same height could not exceed one part in 200,000,000.

The prize jury was somewhat critical:

“Certainly, the authors’ study did not meet the expectations of the faculty in some essential aspects. Moreover, we do not find certain details of their arguments acceptable. Despite this, the results of the investigations are of the highest value and form the basis of any theoretical speculation concerning the extremely wide range of validity of Newton’s laws. Nevertheless, the faculty was not able to award the full prize for the submitted work."

Neither the jury nor the authors could have been aware of the real significance of the findings, which lay not in the extension of the validity of Newtonian mechanics, but in the highly accurate experimental verification of a most crucial principle of the general theory of relativity.

The era of Eötvös-type experiments (1963–2008)

Confirmation of the equivalence principle was acknowledged with appreciation by Einstein in January 1918 in a letter to Eötvös: "I cannot close my letter without expressing my gratitude for your work, which greatly advances our knowledge of the identity of gravitational and inertial masses."

Alternative gravitational theories have since reinforced the significance of Eötvös's experiment. In 1963, Robert Dicke and his colleagues performed an Eötvös-type experiment in Princeton using more advanced technology. They compared the gravitational acceleration of various samples attracted by the Sun and improved the limit set by Eötvös by three orders of magnitude. Braginsky and Panov performed their measurements in Moscow using the same concept in 1972. It is interesting to note that, in a famous paper published posthumously in 1922, Eötvös and his colleagues also considered an experiment exploiting the gravitational attraction of the Sun. They were aware of the enormous advantage of this potential measurement – namely, that the rotation of the Earth automatically inverts the position of the samples relative to the Sun every 24 hours. However, they estimated lower sensitivity for this method compared to that in which the attraction of the Earth is exploited.

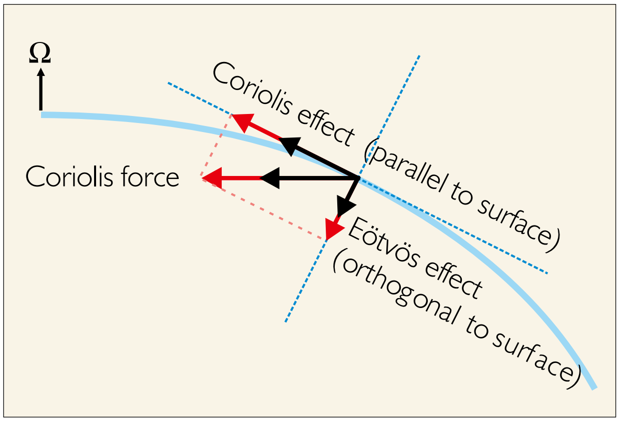
In 1986, Ephraim Fischbach analysed Eötvös's original data and discovered a non-trivial relationship between the measured differences in the mass ratios and the differences in the number of nucleons in 1 mol of the samples. To interpret this relationship, he proposed the existence of a new and unknown fundamental interaction with a range of about 10–100 m. His conjecture was investigated by a research group led by Eric Adelberger at the University of Seattle. Over the years, this group gradually improved the sensitivity of their torsion balance rotated with an angular velocity of 1 mHz, and by 2008 they had been able to improve on Eötvös's original results by five orders of magnitude. However, they could not find any sign of the new hypothetical fundamental force.

The quest for such a new, fundamental interaction hidden in the Newton-Einstein gravitational force is still at the forefront of present-day research. The most recent tests were performed in space in 2017. A new experimental arrangement was used, rather than the torsion balance. Nevertheless, this series of experiments was initiated by Roland Eötvös around 130 years ago, thus a well-deserved place is reserved for him in the history of science.

The Eötvös Balance of the Eöt-Wash group (University of Washington, Seattle) rotates with an angular velocity of 1 mHz. Its rotation period was chosen to minimise the expected noise from the environmental oscillations and the instrument itself. The geographical location of the instrument made it possible to check the existence of any "fifth force" with a range of action of no less than 1 m.

The weight of bodies moving on the surface of the Earth

Beyond the centrifugal force experienced by all bodies that rotate together with the Earth, those moving on the Earth's surface are subject to an additional force, known as the Coriolis force. The action of the vertical component of this force, orthogonal to the surface, is referred to as the Eötvös effect in the geodesy literature. It increases the weight of bodies moving westwards, while those moving eastwards become lighter. The change in weight of a person walking is a few parts in 10,000, although the effective gravitational acceleration of ships or aeroplanes changes more significantly.

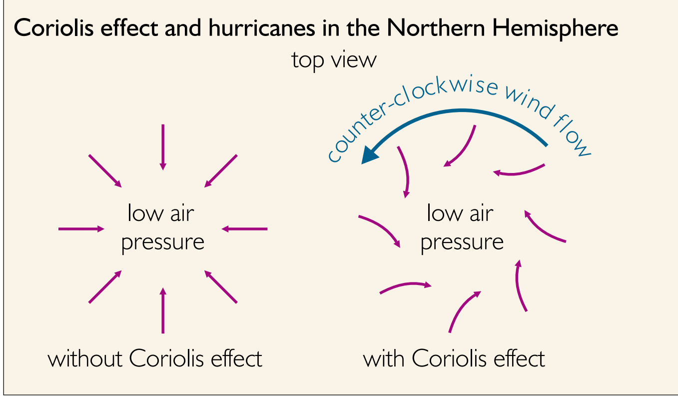


The Coriolis force exerts two types of action on a body moving on the surface of the Earth rotating with angular velocity Ω. A westward motion is deviated to the north (towards the rotation axis). Vertically (orthogonal to the surface), it increases the effective weight of the body. The Eötvös effect, the variation of the effective gravitational acceleration, is due to the joint action of the Coriolis and the centrifugal forces.

Cyclones, hurricanes, typhoons and the Coriolis force

The Coriolis force parallel to the surface of the Earth has a significant effect on the motion of the air. In a cylinder at rest, the pressure difference between the centre and the edge pushes the gas particles filling the cylinder towards the centre if the pressure is lower there. If the cylinder is rotating in an anti-clockwise direction (to the left), the trajectory of the particles starting to move radially inwards

Left: The trajectory of the particles flowing towards the low-pressure locations in the Northern Hemisphere deviates to the right under the effect of the Coriolis force. This phenomenon generates an anti-clockwise whirling of the air. Right: A natural realisation of the phenomenon is visible on a satellite image of Hurricane Rita over the Gulf Mexico.



will deviate to the right. The gas flow will start to whirl: this motion of the particles in the atmosphere is called a cyclone, hurricane or typhoon. The flow from a centre of higher pressure rotates clockwise (to the right) and is known as an anti-cyclone.

The history of the discovery of the Eötvös effect

Between 1901 and 1905, Oskar Hecker studied the geographical variation in the gravitational acceleration on a ship moving on the sea by comparing atmospheric pressure measured both by the height of the mercury column in a barometer and by the temperature at which water boiled. Looking into Hecker's data, it was Eötvös who realised the effect of the vertical component of the Coriolis force. On Eötvös's recommendation, Hecker reconsidered his data, and using the correction proposed by Eötvös he evaluated new experimental data obtained in two ships moving on the Black Sea, one in an East–West direction, and the other in the opposite direction, and obtained perfectly consistent results for the gravitational acceleration. Since Hecker, the modification in gravitational acceleration due to the vertical component of the Coriolis force has been known as the Eötvös effect.

New evidence for the Earth's rotation: the rotating seesaw of Eötvös

Any parent who has pushed a child on a swing will know that the best time to push is when the swing is at its maximum height, at the moment when it stops. Then, on the next return, it will fly even higher. Eötvös made use of this idea for an indoor demonstration of the Eötvös effect.

He constructed a seesaw on a rotating platform, placing equal weights on the two ends of the beam. In the non-rotating state, the balance is in equilibrium – that is, the two arms are horizontal. When the platform starts to rotate, one of the weights moves eastwards, while the other moves west. According to the Eötvös effect, the weight of the two bodies changes in an opposite way. This is a very small effect. However, if the force acting on the bodies changes in the same frequency as the eigenfrequency of the seesaw, then, as in the case of the child's swing, the amplitude of the seesaw motion will gradually increase.

Although already suffering from the illness that would ultimately prove fatal, Eötvös was not satisfied with the spectacular demonstration of the effect, but chose to complete his instrument with a unit that made possible the accurate measurement of the angular velocity of the Earth. To this end he placed the equipment on the axis of a solenoid and attached a small magnet to each of the bodies located at the ends of the beam. The magnetic field along the axis of the solenoid exerts a torque on the rotating "magnetic" seesaw. By tuning the cur-

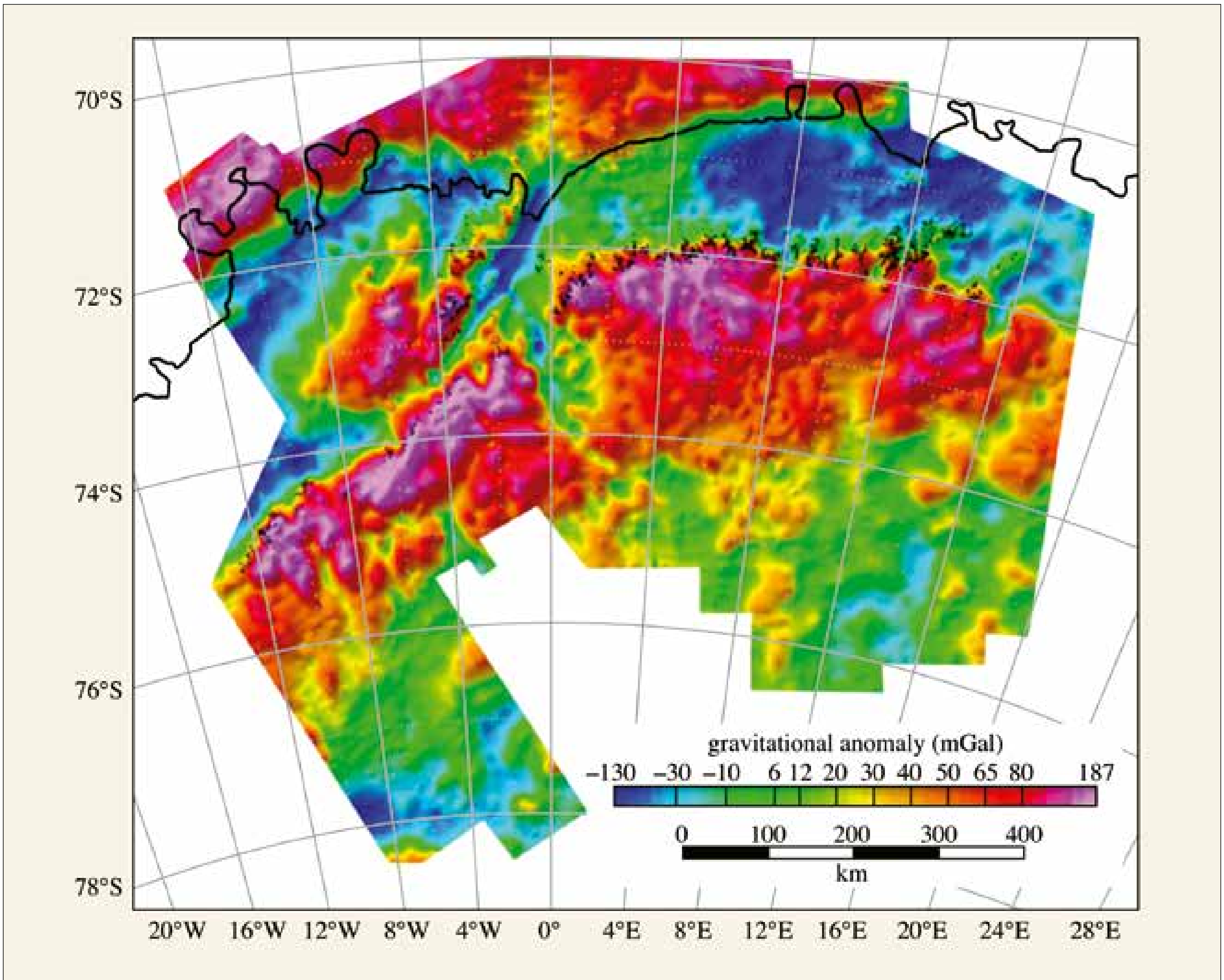
The Eötvös rotating seesaw, which measures the angular velocity of the Earth by exploiting the Coriolis effect. (The seesaw in the photo belongs to the Eötvös Loránd Memorial Collection, Budapest.)

rent to a certain value, the effect of the magnetic field entirely counteracted the Eötvös effect and suppressed the swinging. From the value of the current, it was possible to deduce the angular velocity of the Earth using the expression of the vertical component of the Coriolis force.

In this way, Eötvös proposed new and innovative evidence for the Earth's rotation, independently from, although equivalent to, the famous pendulum experiment of Foucault. Physics students at the Eötvös Loránd University can now carry out an experiment with a modern version of the Eötvös rotating balance in the framework of their laboratory experiments.

The Eötvös correction in contemporary geodesic surveys

The terrestrial landscape is surveyed relative to an ideal ellipsoid form. At a given point, the deviation of the real gravitational acceleration from that calcu-



Terrain map of Dronning Maud Land derived from gravitational anomaly measurements. The sequence of black points near the largest (most positive) values of the gravitational anomaly represent the mountain cliffs piercing the surface of the ice. (These are known as nunatak, from the Inuit word.) In conventional satellite images, only these points mark the extension of the mountain system. (This illustration is based on a figure from Sven Riedel (2009): "Airborne based investigation in Dronning Maud Land, Antarctica", PhD thesis, Bremen.)

lated by assuming an ideal geometric form with an average material density is positive in the case of a more massive environment, and negative if mass is missing relative to the ideal ellipsoid. Today, airborne measurements of gravitational acceleration are used to map the gravitational field in regions covered by thick layers of ice or seawater. The data measured in a lab moving relative to the surface with a speed of several hundred kilometres per hour have to be corrected according to the Eötvös effect.

The Dronning Maud Land area in Antarctica is believed to have been joined to Africa in the Atlantic Ocean several million years ago, along the coast of what is today Mozambique. Both belonged to the ancient supercontinent Gondwana. It was a big challenge to verify this hypothesis, namely finding the continuation of the East African mountain chain below the 2 km of ice that cover Antarctica. From raw data obtained by airborne gravimetric measurements and taking into account the Eötvös correction, gravitational anomalies over a region of 1.2 million square kilometres were established. It was then possible to draw an entire terrain map around the nunataks (the cliffs that rise above the icy surface).

Eötvös would no doubt be satisfied that, through continuous improvements in measuring the gravitational field of our planet, “we [can] establish a more stable basis for the tenets of the architecture of the Earth’s crust, gaining insights into depths not seen by our eyes or accessible to our drilling equipment.”

ZOLTÁN SZABÓ
TAMÁS BODOKY

Roland Eötvös, geophysicist, father of instrumental geophysical prospecting

"Beneath our feet stretches the open country of the Hungarian Plain, encircled by mountains. Its surface has been smoothed by gravity, which shaped it at will. I wonder what form it once had. What kind of hills were buried and what depths were filled with loose materials before this fertile area of golden grain, this life-giving Hungarian Plain came into being? As long as I walk upon it, as long as I eat its bread, I would delight in finding answers to such questions."

ROLAND EÖTVÖS

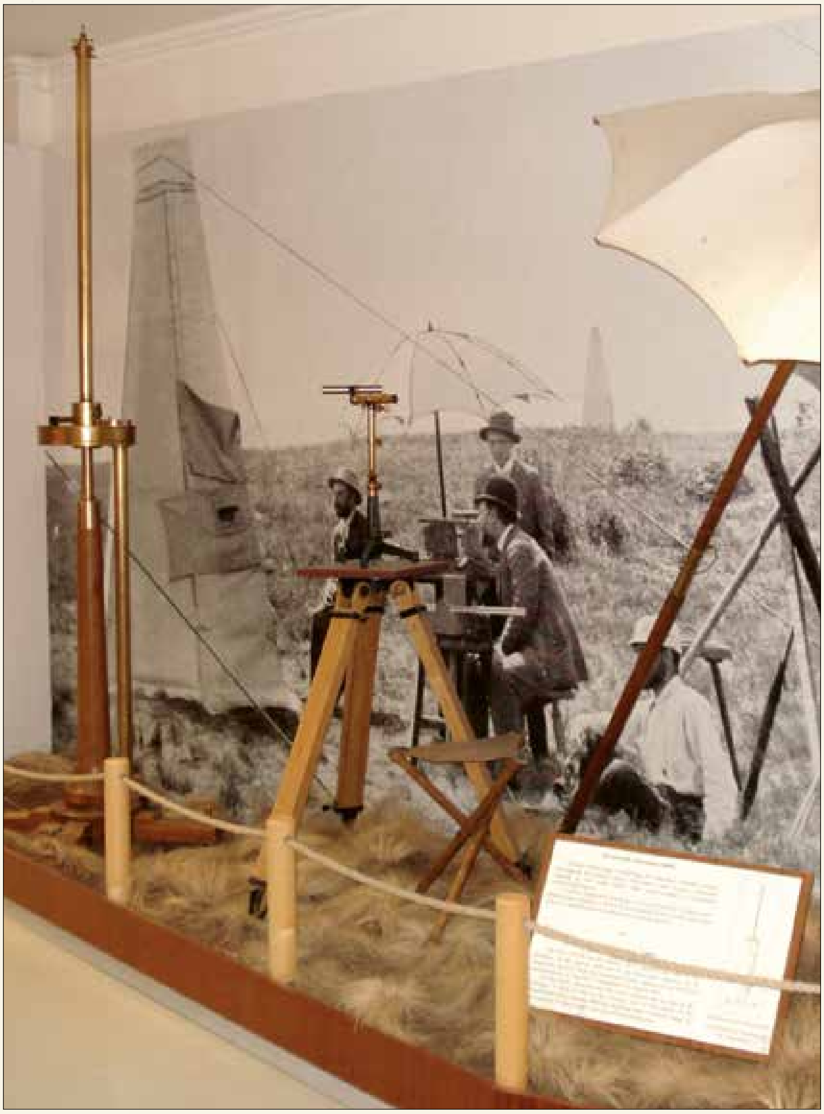
Geophysics, as a branch of physics, deals on the one hand with the physical phenomena of our Earth, and, on the other, uses the tools of physics to study the Earth. Roland Eötvös was primarily a physicist: since his starting point was always physics, it is impossible to distinguish between Eötvös the geophysicist and Eötvös the physicist. This is all the more true since geophysics, as we know it today, did not exist before Eötvös. Applied geophysics became an independent discipline precisely as a result of Eötvös's investigations in the field of gravity.

In the second half of the 1880s, when he began studying gravity, Eötvös focused on the shape of the Earth. The Earth's hypothetical shape – the geoid – is defined as the shape that the ocean surface, and by extension the territory of the continents, would take under the influence of gravity alone. Since the mean sea-level surface is determined by the Earth's gravity, the study of the geoid can be traced back to the investigation of the Earth's gravitational field. When he developed his torsion balance, Eötvös's intention was to use the instrument to determine with a high level of accuracy the local changes in surface gravitational level.

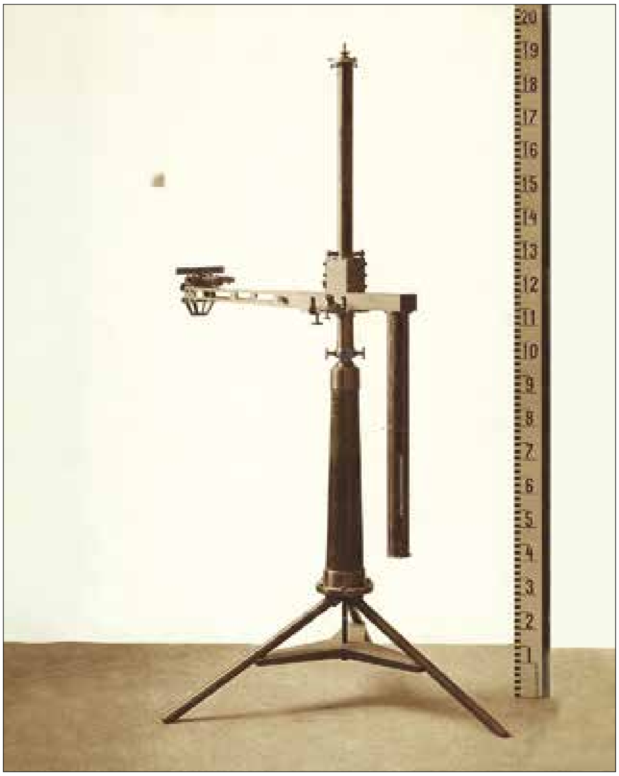
In the course of his investigations, he came up against the almost insuperable barrier that the changes or variations to be measured were extremely small compared to the mean value. The balance, which was one of the physicist's most important tools, could not be used to indicate such small changes, because it was affected by the force of the entire field, and the quantities that needed to be observed were far below the limits of measurement error. In order to observe such small effects, physicists have been using the torsion balance since the end of the 18th century. Coulomb, for instance, had used it to measure various electrostatic and magnetic effects, thus the instrument had become known as the Coulomb balance. This was the instrument likewise chosen by Eötvös to observe the small variations in the gravitational field.

The instrument worked on a very simple principle. Eötvös's torsion balance comprised a light, horizontal metal rod hanging on a very thin metal wire, with two identical ball-shaped or cylindrical masses, one at each end. If the forces acting on the two masses were not entirely equal – that is, if they differed in size or direction – then the rod would turn horizontally, twisting the wire. The total force of gravity loaded the wire lengthwise, while small spatial variations were balanced by its torsional stress. In this way, small changes could be distinguished and studied independently of the total gravitational force. However, the torsion balance in the form described above measured only the biggest change, the direction of the so-called curvature of the gravitational field, but did not measure its size. Eötvös thus referred to it as a "curvature variometer".

Eötvös elaborated the physical and mathematical theory behind the torsion balance and, based on this, modified the instrument in a simple but fundamental way in order to make it suitable for measuring not only the direction but also the size of the variations. He placed one of the weights not directly at the end of the rod, but further down, suspending it from the end of the rod by a thread.



Horizontal variometer (1891), an illustration in a book by Pekár, and the instrument itself shown in front of a picture of the Ság Hill survey at the Eötvös Loránd Memorial Exhibition

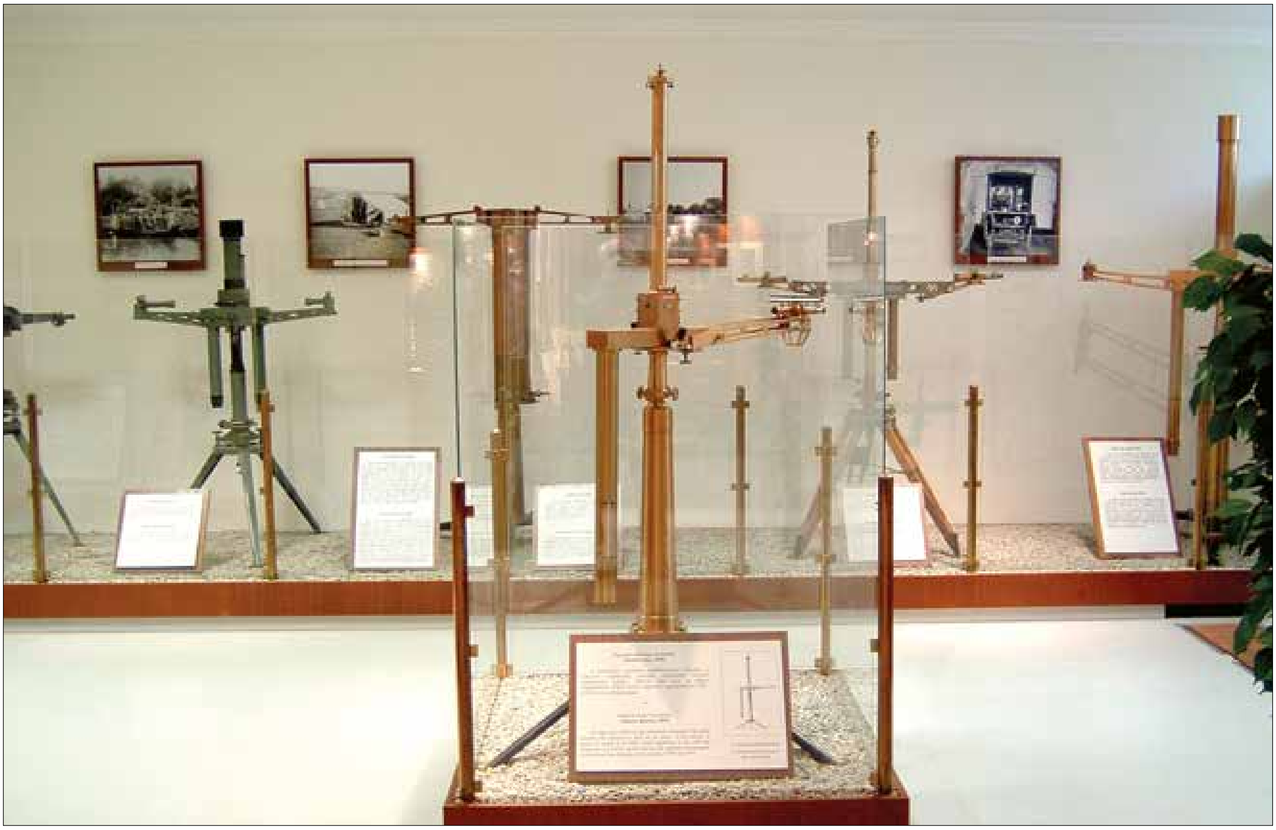


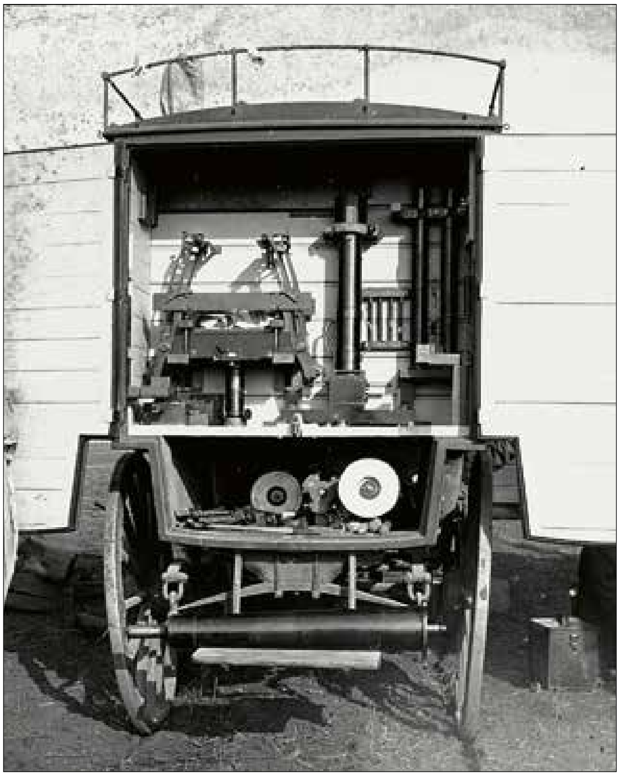
The so-called Balaton balance (a single Eötvös balance), shown in a paper by Eötvös, and the same instrument on display in the Eötvös Loránd Memorial Exhibition today

He named this torsion balance a “horizontal variometer”, and in this form it later became known throughout the world as the “Eötvös balance”.

The first Eötvös balance was completed in the workshop of the Nándor Süss[4] Institute for Precision Mechanics in Budapest in 1891 and can be seen today in the Eötvös Loránd Memorial Exhibition established by the Eötvös Loránd Geophysical Institute at the end of last century.

Following test measurements, the first real observations were carried out at Ság Hill, near the town of Celldömölk, in 1891. The hill rises to a height of 150 metres above the surrounding plain. In order to verify his measurements, Eötvös calculated its approximate gravitational effect, and the correspondence between the measured and calcu-

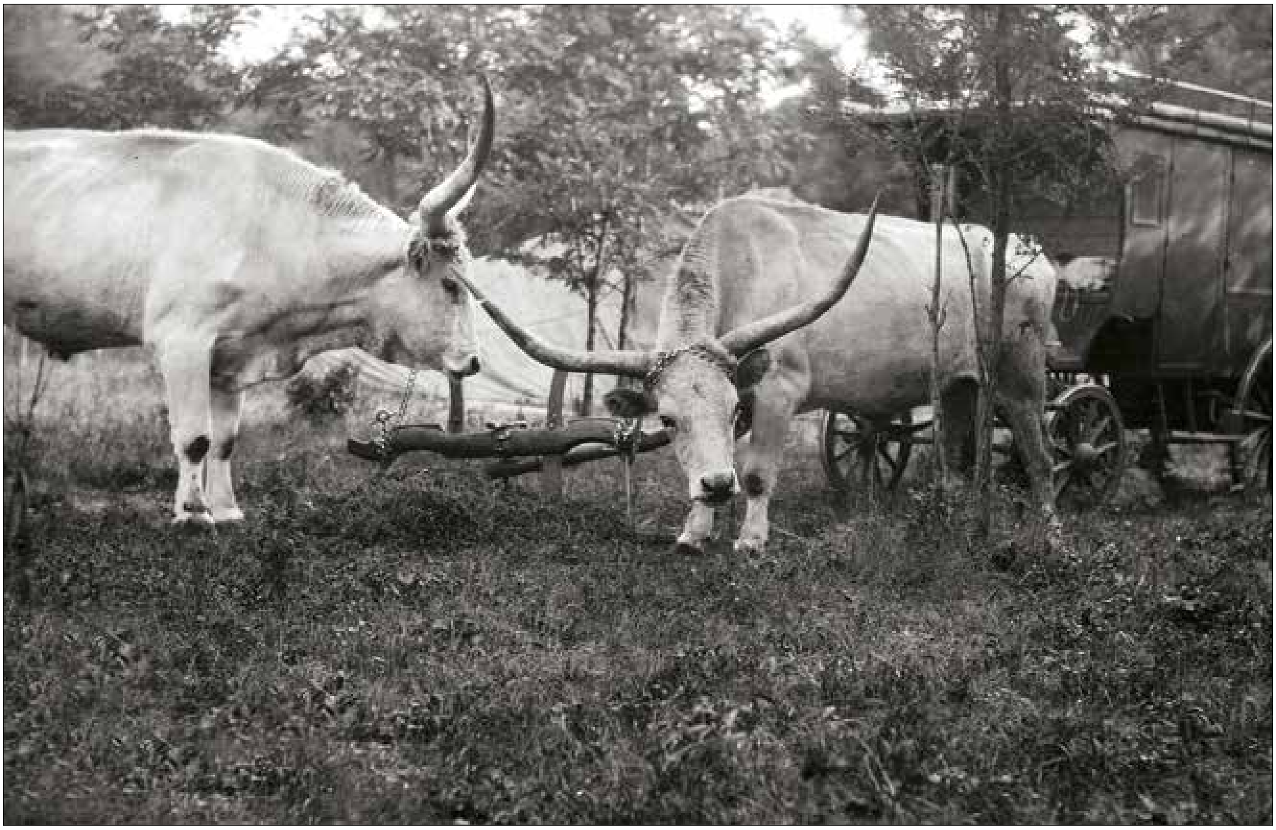


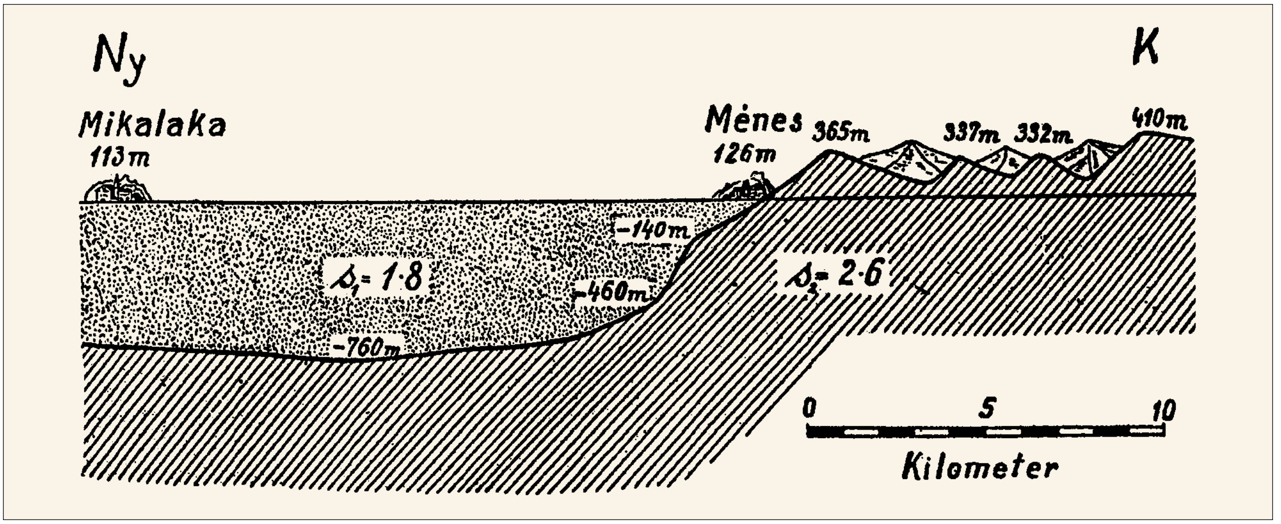


An instrument cart used in field measurements with a double balance dismantled for transportation and the "ox power" for moving it around, c. 1910

lated data proved the reliability of Eötvös's torsion balance.

Based on his practical observations, Eötvös improved his balance to make it more appropriate for outdoor work and to make it easier to handle. The improved Eötvös balance won a Gold Prize at the World Exposition held in Paris in 1900. This instrument was used to carry out numerous measurements in various locations, the most important among them perhaps being those at Lake Balaton in 1901, which were performed on the ice of the frozen lake in order to avoid the disturbing effects of the topography. This instrument was later named the "Balaton balance" after the survey. The measurements revealed that, parallel to the axis of the lake, there was a tectonic line running beneath





One of the first geological sections drawn on the basis of Eötvös balance measurements in 1906. "The measurements carried out in the neighbourhood of Arad clearly indicate that, on the Arad-Hegyalja ridge near the village of Ménes … the rocky layer of the mountain continues below the plain down to a depth of 760 meters… this rocky layer is covered by the loose soil of the Great Plain" [Eötvös]

The prototype of the "double balance" (1902) on display in the Department of Geophysics at Miskolc University, and a "double small balance" (1908) in the Eötvös Loránd Memorial Exhibition

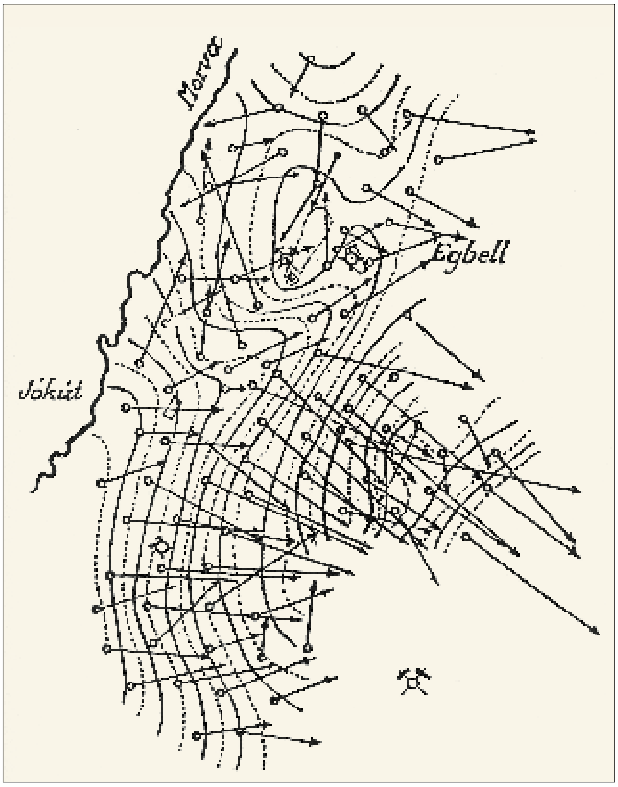
A brief rest at midday during the Eötvös balance survey in Titel in 1910. Eötvös is seated in front of the tent

the Balaton. More than merely a geodetical issue, this was also of geological significance, being the first time anywhere in the world that a surface measurement had indicated a buried geological structure.

The following year, in 1902, measurements were undertaken with expressly geological purposes in Bácska (then in southern Hungary) on the northern side of the Fruska Gora hills, and later in Arad, at the western end of the Zaránd Mountains. According to Dezső Pekár,[5] an assistant of Eötvös, they intended to study the underground continuations of these mountains. In the early years of experimentation, Eötvös's research was made possible by the financial support of Andor Semsey[6], the great patron of the Hungarian sciences.

It is appropriate to say a few words here about the workings of the torsion balance. The rest position of the balance had to be read in at least five different azimuths at each station, and the attenuation time of the balance was one hour. To ensure a calm environment, the measurements had to be performed at night, thus one full day was required for completing them at each individual station. To accelerate the work, Eötvös placed two opposite balances into one instrument case, thus creating the so-called double balance that formed the basis for all subsequent versions of the Eötvös balance. Using the double tool, it was necessary to take readings in three azimuths only, significantly reducing the measuring time at each station.

The year 1906 was a turning point in the story of the balance. The Internationale Erdmessung, or International Federation of Surveyors, held its 15th congress in Budapest. At earlier congresses, Eötvös had presented regular accounts of his research, and his reports had been received with great interest. However, many were sceptical about the accuracy of his results. At the congress in Budapest, the sceptics were given an opportunity to study the torsion balance measurements for themselves. This so impressed the congress participants that they petitioned the Hungarian Government to support Eötvös's research. The request was granted, and the minister of education, Albert Apponyi, remitted an annual 60,000 crowns from 1907 onwards to support Eötvös's experiments with the torsion balance, on condition that the staff, inventory and



Gradient map of the Egbell oil field (1916). "…even if we hadn't had the geological data, the isogamma map would have provided us with a safe basis for locating the exploratory drilling." [Hugó Böckh]

finances related to the experiments were kept strictly separate from the university's Institute of Physics, which was also directed by Eötvös. Compared to the annual budget for the Institute of Physics, which was just 4,000 crowns, the sum of 60,000 crowns was very large indeed. Thanks to this support, a geophysical institute was founded in 1907, the first in the world, which, after the death of the great physicist, was named the Royal Hungarian Baron Eötvös Loránd Geophysical Institute. (After the Second World War, the name was changed to the Eötvös Loránd Geophysical Institute of Hungary.) From this date onward, Eötvös's scientific activities and the story of the Eötvös balance were closely linked to the institute.

The Eötvös Loránd Geophysical Institute of Hungary (1907–2012) preserved the legacy of its founder and carried out its internationally recognised and respected work in the spirit of the great scientist for over a century in the field of applied geophysics, a discipline that was born in Hungary. In the 1980s and 1990s, the institute established the Eötvös Loránd Memorial Exhibition based on items left in the institute by its founder. Some years after its centenary, in 2012, the institute was wound up by the government.

Eötvös recognised early on that his balance could be used not only to investigate the shape of the Earth, but also to reveal geological structures below the surface. He described its practical applications in his report to the 17th congress of the Internationale Erdmessung, which was held in Hamburg in 1912, in which he explained that geological methods that infer gas-bearing structures from the geology of the surface could not be used on depositional plains such as the Hungarian Great Plain. He recommended that anyone looking for this sort of structure, either there or in similar areas, should take note of the conclusions to be drawn from torsion balance observations. Eötvös's advice was heeded by the Hungarian Government, and the site of the drilling for the salt mines at Maroskoppánd in 1913 was marked out on the basis of his measurements. Following the success of that excavation, the next step – that is, the introduction of torsion balance measurements into oil exploration – was obvious.

In 1916, at the initiative of Hugó Böckh, an eminent Hungarian geologist, Eötvös and his team carried out torsion balance measurements in the region of Egbell (now Gbely in Slovakia) in an operational oil field where the geology was already well known. The results of the torsion balance observations were almost identical to the geological and drilling observations. This successful experiment demonstrated the efficiency of torsion balance measurements in oil exploration, thereby creating the basis for geophysical oil prospecting. It made possible industrial gas and oil exploration, which was, and continues to be, of huge significance for the world's economy. Although Eötvös was just one of the outstanding physicists working in the early years of the 20th century, his scientific achievements were unique from the point of view of the world economy. His work launched a new era – the era of oil and gas.

With respect to the Egbell survey, it should be stressed that oil and gas deposits cannot be detected by gravitational measurement. However, they are connected with specific geological features (e.g. dome-like structures), thus geophysicists are looking not for oil or gas, but for buried formations where such minerals may have accumulated.

Below the surface, salt can be found in the form of solid, homogeneous and large salt domes. Since salt has a lower density than other sediments, it is easy to detect by gravitational measurements. On the other hand, oil and gas, as liquid and aerial substances, are found in the cavities and cracks in porous rocks, and their lower densities have no essential impact on those of the rocks that contain them. They move until trapped by some non-porous rock (usually clay) that blocks their further path. Once trapped, they gradually accumulate, and the aim of geophysical exploration is simply to identify these oil- or gas-containing traps.

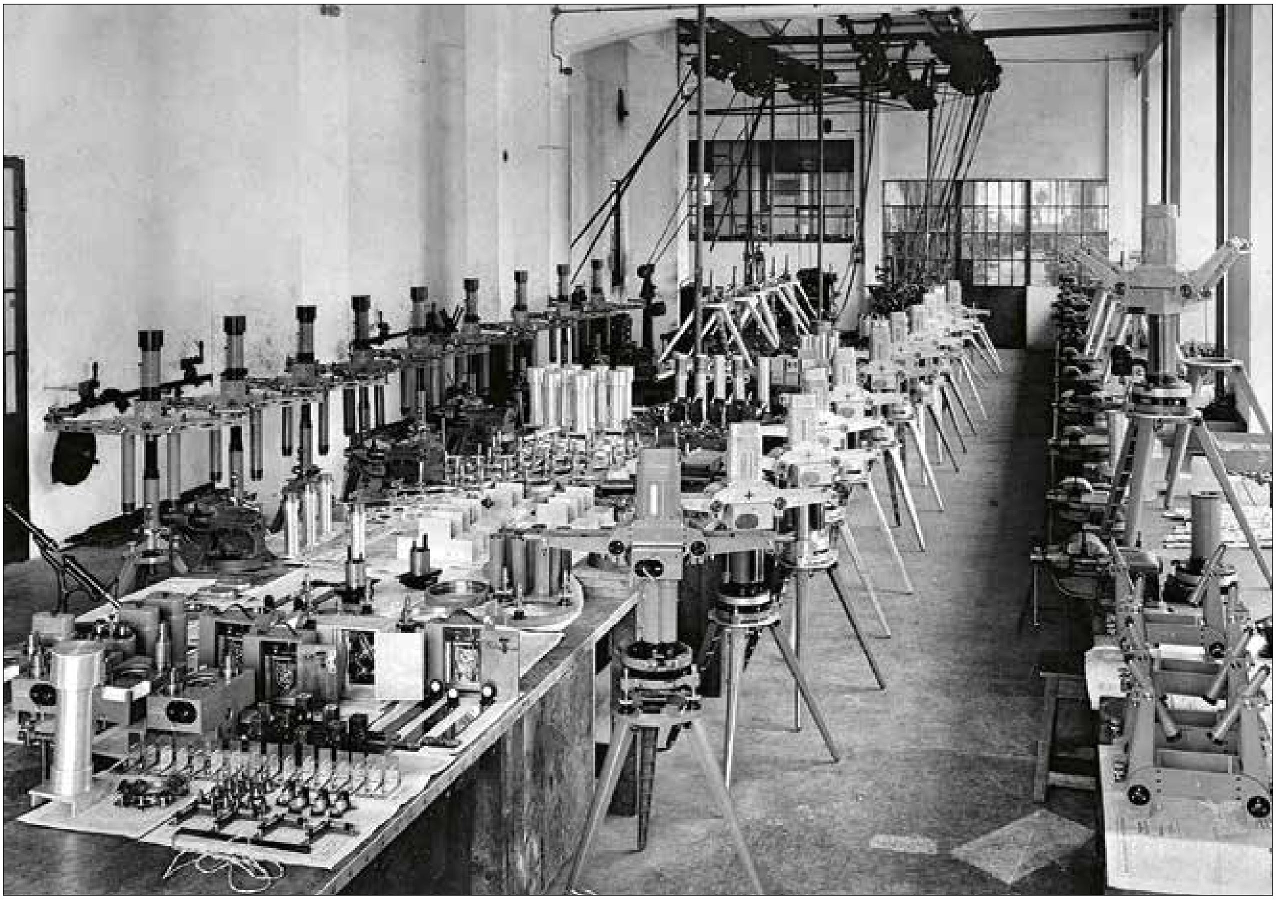
Foreign scientists quickly recognised the significance of Eötvös's balance. The internationally respected director of the Geodetical Institute of Potsdam, F. R. Helmert, considered it, along with the spirit level, to be one of the simplest and yet most important geodetic tools. From the start, the scientific world, and above all geodesists, took an interest in the torsion balance. Already during Eötvös's lifetime, foreign experts, primarily from universities, travelled to Budapest to find out about the research tool and the exploration process, and occasionally also to purchase an Eötvös balance

The Eötvös-Pekár and AUTERBAL balances in the Eötvös Loránd Memorial Exhibition. The telescope arms of the AUTERBAL can be detached from the balance. During surveying they are not used, but have a control function in instrument tests only.

(e.g. the Museum of the University of Zagreb possesses a double balance purchased at this time).

After the death of Eötvös in 1919, the geophysical institute he had founded was named after him, and Eötvös's close colleague, Dezső Pekár, became its new director. Also, following the death of their great mentor, former students and colleagues developed the torsion balance further. They had two basic goals: on the one hand, to reduce disturbances caused by external factors; and, on the other, to shorten the attenuation time of the balance. Pekár insisted on retaining the visual reading of the balance, thus characteristic telescope arms are to be found on the Eötvös-Pekár balances. Another former student of Eötvös, István Rybár[7], automated the rotations of the balance between azimuths by clockwork and carried out the readings by photo-registration. This version was called the "AUTERBAL balance" (Automatic Eötvös-Rybár balance). Both succeeded in shortening the attenuation time of the balance to 40 minutes. Automation was an important step, as it made it possible for an observer to work with several balances simultaneously, thus significantly reducing the time needed per survey.

Outside Hungary, Wilhelm Schweydar was the first to apply the Eötvös balance for the purposes of exploration. In 1917, he performed successful measurements to define the contour lines of a salt dome on the North German Plain south of Hamburg. The results proved satisfactory, as the contour lines of the salt deposit given by the measurements were subsequently proved by well-borings. Schweydar was in contact with Eötvös at an early stage, and, in 1910, following Eötvös's instructions, he had his own balance made, which he equipped



Eötvös-Pekár and AUTERBAL balances being assembled at the Süss factory in around 1930

The Eötvös Loránd Geophysical Institute performing Eötvös balance surveys in India: transportation of equipment in Upper Assam

with photo-registration, for which he obtained the torsion wires from Eötvös. As a foreigner, he did more than anyone to make the torsion balance known in Europe.

After the First World War, due to the rapid development of motorisation, the demand for oil products dramatically increased. By that time, various oil companies and prospecting enterprises had already sent representatives to study the new method of exploration at the Geophysical Institute that by that time bore the name of Roland (Loránd) Eötvös.

Among the foreign companies, Royal Dutch Shell and the Anglo-Iranian Group were the first to carry out surveys using an Eötvös balance. As far as we know, this took place in the Hurghada field in Egypt in 1921. The Eötvös balance was launched on its world-conquering career, which, sadly, its creator did not live to see.

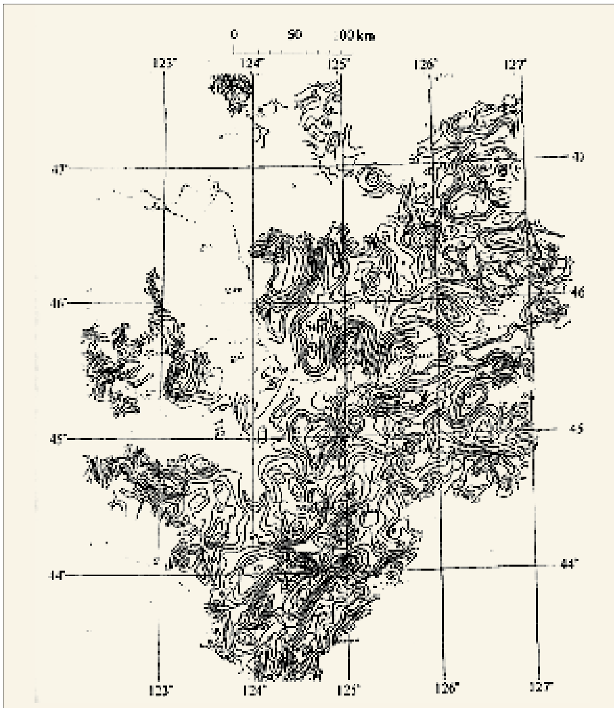
In the meantime, the institute received more and more inquiries about the new method. Occasionally, these came from exotic places such as Honolulu, the island of Java or Haiti. More and more exploration companies were carrying out surveys using the Eötvös balance in more and more countries throughout the world, partly with the help of Hungarian experts and the Eötvös Loránd Geophysical Institute, and partly with their own specialists trained at this institute in Hungary. Jenő Fekete[8], for example, a close colleague of Eötvös, worked for more than a decade in the US following the First World War before returning home, when, following Pekár's retirement, he was appointed director of the Eötvös Loránd Geophysical Institute.

On request, the Geophysical Institute trained specialists and even directed Eötvös balance surveys abroad – as it did, for example, at the request of the Burmah Oil Company in India. In the framework of this agreement, Dezső Pekár and János Renner worked near Khairpur in the Indus Valley (in what is today Pakistan) in 1923–24. In 1925–26, they continued their work 2,000 km to the east of this region in the Dispur district of the Brahmaputra Valley in Upper Assam. Miklós Szecsődy, also a member of the Eötvös Institute, took over their work there in 1927–1928.

The E54 torsion balance, which won a grand prize at the World Expo in Brussels in 1958

On the American continent, Eötvös balance surveys were introduced by Everette Lee DeGolyer and Donald C. Barton, the best-known oil industry experts before the Second World War. DeGolyer, who was vice president of the Amerada Petroleum Company, sent Barton, Amerada's geologist and a graduate of Harvard University, to Hungary to get acquainted with the theory and practice of Eötvös balance measurements. Amerada's first two balances arrived in America in November 1922, and in the same year the company carried out an experimental survey similar to that undertaken at Egbell. This was the first geophysical survey in America.

The first success in geophysical oil prospecting quickly followed. In 1924, Rycade Oil Corporation, a subsidiary of Amerada, marked out its drilling based on an Eötvös balance survey carried out with the contribution of Barton. The excavation opened up the first oil field in America (the Nash Dome Oil Field in Texas) to be discovered solely by means of geophysics. The first strike was soon followed by others. By the early 1930s, there were already more than 125 Eötvös balances in use in



The Bouguer anomaly map of the Sung-liao Plain compiled from Eötvös balance and gravimeter measurements, and the wall hanging donated out of gratitude to the Hungarian expedition by the Chinese Government

The stages of development of the Eötvös balance on display in the Eötvös Loránd Memorial Exhibition, from right to left: double large balance, double small balance, double balance with water cooling (which did not fulfil expectations), Eötvös-Pekár balance, AUTERBAL balance, E–54 balance, Eötvös-Szecsődy balance

the US, and at the peak of the oil exploration boom, Süss's factory was delivering Eötvös balances overseas every two weeks. By 1938, a total of 79 new oil fields had been discovered by means of Eötvös balances on the Gulf Coast alone.

Torsion balance measurements also played an important role in the discovery of the first significant oil and gas field in Hungary, the Budafapuszta field. Torsion balance surveys were carried out here by the Transdanubian Torsion Balance Group of the Eötvös Institute. In 1937, the Budafapuszta 2 oil borehole, which was aligned on the basis of these surveys, proved to be productive.

From the second half of the 1930s, Eötvös balances were gradually replaced in geological prospecting by spring-based gravimeters. Gravimeters were less accurate and provided less information than torsion balances, although their performance was adequate for the demands of industrial exploration. On the other hand, they were simple to handle and had a very short operating time per station, which meant much greater prospecting productivity.

In this context, it should be noted that Eötvös had already produced a gravimeter in 1901, although because it was less accurate he was not satisfied with it and set it aside. Had his gravimeter and the notes made during the experimental measurements not been in his legacy, no one would have known that he was ahead of his time by almost two decades in this field, too.

To add special piquancy to the story of the Eötvös balance, the torsion balance was to enjoy a revival after the Second World War. At the start of the Cold War, tools for raw material prospecting were considered of strategic importance and were placed on the embargo list. This meant that Soviet bloc countries were unable to get hold of the most advanced American gravimeters. As a result, they resorted to reviving production of the Eötvös balance. A new version, the E-54 balance, was developed, which won an award at the World Expo in Brussels in 1958. This is how the Eötvös balance was able to win grand prizes at two World Expos – with a gap of almost 60 years.

Among the successes achieved during this revival, perhaps the most important was the Chinese–Hungarian oil exploration expedition that made a significant contribution to the discovery of China's largest oil field to date, the Ta-Ching Oil Field on the Sung-liao Plain, by means of its torsion balance and seismic and telluric measurements.[9] The objects on display in the Eötvös Loránd Memorial Exhibition include a photograph of the red silk hanging donated in gratitude to the Hungarian expedition by the Chinese Government.

Here, the story of Roland Eötvös's most significant achievement, the use of the Eötvös balance in raw material prospecting, comes to an end. Today in Hungary, the Eötvös torsion balance is used for scientific research purposes only by the Chair of Geodesy at the Technical University of Budapest.

EPHRAIM FISCHBACH

The enduring significance of Eötvös's most famous experiment

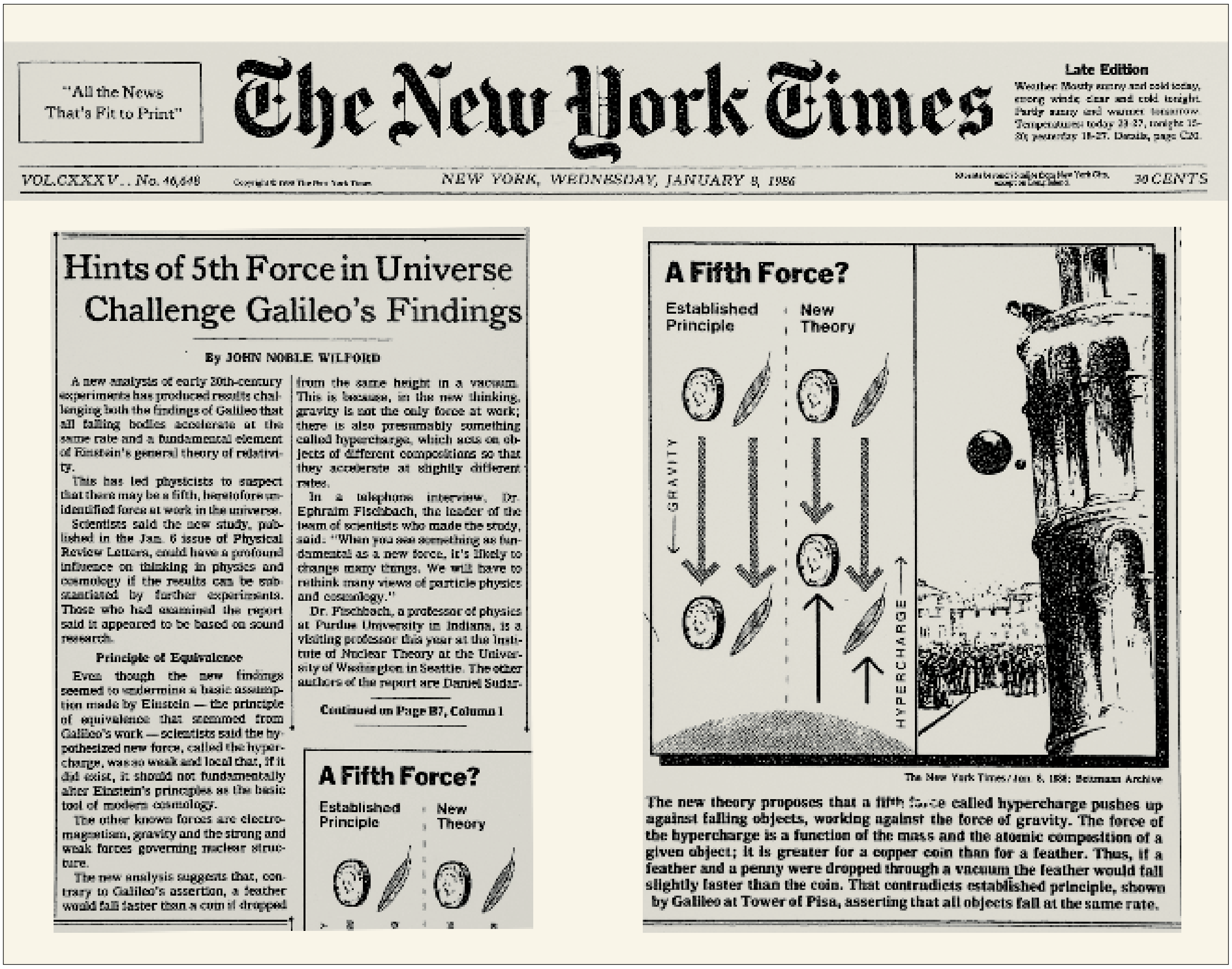
As we celebrate this year the centenary of the passing of Baron Roland Eötvös on 8 April 1919, it is appropriate here to reflect on the experiment most closely identified with him. This is, of course, his last published paper: "Contributions to the Law of Proportionality of Inertia and Gravity," co-authored with his collaborators Dezső Pekár and Jenő Fekete and published posthumously in German in 1922[10]. As I will describe in detail below, an analysis of the data obtained by Eötvös, Pekár and Fekete (EPF) was published by my group (E. Fischbach, D. Sudarsky, A. Szafer, C. Talmadge, and S. H. Aronson, abbreviated to FSSTA) at Purdue University in 1986.[11] It revealed compelling evidence for the presence of a new fundamental interaction in nature, which came to be known as the "fifth force" due to a title page report in the daily *New York Times*.[12] However, no credible evidence for the existence of such a force has been produced to date, notwithstanding many attempts by a large number of experimental groups.

Now that more than 30 years have passed since the publication of our article, it is safe to summarise our understanding of the content of the paper by Eötvös and collaborators in the following three statements:

#1. There is consensus in the community that there were no obvious flaws in the EPF experiment, or in their published paper.
#2. There is additional consensus that the analysis of the EPF data reported by FSSTA is also correct, along with its suggestion of a new "fifth force" in nature.
#3. There is no credible experimental evidence for a new force, with the characteristics presented by FSSTA.

Since the preceding three statements appear to be mutually contradictory, it is certain that interest in the EPF experiment will endure until such time that we resolve this paradox with some combination of new theory and additional experiments. In what follows, I elaborate on the above observations in the hope of pointing to some possible resolutions of the apparent paradox arising from the incompatibilities among observations #1 to #3.

We begin with an elaboration on #1, the correctness of the EPF experiment. As noted above, following the FSSTA publication many efforts were undertaken to attribute the EPF data to conventional systematic influences, such as temperature gradients. The extensive discussion of these hypotheses is summarised in the book *The Search for Non-Newtonian Gravity* by C.L. Talmadge and myself (the FT-book).[13] Not surprisingly, none of these has succeeded to date: This is because the EPF data on the acceleration differences of various pairs of samples correlate with a non-classical characteristic of the samples, namely their baryonic charge-to-mass ratios B/μ, where the mass of an object is measured in proportion to the mass of the hydrogen atom $\mu = m/m_H$. In the previous equation $m_H = m(^1H_1) = 1.00782519(8)u$ is the mass of hydrogen, and u is the spectroscopic mass unit. The concept of baryon number (the number of protons and neutrons) did not arise until the discovery of the neutron by Chadwick in 1932, many years after the completion of the EPF experiment



"All the News That's Fit to Print"

The New York Times

Late Edition

Weather: Mostly sunny and cold today, strong winds; clear and cold tonight. Partly sunny and warmer tomorrow. Temperatures: today 23-37, tonight 15-30; yesterday 18-27. Details, page C20.

VOL.CXXXV . . No. 46,648 — NEW YORK, WEDNESDAY, JANUARY 8, 1986 — 30 CENTS

Hints of 5th Force in Universe Challenge Galileo's Findings

By JOHN NOBLE WILFORD

A new analysis of early 20th-century experiments has produced results challenging both the findings of Galileo that all falling bodies accelerate at the same rate and a fundamental element of Einstein's general theory of relativity.

This has led physicists to suspect that there may be a fifth, heretofore unidentified force at work in the universe.

Scientists said the new study, published in the Jan. 6 issue of Physical Review Letters, could have a profound influence on thinking in physics and cosmology if the results can be substantiated by further experiments. Those who had examined the report said it appeared to be based on sound research.

Principle of Equivalence

Even though the new findings seemed to undermine a basic assumption made by Einstein — the principle of equivalence that stemmed from Galileo's work — scientists said the hypothesized new force, called the hypercharge, was so weak and local that, if it did exist, it should not fundamentally alter Einstein's principles as the basic tool of modern cosmology.

The other known forces are electromagnetism, gravity and the strong and weak forces governing nuclear structure.

The new analysis suggests that, contrary to Galileo's assertion, a feather would fall faster than a coin if dropped from the same height in a vacuum. This is because, in the new thinking, gravity is not the only force at work; there is also presumably something called hypercharge, which acts on objects of different compositions so that they accelerate at slightly different rates.

In a telephone interview, Dr. Ephraim Fischbach, the leader of the team of scientists who made the study, said: "When you see something as fundamental as a new force, it's likely to change many things. We will have to rethink many views of particle physics and cosmology."

Dr. Fischbach, a professor of physics at Purdue University in Indiana, is a visiting professor this year at the Institute of Nuclear Theory at the University of Washington in Seattle. The other authors of the report are Daniel Sudar-

Continued on Page B7, Column 1

A Fifth Force?

Established Principle — New Theory

A Fifth Force?

Established Principle — New Theory

The New York Times / Jan. 8, 1986; Bettmann Archive

The new theory proposes that a fifth force called hypercharge pushes up against falling objects, working against the force of gravity. The force of the hypercharge is a function of the mass and the atomic composition of a given object; it is greater for a copper coin than for a feather. Thus, if a feather and a penny were dropped through a vacuum the feather would fall slightly faster than the coin. That contradicts established principle, shown by Galileo at Tower of Pisa, asserting that all objects fall at the same rate.

Title page report in *The New York Times* (8 January 1986), which employed for the first time the terminology "fifth force", that has since widely prevailed, as an explanation for the systematic regularity found by Fischbach and his co-workers in the data of the Eötvös–Pekár–Fekete experiment.

in 1908, and its publication in 1922. The related concept of baryonic charge, for which a conservation law was established by Eugene Wigner in 1949, is clearly a quantum property.

A dramatic example of the non-classical nature of the influence responsible for the EPF data is the comparison of their measured values of the acceleration of platinum and copper-sulfate crystals ($CuSO_4 \cdot 5\ H_2O$): These two substances differ in every known physical property (density, electrical conductivity, thermal conductivity, etc.). Yet, remarkably, they have very nearly the same values of the non-classical property B/μ, and from the EPF data we can infer that, in fact, they have the same accelerations to the Earth as one finds from the FT-book.

Additional support for the EPF results comes from a recently discovered handwritten draft (autograph) by Eötvös himself of what would eventually become the published 1922 paper. (A new translation of the EPF paper incorporating the Eötvös autograph will be published as part of the Eötvös centenary celebration.)[14] One of the questions that has surrounded the EPF paper since its publication has been why their results were not published shortly after the completion of their experiment in 1908. This question becomes even more relevant in the light of Eötvös's observation in the autograph that the sensitivity of his experiment is "more than 300 times greater than that of an earlier experiment of Bessel". In modern times, an improvement in the determination of any quantity by a factor of 300 would surely lead to immediate publication. A possible answer to this question may be contained in the data themselves, particularly the measured fractional acceleration difference (Δκ in the EPF notation) of copper and water:

$$\Delta\kappa \text{ (water} - \text{copper)} = -(0.010 \pm 0.002)\times 10^{-6}.$$

Since this represents a 5-standard deviation (5σ) from the expected null result, we can assume that Eötvös's delay in submitting these results for publication may have been motivated by his desire to redo his experiment, as is suggested by the introduction to the published paper. The meaning of this statement is that the probability that this difference has occurred by mere chance is 1 to 3.5 million. By curiosity, one notes that nowadays in subnuclear physics the so-called discovery threshold is just the quintuple of the standard deviation. This means that an effect is recognised as real, not due to statistical fluctuations, when its measured value deviates from the value based on the generally accepted interpretation by more than 5 times the range of standard fluctuations.

Other examples of the great care that Eötvös exercised in carrying out his famous experiment are discussed in the FSSTA paper and the FT-book. Based on these references and the preceding discussion I believe that it is safe to assume that the Eötvös experiment, as described in the 1922 paper and the newly discovered autograph, was in fact done correctly. Thus, a resolution of the incompatibility of observations #1, #2, and #3 above must depend somehow on observations #2 and #3.

We turn next to observation #2 dealing with the correctness of the FSSTA analysis that led to the suggestion of a "fifth force". Motivated by various hints of possible deviations from the predictions of Newtonian gravity, it was suggested that there existed in nature an additional long-range interaction between any two objects i and j that was proportional to their respective baryon numbers B_i and B_j. Given that $B = N + Z$, where N and Z are, respectively, the numbers of neutrons and protons in each object, B is approximately proportional to the mass M of any object, since the magnitude of M is dominated by its number of neutrons and protons. It follows that such an interaction would behave in some ways as an additional contribution to gravity, except for presumably small deviations which would reflect differences in the actual chemical compositions of the interacting samples. To give this interaction a concrete mathematical expression, it was proposed that the potential energy of interaction $[V_5]_{ij}$ for the new interaction between the objects i and j had the form of a modified Newtonian interaction given by

$$[V_5(r)]_{ij} = \pm f^2 \frac{Y_i Y_j}{r} e^{-r/\lambda}.$$

Here f is a coupling constant, defining the strength of the new interaction, and $Y = B + S$ is the hypercharge quantum number, which allows $V_5(r)$ to also describe possible new interactions of K-mesons for which B=0 but has "strangeness" $S \neq 0$.[15] (K-mesons or kaons are elementary particles discovered in the second half of the 1940s and turned out to be the first elementary particles possessing the quantum property of strangeness. Anomalies observed in experiments involving K-mesons partially motivated FSSTA for the reanalysis of the EPF experiment.) The characteristic length $\left(\lambda = \frac{\hbar}{m_Y c}\right)$ accommodates the possibility that the hypothesised interaction could have a finite range ($\lambda < \infty$) if the quantum ("hyperphoton") mediating the hypercharge interaction (analogous to the photon) had a non-zero mass. Since ordinary matter has S=0 and always interacts gravitationally, it is straightforward to show that the combination of the Newtonian gravitational potential $V_N = -Gm_i \frac{m_j}{r}$ and the potential V_5 characterising the new force leads to a total interaction potential V(r) having the form

$$V(r) = -G_\infty \frac{m_i m_j}{r} (1 + \alpha_{ij} e^{-r/\lambda}),$$

with $\alpha_{ij} = -(B_i/\mu_i)(B_j/\mu_j)\,\xi$; $\xi = f^2/(G_\infty m_H^2)$, and G_∞ is the Newtonian gravitational constant as r → ∞. The gravitational acceleration of the object j in the force field of the Earth (object i) follows from the above equations. The acceleration difference of two samples of j and j' in the gravitational field of the Earth is proportional to

$$\xi \frac{B_{Earth}}{\mu_{Earth}} \left(\frac{B_j}{\mu_j} - \frac{B_{j'}}{\mu_{j'}} \right) \equiv \xi \frac{B_{Earth}}{\mu_{Earth}} \Delta \left(\frac{B}{\mu} \right)_{jj'}$$

A tabulation of B/μ values for the first 92 elements in the periodic table is presented in Table 2.1 of the FT-book. One finds that all B/μ values are close to 1, but differ from unity at the parts per mille level.

Remarkably, the theory that follows the simple equations above correctly describes the EPF data for the acceleration differences of pairs of samples j'–j measured in their experiment. As FSSTA have shown, this theory implies that the measured fractional acceleration differences $(\Delta\kappa)_{j'j}$ in the EPF notation should be given by

$$(\Delta\kappa)_{j'j} = a\Delta \left(\frac{B}{\mu} \right)_{jj'},$$

where a is a constant that is determined in part by the strength of the new interaction represented by the square of the constant f through the proportionality factor ξ. In a pure Newtonian world a=0 should hold for any pair jj' of samples. This represents the statement that the accelerations of all objects in the same gravitational field should be identical, what is now generally referred to as the Weak Equivalence Principle. However, the fit to the EPF data (see Fig. 1 in the FSSTA paper) gives


The New York Times

PRESIDENT BREAKS ALL ECONOMIC TIES WITH THE LIBYANS

Hints of 5th Force in Universe Challenge Galileo's Findings

Why Reagan Shuns Attack

A Fifth Force?

Safety Violations at Nuclear Plant Were Cited by U.S. in '85 Report

Many Tourists Revamping Plans In Fear of Terrorism, Experts Say

For Pennzoil, A Surging Stock but No Deal

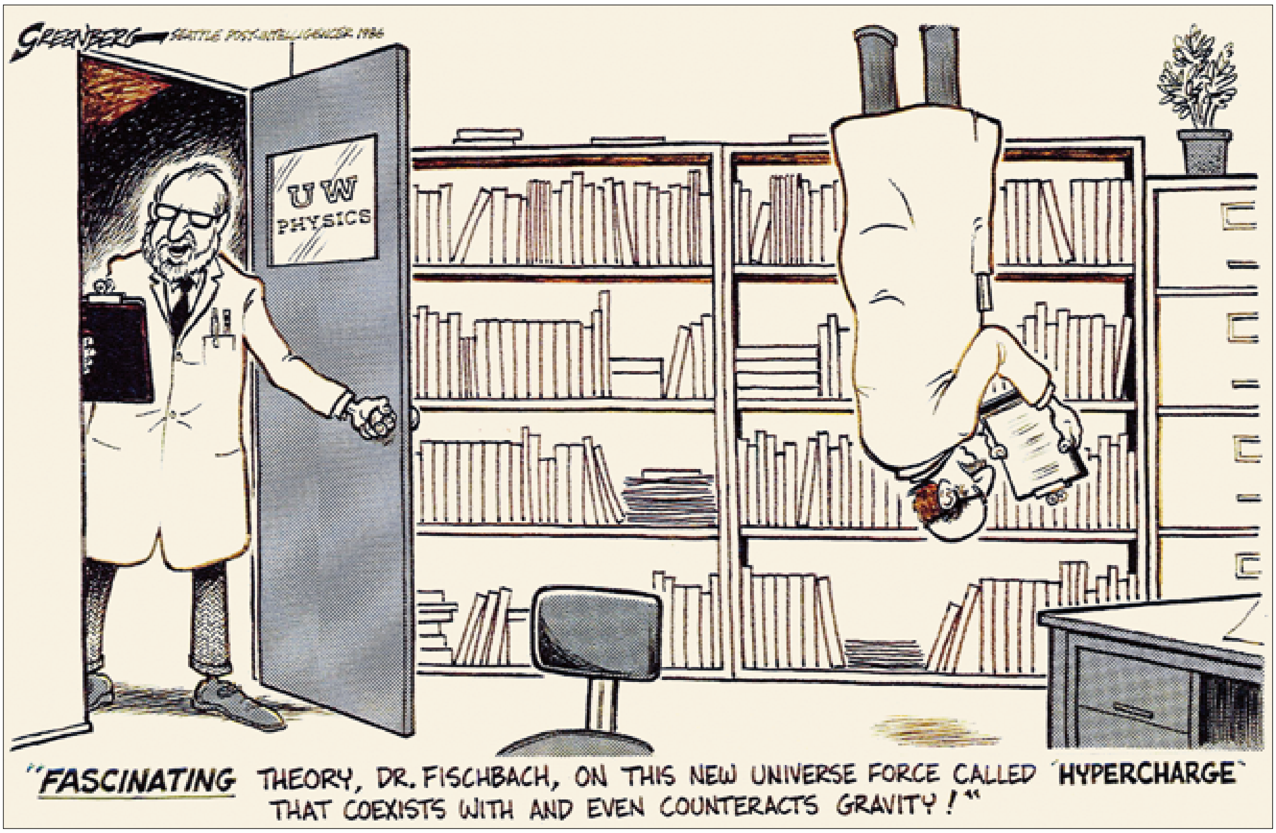
The complete title page of *The New York Times* (8 January 1986)

$$a = (5.65 \pm 0.71)\times 10^{-6},$$

which is a surprising non-zero 8σ effect.

The computations leading to this value of a have been described and checked in great detail elsewhere in the FT-book and the publications quoted in it, and hence are very likely correct given that the compositions of the EPF samples are well known. These include water, copper, platinum, copper sulfate crystals, a copper sulfate solution, and magnalium (a magnesium-aluminum alloy). Although snakewood (Schlangenholz) is a relatively exotic wood, the authors of another FSSTA paper published in 1988 were able to obtain a sample, which was subjected to chemical analysis, from which its B/μ value was obtained. The composition of the remaining sample, talg (fat, suet, …) is somewhat uncertain, and was estimated by the authors of the FSSTA paper. Whether or not this point is included does not significantly affect the EPF (quasi-linear) correlation between $\Delta\kappa$ and $\Delta(B/\mu)$ as appears in the equation above.

Summarising to this point, it appears very likely that the EPF experiment was done correctly (observation #1), and that the analysis of the EPF data as presented in the first FSSTA paper is also correct (observation #2). This leads us next to a discussion of observation #3, that there is no experimental support for the existence of a fifth force giving rise to the deviations from the predictions of Newtonian gravity implied by #1 and #2. We begin by noting that $V_5(r)$ suggests two broad classes of tests of Newtonian gravity: (a) composition-dependent tests such as EPF, and (b) composition-independent tests which search for an additional r-dependence such as might arise from $\exp(-r/\lambda)$ or some similar factor. Even before the publication of the FSSTA paper, composition-independent tests (also called searches for deviations from the inverse-square-law of gravity) were carried out by a number of authors. In the post-1986 era, many more such tests were carried out over various distance scales. (A detailed compilation of both composition-independent and composition-dependent



The cartoon and its caption refer to the fact that the value of the coefficient *a* determined from the experiment of Eötvös et al. actually leads to a repulsive force between samples with the same sign of their baryonic charges.

tests for new interactions and related theoretical papers through 1992 can be found in a paper published by Fischbach and collaborators in a journal specialised in metrology (*Metrologia*, vol. 29, p. 215).[16] To date, the most extensive tests for composition-dependent deviations from Newtonian gravity have been carried out by Adelberger, et al. (the Eöt-Wash Collaboration, working in Seattle at the University of Washington), whose careful experiments have set stringent limits on possible deviations from Newtonian gravity over a range of distance scales. With the exception of the "floating ball" experiment of Peter Thieberger, no credible experiment carried out to date has reported a deviation from the predictions of Newtonian gravity in either composition-dependent or composition-independent experiments.

Having reviewed the support for our opening observations #1, #2 and #3, we find that they are in fact strongly supported by a variety of experimental and theoretical results, and hence remain mutually contradictory at present.

Confronted with this impasse, we may now be forced to rethink some of the subtle assumptions that have been made in arriving to this point. Here I propose that we begin by reconsidering our reanalysis of the EPF experiment described in FSSTA. Our starting point is based on a 1955 paper[17] by T.D. Lee and C.N. Yang, who first raised the question of whether conservation of baryon number would lead to the existence of a long-range field in analogy to electromagnetism. Although that paper led naturally to the formalism of FSSTA as an explanation of the EPF data, it appears likely that almost any interaction or mechanism whose influence on the EPF samples is proportional to baryon number B could account for the EPF results. As an example, a "baryonic neutrino" (i.e. a new particle that interacts extremely weakly with baryons) component of dark matter might work, but its effects could require experiments that are different from those that have been carried out to date.

Another, perhaps more speculative, approach to understanding the EPF data is to return to the Guyot experiment described in the FT-book (p. 126), which was the precursor to the EPF experiment. In the Guyot experiment, a pendant suspended over a pool of mercury was used to search for a difference between $\vec{g}$ (mercury) and $\vec{g}$ (pendant) where $\vec{g}$ is the local acceleration of gravity. As noted in the FT-book, the Guyot experiment is a direct test of the equality of the gravitational and inertial masses of the pendant and, as such, depends on the Earth's rotation. By implication, so does the EPF experiment, as is also abundantly clear from EPF. Although the Earth's rotation is clearly an influence in modern torsion balance experiments, these experiments could still produce meaningful results if the Earth stopped rotating, whereas the Guyot and EPF experiments would then be meaningless. Naturally, this distinction between the Guyot/EPF experiments and the modern torsion balance experiments raises the question of whether the striking EPF data arise in some way from a coupling to *B* which is "activated" or "catalysed" by the Earth's rotation.

I conclude with a suggestion I have made previously to the effect that there may be a feature of the EPF experiment which would explain everything, but which we are ignoring because it is "hiding in plain sight" (quoted from FT-book, p. 207). Could it be there is some characteristic of the location of the EPF experiment that we are ignoring? At the other end of the distance scale, suppose that the source of baryon number, which the EPF experiment appears to call for, is not some local feature of the Earth but is cosmological in origin. Perhaps if we then combined the puzzle of the EPF experiment with other puzzles arising from neutrino physics, dark matter and dark energy, etc., a grand unified scheme might emerge. It thus appears that, however the paradox raised by the EPF results is eventually understood, interest in that experiment will endure into the future.

I am deeply indebted to my colleagues Virgil Barnes, Gabor David, Dennis Krause, Andrew Longman, and Michael Mueterthies for many helpful conversations relating to the EPF experiment.

LÓRÁNT FÖLDVÁRY
JÁNOS KISS
LÁSZLÓ SZARKA
ESZTER SZŰCS
GÁBOR TIMÁR
VIKTOR WESZTERGOM

Contemporary geodetical-geophysical results: unfolding the work of Eötvös

Through his study of the surface tension of liquids, Roland Eötvös (in Hungarian: Eötvös Loránd) discovered what would become known as the Eötvös rule at a young age. (His paper on the relationship between the surface tension of liquids and molecular weight was published in German in 1886.) From the early 1880s, his interest gradually turned to gravity (and the related magnetism).

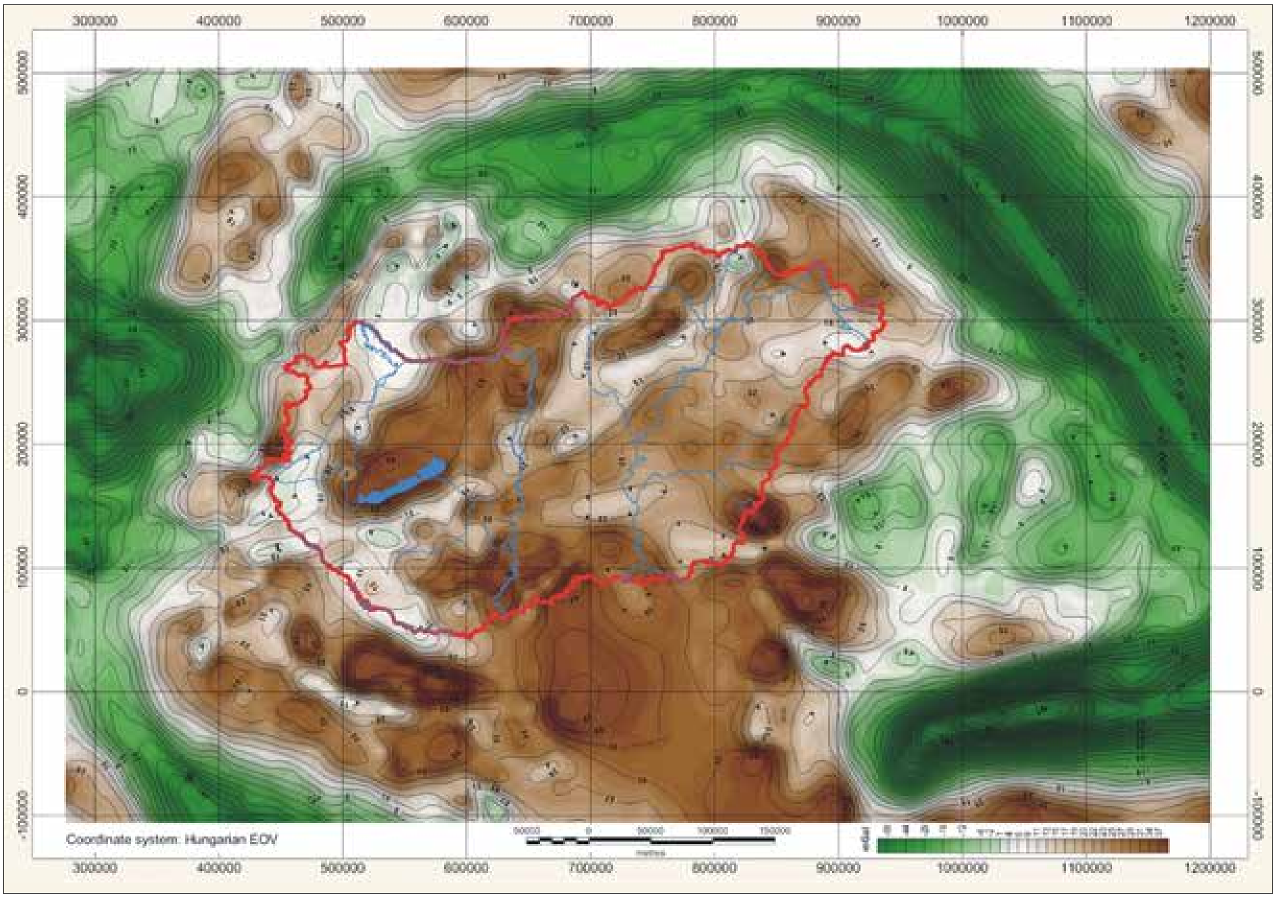
His first aim in this research was to repeat Cavendish's experiment as accurately as possible. The essence of this was to determine the gravitational constant as accurately as possible, based on the attraction between various masses. This constant was then, and still is, one of the least accurately known physical constants[18] – that is, it is known to the fewest decimal places – thus its investigation was a natural objective of his research.

However, Eötvös's attention was soon drawn to the fact that the Coulomb balance used by Cavendish was not only capable of detecting the forces between the suspended masses and a test mass approaching from a distance, but also of determining the maximum curvature of the gravity field, merely on the basis of its position in the gravity field, without the application of any external test weight. This is how his first instrument, the "curvature variometer", was developed.

Although this measurement was already pioneering in terms of gravimetry, Eötvös's truly brilliant innovation was to place the test weight on one of the scales of the Coulomb balance lower than the other. This improved instrument is known as the Eötvös torsion balance (sometimes also called "pendulum"). It should also be noted that, compared to the traditional pendulum suspended on a horizontal axis and swinging in a vertical plane (e.g. the pendulum clock), the suspension is realised by a vertical torsion thread, and the pendulum pivots in a horizontal plane with a gradually decreasing displacement until it reaches its equilibrium position. The measured data are the direction of the equilibrium.

The interpretation of the measurements is based on the theoretical background derived by Eötvös, referred to as the torsion balance equation. The Eötvös torsion balance was the first instrument in the earth sciences that was able to measure gravity gradients – that is, spatial changes in the gravity field. In addition, this instrument was the first to have a robust construction and stable measurement system for truly high-precision field observations. Thus, from the surface of the Earth, the instrument was able to detect mass anomalies at a depth, enabling exploration for raw minerals without drilling, even though the torsion balance had been developed by Eötvös for fundamental research and primarily for laboratory use. The first geological field deployment of the torsion balance took place in 1891, near Ság Hill in the vicinity of Celldömölk. The agreement between the measurements and the theoretical calculations proved the practical applicability of the torsion balance for field measurements for geological purposes. The method and the instrument revolutionised hydrocarbon research from the 1920s on, and the Eötvös torsion balance became famous throughout the world. Modern applied geophysics was born when underground geological structures were detected on the basis of the mapped gradients. In this way, the Eötvös torsion balance became the world's first geophysical tool for prospecting. The Eötvös torsion balance revealed hundreds of productive structures and billions of barrels of crude oil.

Gradients of gravity refer to the spatial variations in gravity acceleration, in terms of both direction and magnitude. In practice, this is the change in the gravity acceleration vector at a unit distance along the coordinate axes – that is, the difference between the acceleration vectors taken at the end points of the unit distance. Gravity is a relatively weak force (the value of the above-mentioned general gravitational constant in the SI system contains ten zeros after the decimal point before non-zero numbers begin) and its gradients are very small. It is no coincidence that the unit of gravity gradient known as the eötvös (written with lower case *e* as 1 *eötvös*, and abbreviated to 1 E), is one-billionth of an SI unit: 1 E = 10^{-9} 1/s^2.



Gravity map of the Carpathian–Pannonian region

In the brown-coloured areas, higher-density formations are closer to the surface, while greenish areas are characterised by thick, low-density formations. (The figure is a so-called Bouguer anomaly map, cleaned from other effects, and reflects the density distribution of the lithosphere only, in milligals. 1 mGal = 10^{-5} m/s^2, corresponding to one digit difference in the fifth decimal place of the change in the gravity acceleration. The scale ranges from dark green –69 mGal to dark brown +40 mGal, with contour intervals of 5 mGal.) This kind of gravity map already existed in Eötvös's imagination. The database on which the map is based was compiled from the results of many decades of work (predominantly relative gravimetric surveys).

Using other measurement methods, not only the gradient but also the vector of the gravity, its direction and/or magnitude, can be measured. These measurements belong to the field of gravimetry, while the discipline in which gradients are measured is known as gradiometry.

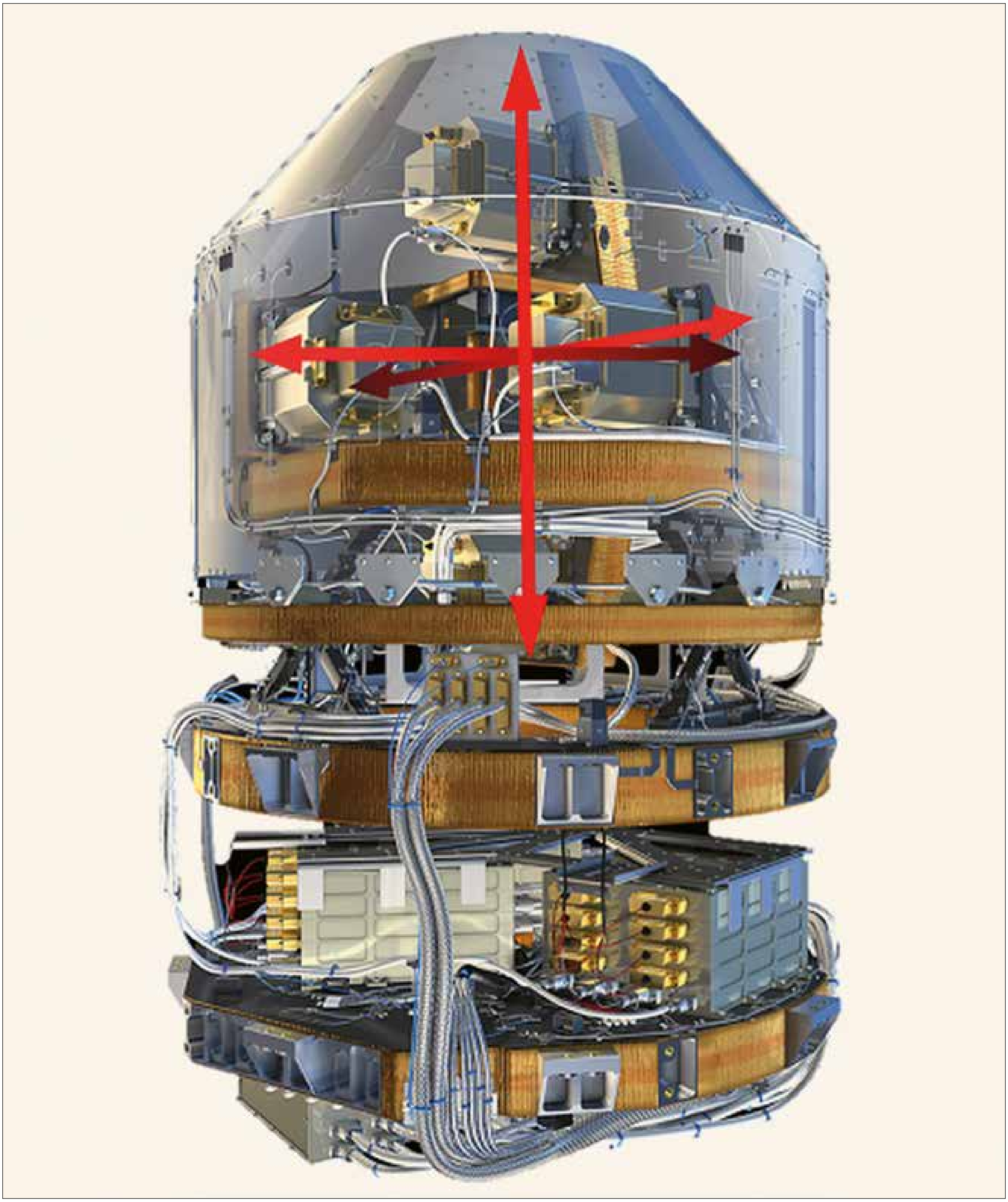
In the 1940s, small-scale gravimeters became available, making possible rapid measurement in the field (such as instruments measuring relative accelerations, e.g. the LaCoste–Romberg gravimeter in 1942), which superseded the use of the Eötvös torsion balance worldwide. In the 1950s, the Eötvös Loránd Geophysical Institute (ELGI) established a national gravity base network with new gravimeters, and measurements were carried out throughout the country. The relative gravimetric measurements entered in the national base network resulted in a unified data system, thus all further observations expanded the national survey. Data systems for larger areas were available (figure on page 69), which made possible an ever wider geological and geodetic application.

The 1960s saw the beginning of cosmic geodesy, when, for the first time, large-scale forms of gravity field were determined based on the analysis of satellite orbits. Until the end of the last century, the satellite method for determining gravity fields was based on observations of the orbital elements during passages above ground stations. If a satellite's orbit showed a deviation from the one predicted (based on an a priori known model) above a ground station, the deviation was interpreted as a consequence of the difference between the actual and the modelled gravity field, which provided the basis for modelling the gravity field more accurately.

The method has two major drawbacks. On the one hand, it provides only a small amount of measurement data; and, on the other hand, it provides measurement for only short arcs of the orbit. Both these gaps can be resolved by using GPS (Global Positioning System). In order to determine the Earth's gravity field, it is worth using low altitudes of a few hundred kilometres so as to obtain a detailed resolution. Since Low Earth Orbiters travel well below the 20,200 km altitude of GPS satellites, on-board GPS receivers can track the orbit almost continuously with high accuracy. Nevertheless, measurements by satellites orbiting at low altitude are affected by noise from various sources generated by the upper layers of the atmosphere. Such effects can be eliminated by using accelerometers located at the centre of gravity of the satellites. This was the principle behind the CHAMP satellite that was operated by the German GeoForschungsZentrum (GFZ) between 2000 and 2010. The CHAMP satellite can be regarded as the first gravimetric satellite that (continuing the earlier cosmic practice) enabled the determination of the gravity field based on satellite orbits.

A very interesting solution was provided by the GRACE twin satellites between 2002 and 2017. The GRACE satellites – operated jointly by NASA and the GFZ – were equipped with instruments that had been successfully applied in the CHAMP project: GPS receivers and accelerometers located in their centre of gravity. The two GRACE satellites revolved on identical orbits, following one another at almost the same distance (approximately 220 km). This arrangement is known as a "Tom and Jerry" configuration, referring to the way in which the cartoon cat chases the mouse so that the distance between them never changes. However, due to the irregular distribution of the Earth's mass and its polar flattening, the gravity field is not regular, therefore the distance between the GRACE satellites did not remain constant, but varied. The essence of the "Tom and Jerry" configuration is that the range-rate between the satellites can be measured accurately and continuously, an observation that makes it possible to determine the irregularities in the gravity field. For this purpose, in addition to the instrumentation mentioned above, another essential instrument was the interferometric microwave tracking system, which made it possible to measure the range-rate between the two satellites with an accuracy of less than 1 μm/s.

The success of GRACE is substantiated by the launch of the GRACE Follow-On (GRACE-FO)



The GOCE gradiometer consists of three pairs (six in total) of accelerometers located at a distance of 25 cm from the centre of mass along three perpendicular spatial directions. The direction of the instrument arms is indicated by the red arrows.

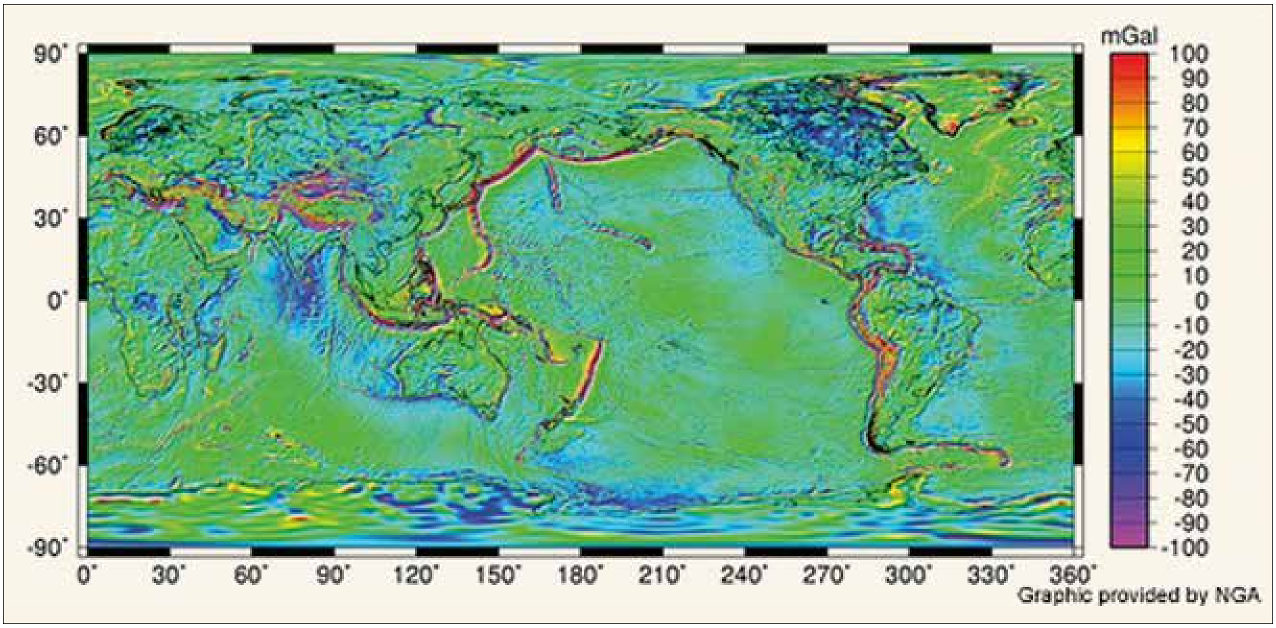
twin satellites in 2018. This was an exact equivalent of the GRACE mission, except that the range-rate measurement method was improved. As a result of technological development, the accuracy of the range-rate measurements (and consequently the accuracy of the derived gravity field models as well) improved by one order of magnitude. Another proof of the success of GRACE is that the Moon's gravity field was determined in 2012 by the GRAIL twin satellites using the same "Tom and Jerry" configuration. In the case of GRAIL, the tracking of the satellites' orbit around the Moon – in the absence of a GPS satellite system – was performed using the Earth-based Deep Space Network.

While in the satellite missions described above, the gravity field could have been detected indirectly (in the case of CHAMP, the observable was the satellite's orbit; while in the case of GRACE it was the range-rate variation between the satellites), the GOCE satellite provided direct observation about the gravity field. The observable in the case of GOCE were the gradients (also provided by the Eötvös torsion balance), which were measured by a dedicated on-board instrument known as the space gravity gradiometer, located at the centre of mass of the satellite. The space gravity gradiometer consists of three pairs of accelerometers (i.e. a total of six), spaced at equal distances (25 cm) from the centre of mass along three perpendicular directions (see page 71). The space gravity gradiometer can be construed as minified "Tom and Jerry" configurations along each axis; the role of each satellite here is taken over by an accelerometer, which enables the measurement of the gradients along the axial directions.

Due to the very low altitude (220–270 km) of the GOCE orbit, the gravity field could be determined with a fine resolution (i.e. of a few 100 km). In this way, a gap could be filled: formerly, from satellite-borne measurements only coarse (1,000 km scale) forms of the gravity field could be determined, while from field measurements only local ones (up to a scale of a few tens of kilometres) were accessible. However, due to GOCE, the medium features of the gravity field also became known. We will return to this point later.

To return to the GRACE twin satellites: it is no surprise that the space research community decided to continue this mission. The orbit of the GRACE satellites was designed in such a way that one month's measurements completely and homogeneously cover the surface of the Earth. This configuration makes possible the determination of gravity field models with a temporal resolution of one month (with a coarse spatial resolution, due to the relatively small number of measurements). Although the successive models are essentially similar to one another, since they describe the same gravity field, they also show minor differences, since the gravity field is not constant in time. Of course, the gravity field is generated by the Earth's gravitation (among other sources), thus it reflects the mass distribution of our planet. However, we know that there are geophysical processes – on the Earth's surface, in the crust and in the Earth's mantle – that involve remarkable redistributions of mass. These surface (or near-surface) processes include ocean currents, hydrological processes in river basins (water bodies transformed by rainfall, runoff in catchment areas, fluctuations in groundwater storage, evaporation processes, etc.), and changes in ice cover (ice melting processes and the accumulation of permanent snow). The lithospheric plates are known to be in permanent motion. Moreover, minor fractures can also be detected by displacements that, in many cases, trigger earthquakes. The time variation in mantle inhomogeneities may indicate a flow in mantle materials. In sum, it can be concluded that if the mass distribution changes (and it is obviously changing), then it necessarily also changes the gravity field.

GRACE was the first satellite-borne technology to monitor and investigate temporal variations in the gravity field. The spatial resolution was in the range of 1,000 km, and the technology made it possible to detect variations that can be described by monthly models (such as processes with annual periodicity). The results of satellite gravimetry in



The most up-to-date global gravity field model, the EGM08

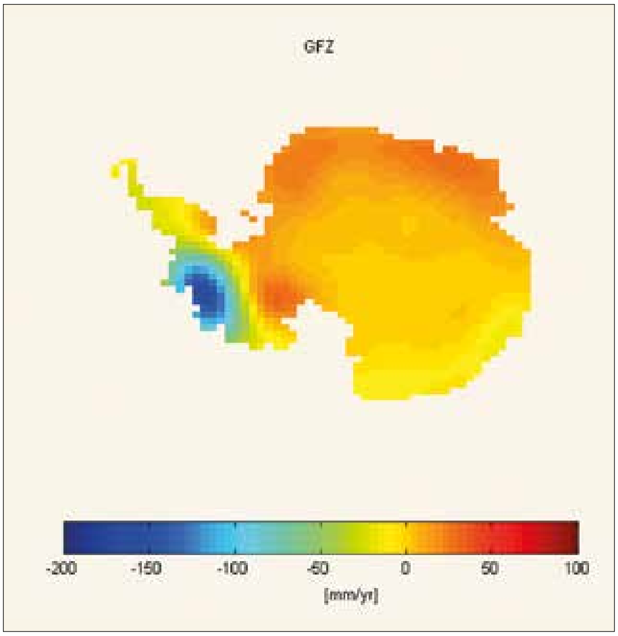
The anomalies averaged over the 5” cells show the ocean trenches and ridges, subduction zones and seabed mountain chains.

the 21st century are worth presenting in both spatial and temporal resolutions, by separating the static and dynamic (time-varying) parts of the gravity field. About 99% of the gravity field is basically permanent, and only the remaining 1% shows temporal variations.

In order to improve the static part, several years of gravimetric satellite data (CHAMP, GRACE, GOCE) are taken into account. Based on these observations, a very precise gravity field model with a fine resolution can be derived. Of course, satellite-borne technologies are not suitable for detecting variations at local resolutions (i.e. of a few meters), as the details on the surface are blurred from the satellites' altitude. As already anticipated in the context of GOCE, these satellites made it possible to provide reliable information in a spatial resolution of some 100 km, which had formerly been unavailable from terrestrial and satellite measurements. It is no coincidence that the EGM08, the most advanced global gravity field model, was based on a GOCE gravity field model refined with available terrestrial measurements. Processing the combined satellite-borne and terrestrial data, the gravity field can be determined with a resolution of some 10 m.

As for the time-varying gravity field, the monthly GRACE models have provided a new tool for geoscience that allows us to observe many present-day environmental processes. Compared to the different remote-sensing satellites, the great advantage of satellite gravimetry is that the underground processes cannot "hide" from the satellite, as their impact is part of the perceived mass redistribution.

Global climate change has a significant impact on the polar ice caps. According to the GRACE monthly models, Greenland will be "green" again within 100 years, although the situation in Antarctica is not obvious: while West Antarctica melted undeniably and rapidly between 2003 and 2014, the larger part of the continent, East Antarctica, still appears stable. In fact, in some areas, due to the significant snow accumulation, a growth in the ice cover has been detected.

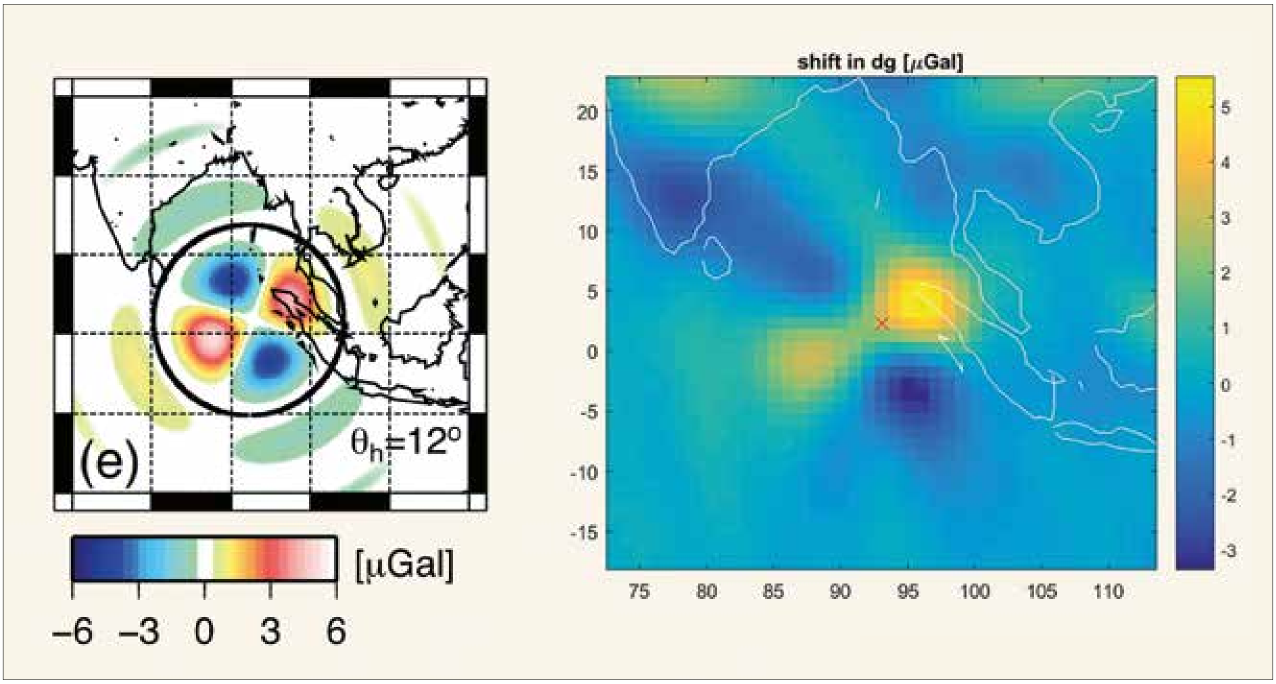


Mass changes in Antarctica [in mm/year] based on GRACE monthly models for the period 2003–2014

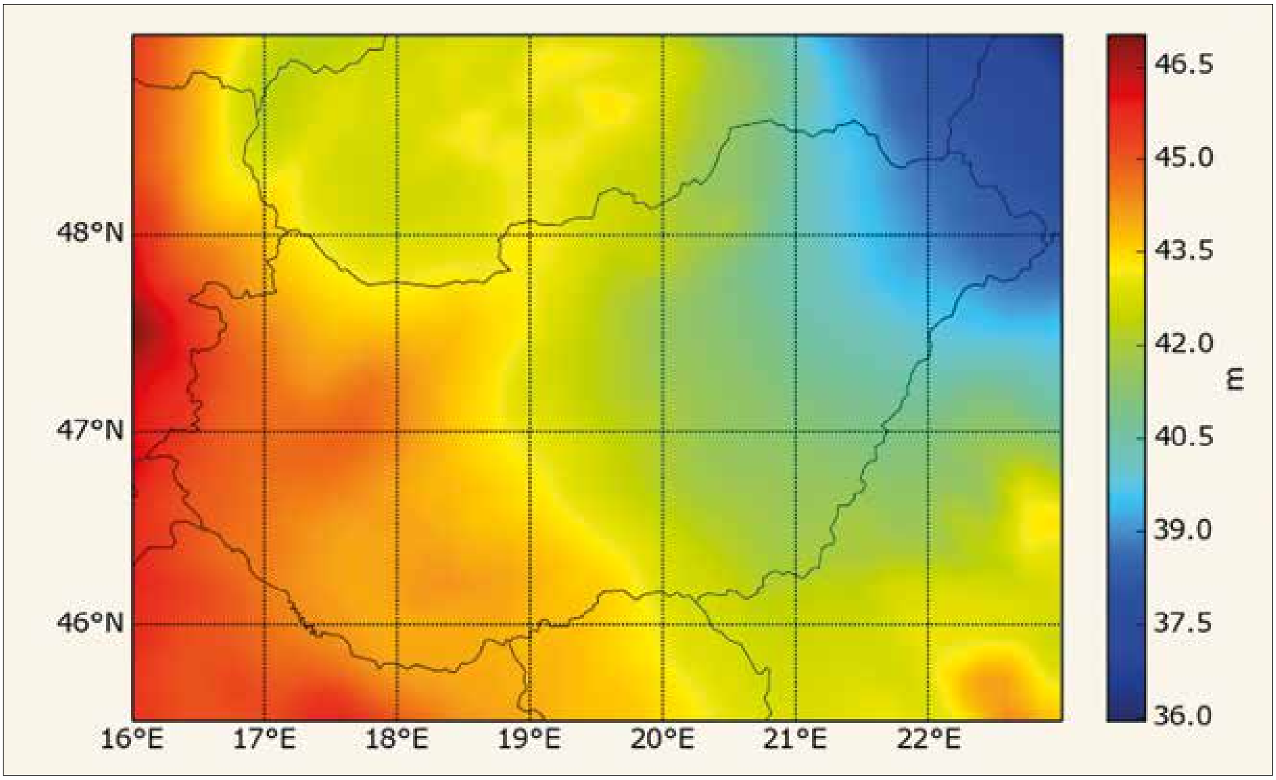
The ice mass of Antarctica is decreasing unambiguously only in the southwest, where the heat flow from depth is notable.

The ice-melting process is also contributing to changes in world ocean level. Since ocean areas cover two-thirds of the Earth's surface, the excess water that appears in this way is distributed over a large surface. As a consequence, the detection of water level rise is ambiguous, and as such it has not been shown reliably by GRACE either. In any case, the amount of fresh water is far more important in terms of life on Earth, and GRACE has added surprisingly vast amounts of relevant information to its quantitative estimates. It is not only surface water, but also subsurface water storage that can be seen from the GRACE time series. In fact, in the case of several major river basins, water mass in the ground and/or in the vegetation with annual periodicity was detected. For example, in the Amazon basin, hydrologists now assume there to be 20% more fresh water than they thought earlier based on the previous hydrological estimates.

There are also some surprising aspects to temporal gravity changes, which were not considered when the GRACE satellites were launched: major



Mass redistribution as modelled (left) and as observed by GRACE (right) due to the earthquake in Sumatra on 11 April 2012. The similarity draws attention to the fact that mass redistributions caused by major earthquakes can also be detected in the temporal change of the gravity field.



Geoid model based on GOCE measurements and geophysical field measurements [in meters] in Hungary

This figure can be regarded as a promising practical utilisation of geodetic-geophysical basic research, since knowledge of the Earth's gravity field, the horizontal level surface, is the basis of many engineering applications.

earthquakes may cause surface movements, which may also appear in the time series of the gravity field. The GRACE monthly time series can be a useful tool for understanding and quantifying the physical causes of a deep earthquake. The figure on the previous page shows an example of a model of mass redistribution due to the earthquake in Sumatra on 11 April 2012 (left), and as it was observed by GRACE (right). Based on the observation, the model can be refined.

Based on the GOCE gravity models and geophysical field measurements, a local gravity field model optimised for Hungary has been developed (see above). The results of satellite gravimetry are thus not only useful for global or continent-scale applications, but can also be utilised for country-scale purposes.

In summary, it can be stated that, just as the Eötvös torsion balance revolutionised prospecting for deposits of raw minerals one hundred years ago, today the extremely accurate measurements provided by satellite gravimetry (the descendant of the Eötvös torsion balance method) plays a similarly essential role in Earth sciences, helping researchers to obtain greater knowledge of the ongoing processes both on the surface of and in the interior of our planet.

LÁSZLÓ KOVÁCS

From the Society of Natural Sciences to the Mathematical and Physical Society

In the early 19th century in Hungary results and events in the scientific field were reported only in the political weekly *Magyar Kurír* and in an encyclopaedic monthly *Tudományos Gyűjtemény*. Meanwhile, the field of literature already had a prominent and literature-specific publication *Kisfaludy Társaság Évlapjai*, published by the Kisfaludy Society. It is no coincidence that the Hungarian Academy of Sciences (MTA), originally the Hungarian Scholarly Society, was founded with the objective of cultivating the Hungarian language and strengthening national consciousness. At the same time, similar attempts were being made in the field of natural sciences. In 1802, Pál Kitaibel (1793–1817), the great Hungarian botanist, proposed a plan for the foundation of a society for the natural sciences. The idea came to fruition in the spring of 1841, when the Hungarian Society of Natural Sciences was established at the initiative of Pál Bugát (1793–1865), professor of theoretical medicine.

The establishment of the Society and its first period of operation

Convened by Ferenc Bene (1775–1858), president of the Pest University Medical School, a meeting was held on 29 May 1841 at which a decision was made on the inception of an itinerary series of Congresses of Hungarian Naturalists and Physicians. One day earlier, Pál Bugát had published a call addressed to the assembled naturalists for the establishment of the Hungarian Society of Natural Sciences, which was then signed by 134 attendees. At the inaugural meeting, held on 13 June, those present approved the proposed statutes and elected Pál Bugát as president. The Society, which initially operated as a private club, managed to attract a patron from the royal house and was transformed into a nationwide association in June 1843. The patron was the nature-loving Archduke Stephen (1817–1867), who later became palatine. The association was henceforth known as the Royal Hungarian Society of Natural Sciences, and also obtained the right to issue diplomas to members, whom it admitted on the basis of recommendation.

While studying at university abroad, Roland Eötvös became a member of this professional society, probably on the recommendation of Kálmán Szily. Interestingly, its members included a remarkably

An old diploma of the Society of Natural Sciences signed by Archduke Stephen and Pál Bugát

An ornate certificate was presented to all new members for a price of 2 forints. (The annual membership fee was 3 or 5 forints.)

The seat of the Royal Society of Natural Sciences in Eszterházy Street. The building, in what is today Puskin Street, included an auditorium with a "Leitz projector", a meeting room, library and reading room.

large number of university students. It is also worth noting that father and son were both members: Baron József Eötvös joined the Society in 1854, and his son Roland Eötvös in 1869. According to the Society Bulletin, they paid their fees together in 1869.

In 1872, the association had "2,737 full members; of these 672 are from Budapest, and 2,065 from outside Budapest"; by 1899, however, "the number of members had increased to 8,098; including 248 founder members and 189 ladies". The membership included representatives of almost all educated social groups, including teachers, priests, head physicians, mayors, chief justices, engineers, officials, mine officers, estate stewards, and others. Separate sections were established within the Society, which regularly organised lectures, as well as issuing tenders and founding a library. Eötvös soon became part of the management, where he worked very actively. Life in the Society proved to be good training for him, as he had to organise and make decisions at the same time; he was able to exploit the skills obtained in this area in the positions he held later. At the general assembly, he was immediately elected as a committee member on 4 January 1870. When specialist areas were designated in January 1871, Eötvös, along with Ányos Jedlik and others, was put in charge of the physical sciences. Eötvös was kept busy within the Society and was always happy to carry out this work. Among other things, he was a member of the five-member delegation that submitted to the minister of education an account of the national subsidy given to the Society for the year 1870. In March 1871, he participated in the discussions on the proposal for the foundation of the Association of Hungarian Engineers and Architects; on 12 November he represented the Society at the Toldy Fest of the Kisfaludy Society, after which he gave his opinion concerning the purchase of physics teaching materials for elementary schools; and in December he was elected as a member of the board of the 1873 Vienna World Expo. He was, one might say, a life member of the committee for the auditing of the library of the Royal Hungarian Society of Natural Sciences, and as such was asked to report on the usage of the library, in addition to its quantitative analysis, in 1878. He was chosen to represent the Society on the Publications Committee of the Academy of Sciences. In 1899, Eötvös became a member of the property purchasing committee, as the substantial total amount of the "hereditary membership" fees of several hundred forints, as well as donations and state subsidies, provided sufficient income for the Society to purchase its own headquarters.

To mention just a few of Eötvös's important proposals: in November 1870, he suggested launching a call for research projects of national interest; in June 1871, he proposed a petition for regulating applications, as well as secretarial and editorial tasks; in his proposal at the end of that year he outlined how the annual amount of 2,000 forints should be used for research of national interest. It was a significant event when, at the general meeting for the re-election of officials "held on 21 January 1880 in the small hall of the Academy of Sciences and chaired by [chemist] Károly Than (1834–1908)", he was elected by 157 votes out of 197 as one of the two vice-presidents, a position that he held until his death. Eötvös maintained very strong ties with this community. In addition to his activities in the Mathematical and Physical Society that he founded, and his work for the Academy of Sciences and other societies, and his university and research work, he regularly participated in general meetings and committee and board meetings, which he sometimes also chaired.

The era of prosperity: Communications in Natural Sciences

"In 1868, secretary Kálmán Szily (1838–1924), the excellent, 30-year-old physicist [and linguist, later secretary general of the Hungarian Academy of Sciences], proposed the publication of the monthly journal *Természettudományi Közlöny* [Communications in Natural Sciences]. He was appointed editor, and the first issue appeared on 8 January 1869. […] The impact of the journal on national scientific culture was immeasurable", wrote chemist Mihály Beck (1929–2017) in his study on the history of the Society. On 17 April 1990, it was Beck, along with professor of geology Viktor Dank (1926–), who reorganised the association following its ban in 1953.

"The Hungarians must learn to like scientific knowledge", Kálmán Szily stated. To achieve this, in addition to educational articles and regular, informative columns, the journal ran what would now be called an "interactive" feature: from 1873, the "letterbox" answered readers' questions, and from 1887, readers could also submit "old Hungarian observations". This suggests that the influence of the journal in shaping the professional community should not be neglected.

A brief look at the detailed results of the various calls for research applications suggests that the members of the Society put a lot of work into carefully and rigorously evaluating the submitted proposals. Eötvös and another academician and physicist Alajos Schuller (1845–1920) formed the jury of a competition announced for the presentation of physics experiments in high schools. According to the Society's journal, the name of the winner, high school teacher Károly Antolik (1843–1905) "was greeted with cheers by the General Assembly" [1890].

In contrast to the scarcely digestible texts of previously published yearbooks, the articles published in the journal were deliberately designed to be readable. The related publication of books was characterised by accurate works nevertheless written in an enjoyable style. In 1910, Eötvös preferred the publication of a work on electricity by one of his favourite pupils, the physicist and academician Győző Zemplén (1879–1916), over the two other submitted works, precisely for this reason. Not only the style of the books, but also their format was of high quality: they were published either with a gilded cloth binding or with hard covers. About 60 percent of contemporary scientific works, along with the journals, making a total of 400 volumes, were published by the Society. Besides the work by Zemplén already mentioned above, works by Szeged high school teacher Alajos Czógler (1853–1893) and the Society's librarian, academician and physicist Ágost Heller (1843–1902) on the history of physics, were published in the form of handbooks (in 1882 and 1891). These works were the fruits of a call for submissions. The Society also took care to ensure that valuable works were not lost. In January 1881, Eötvös stated that two of the three works submitted in response to a call issued by the physics committee were outstanding: and, because of "the skilled compilation" and "painstaking, professional and objective discussion" they doubled the prizes, so that both candidates received 300 forints.

From 1888, supplementary papers of varying length were regularly published as attachments to the Communications in Natural Sciences, containing longer articles and also reporting original scientific findings.

Eötvös also took an active part in the editorial work. At a commission meeting on 7 December 1870, when the editorial board was expanded, Eötvös was appointed editor of the "Astronomy, physics and meteorology" section, with four colleagues. In 1872, when the journal's structure became further differentiated, Eötvös was asked to take responsibility for the physical science section.

Eötvös's career as an author began at this time, in association with the journal. His presentation "The Doppler effect and its application in acoustics and optics", delivered at a "section session on 7 December 1870", was published as a supplementary paper on 19 January 1871, in Volume III of the Communications in Natural Sciences. His article "On the colour spectrum of the Northern lights", signed by "Dr. B. Eötvös Loránd", also deserves mention. His first publications were reviews, as documented in detail in the bibliographic literature on him (see the chapter on bibliography by Sándor Mikola [1871–1954] and János Renner [1889–1976] in the Baron Roland Eötvös memorial book of 1930). Overall, 29 of his articles and presentations were published in the journal, some as complete publications and others as resumés, and there are also references to his lectures given at the Society or the Academy.

Eötvös probably learned the importance of the popularisation of science and the self-organisation of the academic community from Hermann Ludwig von Helmholtz (1821–1894) during his university years in Heidelberg.

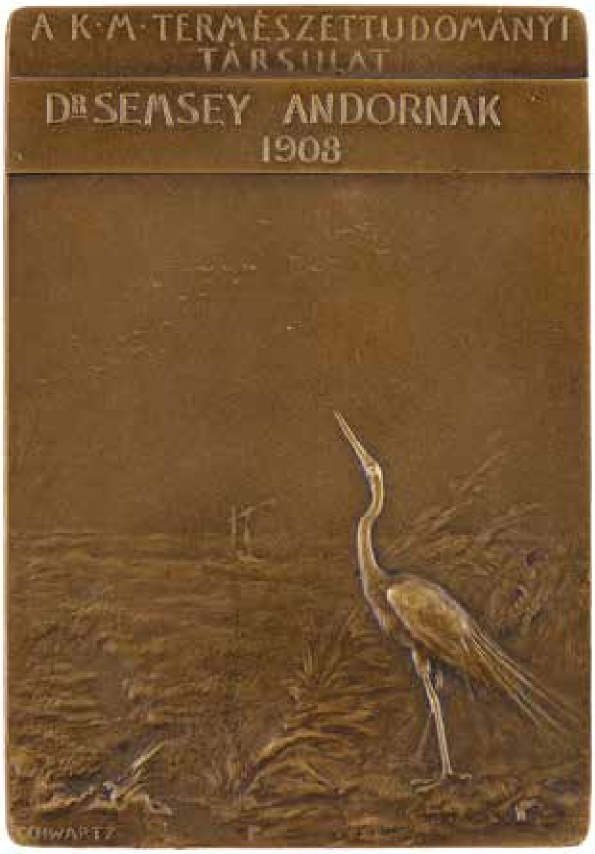
Presentations by Roland Eötvös

Eötvös's work as a lecturer surpassed his administrative activities and his writing of articles for the popularisation of science. Eötvös gave presentations at a wide variety of forums, and in many different forms. Leaving aside his presentations at specialist meetings and assembly meetings, we discuss below only the two large-scale ventures organised by the Hungarian Society of Natural Sciences, which "he undertook with the greatest of pleasure." Eötvös had been convinced by his teachers in Heidelberg, who included Robert Wilhelm Bunsen (1811–1899) and Gustav Kirchhoff (1824–1887), of the fundamental importance of experimentation, and he adopted their methodology, the practice of experimental demonstrations integrated into his presentations. The experiments added spice to his presentations by combining visual elements with the power of the spoken word, enhancing the impact of Eötvös's charming personality. Not every interested contemporary was able to attend these presentations, but fortunately printed versions of them were published in the Society's journal.

The following statement, for example, was delivered at the general meeting in January 1889: "The highlight of the public sessions was the series of lectures on physics. Baron Roland Eötvös, university professor and vice president of our Society, gave a series of 10 lectures [weekly from January to Easter] in which he described the current state and research methodologies in the field of physics." According to the report, the audience included secretaries of state, ministerial councillors, and several other "prominent figures" from public life. The lecturer had at his disposal all the necessary instruments both for the lectures at the Budapest University as well as for the chemistry lectures held earlier at the Technical University in 1887. One and a half decades later, his six-lecture series, "Popular courses. Baron Roland Eötvös on gravity and earth magnetism" sparked similarly wide interest between 28 February and 4 April 1903.

Society recognition

On the 30th anniversary of the Society's journal, at its General Assembly held on 24 January 1900, the Hungarian Society of Natural Sciences established a gold medal and prize to commemorate the work of Kálmán Szily. The prize was awarded every three years for the most outstanding efforts towards the cultivation or popularisation of the natural sciences in Hungary. In 1912, "the General Assembly approved with great enthusiasm the proposal of the board, and awarded the KÁLMÁN SZILY medal and prize to BARON ROLAND EÖTVÖS," the journal reported. Eötvös donated 1,500 golden crowns of the prize money to three foundations of the Society of Natural Sciences, and the remaining 500 crowns were given to the Mathematical and Physical Society. (The Austro-Hungarian silver-based Forints had been replaced by gold-based Crowns in 1892.) Unfortunately, the gold medal awarded to Eötvös, of which bronze copies were made, has been lost. Landowner and academician Andor Semsey (1833–1923) was a generous patron



The two faces of the Society's Szily commemorative plaque designed by István Schwartz (1851–1924)

The upright rectangle on the front features a half-length portrait of Kálmán Szily, looking towards the right, with dates above it referring to the first 30 years of the Society's journal. The back depicts the Great Hungarian Plain. The inscription on the back reads: R[oyal] H[ungarian] Society of Natural Sciences / To Dr. Andor Semsey, 1908. Size: 49×70 mm.

of Hungarian science and supported Eötvös's experiments on gravity with significant sums. Copies of the Szily medal that was awarded to him are kept in the Hungarian National Gallery and also in the Manuscript Collection of the Hungarian Academy of Sciences.

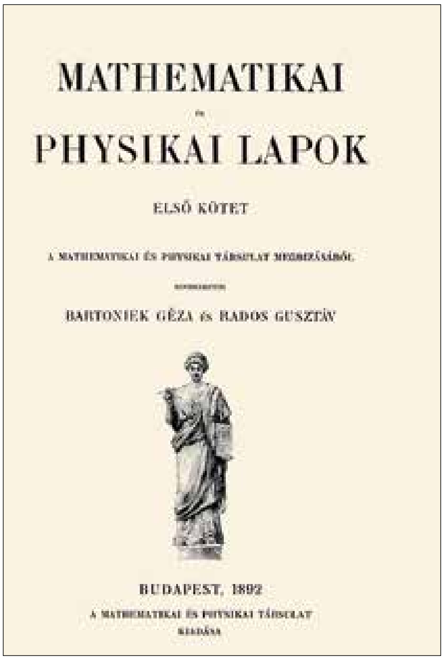
The founding of the Mathematical and Physical Society (MPS)

The Mathematical and Physical Society grew out of the mathematicians' roundtable and the Society of Natural Sciences. The declared aim of the association was to provide further training for teachers in a more appealing style than the poorly attended abstract academic lectures, while still at a higher level than that of general science popularisation.

In December 1890, Eötvös invited more than 100 high school and university colleagues to two lectures. These lectures can be regarded as the seeds of the MPS, as it was here that the idea of founding the new society first emerged. In January 1891, the preparatory committee held its first meeting, and the inaugural session was held on 5 November the same year. The first president of the Society was "university rector, president of the Hungarian Academy of Sciences" Roland Eötvös, who retained his position until his death.

At the inaugural meeting, the president stated in his speech that "Our duty is to give a verbal account of the progress of science at our regular gatherings, and to write down everything that is worthy of professional attention in our professional journals. […The] success of teaching in both higher and intermediate educational institutions depends primarily on the teachers' academic qualifications." Learning from the example of the Society of Natural Sciences, a journal was promptly established upon the foundation of the Society: the *Mathematikai és Physikai Lapok* (Mathematical and Physical Journal) was launched in June 1891. The cover of the combined issues 1 and 2 refers to Budapest mathematicians and physicists as the publishers, and it was only from the third issue that the Mathematical and Physical Society was mentioned as publisher on the front page. The symbol of the Society that appeared on the cover deserves mention: it was none other than the allegorical figure of "Mathematics". It was not only a reference to the mathematical profile of the journal, but also expressed the intention for (mathematical) exactitude even when discussing physics-related subjects.

Roland Eötvös was inspired primarily by Ányos Jedlik (1800–1895) in constructing innovative tools of physical experimentation and in his steady, disciplined experimental work. The seven years that Eötvös had spent with Jedlik at the University of Pest had converted the bohemian baron into a genuine, serious scholar and teacher, who had learned from Jedlik the importance, and at the same time also the love, of persistent research. Eötvös was grateful to his mentor, as also indicated by the fact that he nominated Jedlik as the first member of the Mathematical and Physical Society. As president of the MPS and the MTA, as well as vice president of the Society of Natural Sciences, he attended Ányos Jedlik's funeral in Győr, which was held two days after Jedlik's death on 14 December 1895, and he delivered a speech commemorating



MATHEMATIKAI

PHYSIKAI LAPOK

ELSŐ KÖTET

A MATHEMATIKAI ÉS PHYSIKAI TÁRSULAT MEGBIZÁSÁBÓL

BARTONIEK GÉZA ÉS RADOS GUSZTÁV

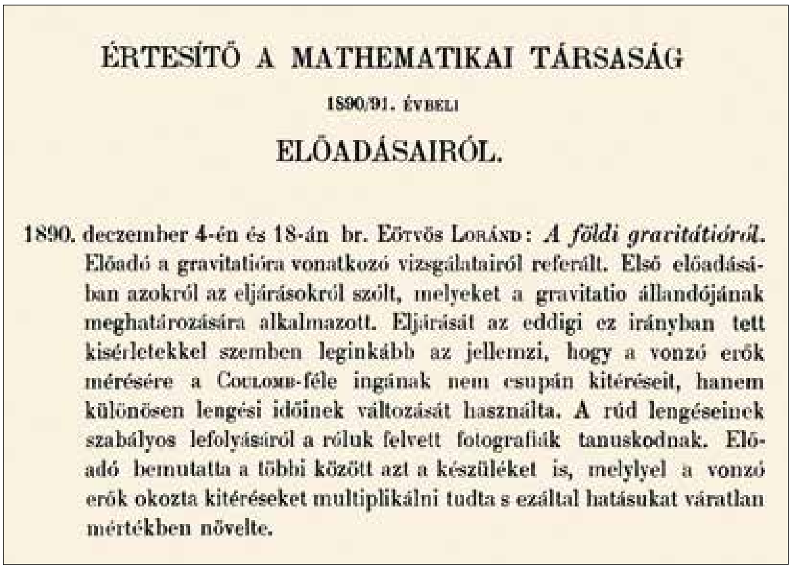
BUDAPEST, 1892

A MATHEMATIKAI ÉS PHYSIKAI TÁRSULAT

KIADÁSA

The cover of the journal of the Mathematical and Physical Society, with the Society's emblem – an ink drawing by the painter and graphic artist Mrs. Nelly Hirsch Radó (1871–1915), based on the statue of "Mathematics" on the facade of the Academy building

The statue representing "Mathematics" on the second-floor facade of the Academy building, by Berlin sculptor Emil Wolff (1802–1879)



ÉRTESÍTŐ A MATHEMATIKAI TÁRSASÁG

1890/91. ÉVBELI

ELŐADÁSAIRÓL.

1890. deczember 4-én és 18-án br. Eötvös Loránd: *A földi gravitátióról.* Előadó a gravitatióra vonatkozó vizsgálatairól referált. Első előadásában azokról az eljárásokról szólt, melyeket a gravitatio állandójának meghatározására alkalmazott. Eljárását az eddigi ez irányban tett kisérletekkel szemben leginkább az jellemzi, hogy a vonzó erők mérésére a Coulomb-féle ingának nem csupán kitéréseit, hanem különösen lengési időinek változását használta. A rúd lengéseinek szabályos lefolyásáról a róluk felvett fotografiák tanuskodnak. Előadó bemutatta a többi között azt a készüléket is, melylyel a vonzó erők okozta kitéréseket multiplikálni tudta s ezáltal hatásukat váratlan mértékben növelte.

An excerpt from the Journal, reporting on a lecture by Eötvös held in December 1890

his mentor at the General Assembly of the Academy on 9 May 1897.

The first General Assembly of the MPS, which served as a model for later gatherings, was held at the physics lecture hall of the Technical University on 4 and 5 April 1893. After the formalities of the Society, the main activities included presentations of experiments, institute and factory visits, and an exhibition of experimental devices. The president of the Society, Eötvös, presented his own experiments on gravitation and on critical temperature. The secretary of the Society, Géza Bartoniek (1854–1930), repeated Hertz's electromagnetic and mechanical experiments, and many other members, arriving mostly from the countryside, also gave presentations.

Life in the MPS

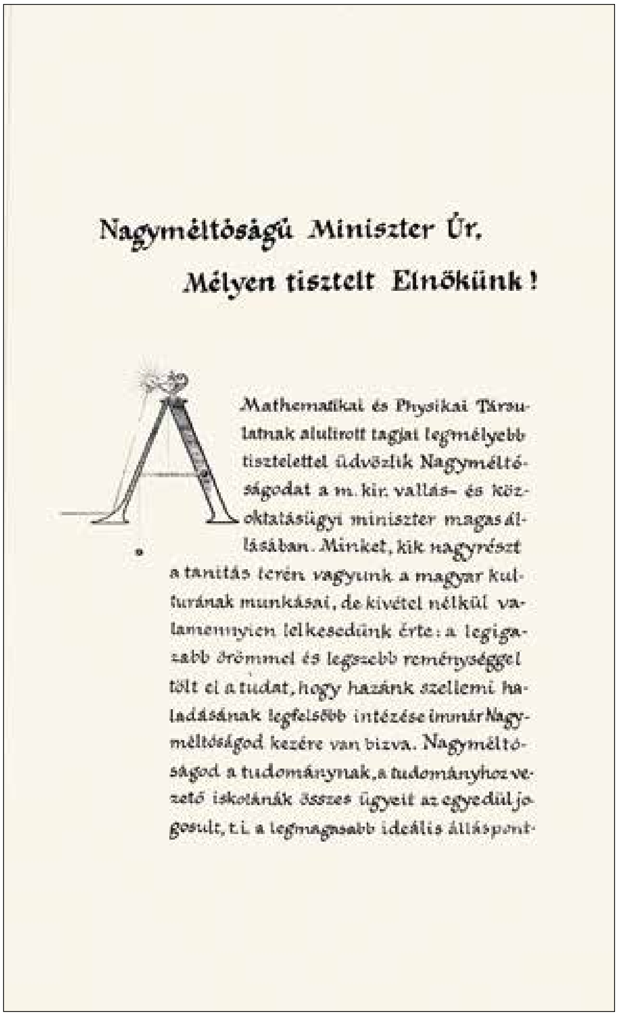
As head of the Society, Eötvös did everything he could to provide professional and methodological training for teachers. He used the monthly journal of the Society in the service of this goal, building on the activity of Society members. A regular problem-solving section was set and detailed solutions were published. Problem 2 on page 98 of the first issue, for example, reads: "How great a variation can the rising or the recession of a large river such as the Danube cause in the direction of a plummet? (B. Eötvös)." In the same issue, the solution by high school teacher Nándor Gruber (1858–1936) and physicist and academician Károly Tangl (1869–1940) was published. In connection with the above problem, the journal reported a large-scale experiment in which 320,000 tons of water were drained from a lake (and later returned) in order to measure changes in gravity. In 1998, in the Eötvös Physics Competition, Dr. Gyula Radnai (1939–), who succeeded Miklós Vermes (1905–1990) as organiser of the competition and who was later made honorary president for life, once again set this problem, combining it with Eötvös's own "swinging" method, presented in his member-recruiting presentation at the inaugural meeting of the Society.

Eötvös used the prestige of the Academy to advertise the scientific work of teachers. In May 1889, at a session of Section III of the Academy, he presented with enthusiasm and appreciation two studies by secondary school teachers from outside Budapest: Károly Antolik (1843–1905) from Arad wrote about the visualisation of sound vibrations; and Károly Fuchs (1851–1916) from Pozsony wrote on capillarity.

The launch of a student competition commemorating Eötvös's appointment as minister

Prior to the Hungarian Society of Natural Sciences, the MPS supported the professional career of talented young people. A high school teacher from Győr, Dániel Arany (1863–1945), who was a regular member of the Society from its foundation, launched a monthly magazine, *Középiskolai Mathematikai Lapok* (Mathematical Journal for High Schools). It also included some physics problems. Closely related to this activity, the MPS celebrated Roland Eötvös's appointment as minister in its own way. At a meeting held on 22 June 1894, the board decided to express "its joy at the appointment of the president of the Society, the Honourable Baron Roland Eötvös, as the Royal Minister of Public Education and Religious Affairs" with a solemn entry in the minutes and a memorandum signed by all members of the Society. They agreed to mark the appointment by organising a mathematics and physics competition for fresh high school graduates in the autumn of each year. The prizes, worth 100 and 50 crowns, were awarded as "First or Second Baron Eötvös Prize", and the award-winning papers were published in the Society's journal. In order to gather signatures, the mentioned memorandum was circulated by mail. The statement that "current transportation speeds make it possible for even those pages that travel furthest to be returned to Budapest within 10 days of being sent" might be a cause of envy even today. Signed by 387 members of the Society and bound in white vellum, the memorandum is still extant and on display.

Drawing of the two sides of the "Baron R. Eötvös Prize for the Eötvös Mathematics Competition". The name of the winner is for illustration only. The medal was commissioned by Roland Eötvös.



Nagyméltóságú Miniszter Úr,
Mélyen tisztelt Elnökünk!

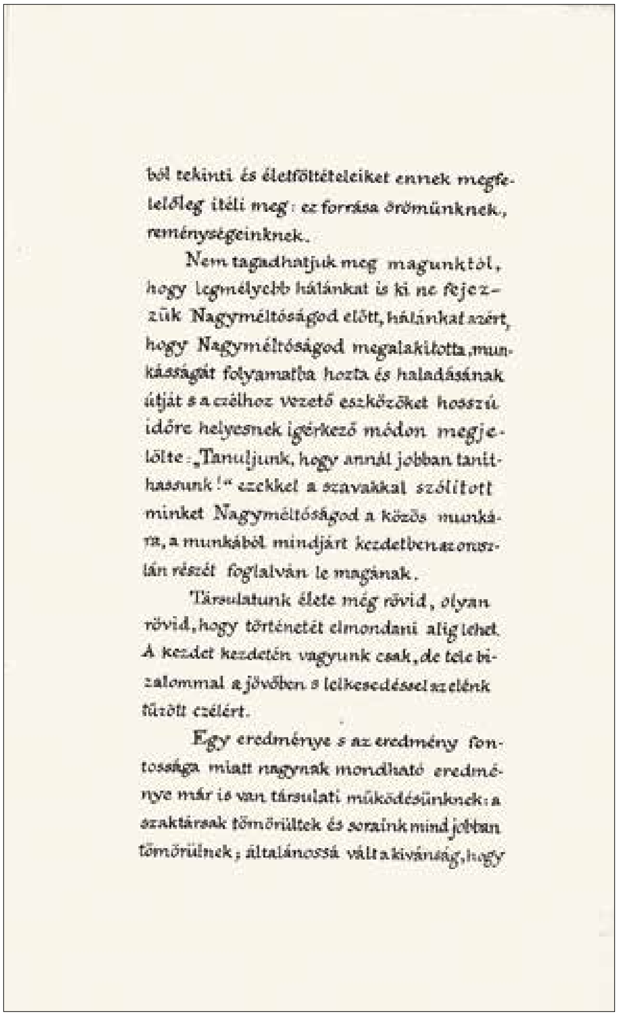
A Mathematikai és Physikai Társulatnak alulirott tagjai legmélyebb tisztelettel üdvözlik Nagyméltóságodat a m. kir. vallás- és közoktatásügyi miniszter magas állásában. Minket, kik nagyrészt a tanitás terén vagyunk a magyar kulturának munkásai, de kivétel nélkül valamennyien lelkesedünk érte: a legigazabb örömmel és legszebb reménységgel tölt el a tudat, hogy hazánk szellemi haladásának legfelsőbb intézése immár Nagyméltóságod kezére van bizva. Nagyméltóságod a tudománynak, a tudományhoz vezető iskolának összes ügyeit az egyedül jogosult, t.i. a legmagasabb ideális álláspont-

Congratulatory document presented to Roland Eötvös in 1894 by the Mathematical and Physical Society on the occasion of Roland Eötvös's appointment as minister, with the emblem of the Society, an ink drawing depicting "Mathematics", on the front

The presentation of the memorandum and competition prizes took place at a "ceremonial session" on 25 October 1894 in the presence of Eötvös, who was accompanied by three members of the Society. "Those gathered welcomed the president with a standing ovation as he entered." Eötvös expressed his gratitude for the celebration, praising the work of the pupils and their teachers at length as he presented the prizes. Winner of the first prize, Mihály Seidner (1875–1968), was a student of electrical engineer and later academician József Winter (1853–1937) in Losonc, while the winner of the second prize, Pál Pap, was taught by József Ellend (1866–1921) from Sárospatak. The winners also received engraved medals.

Encouraged by earlier examples, the Roland Eötvös Physical Society minted new medals for the winners of the Eötvös Physics Competition.

Contrary to the original concept, later only mathematical problems were set for the Eötvös competitions. Teacher Iréneusz József Károly (1854–1929) from a religious order in Nagyvárad (Oradea), founded a genuine physics contest in 1916. The president of the jury at the first competition

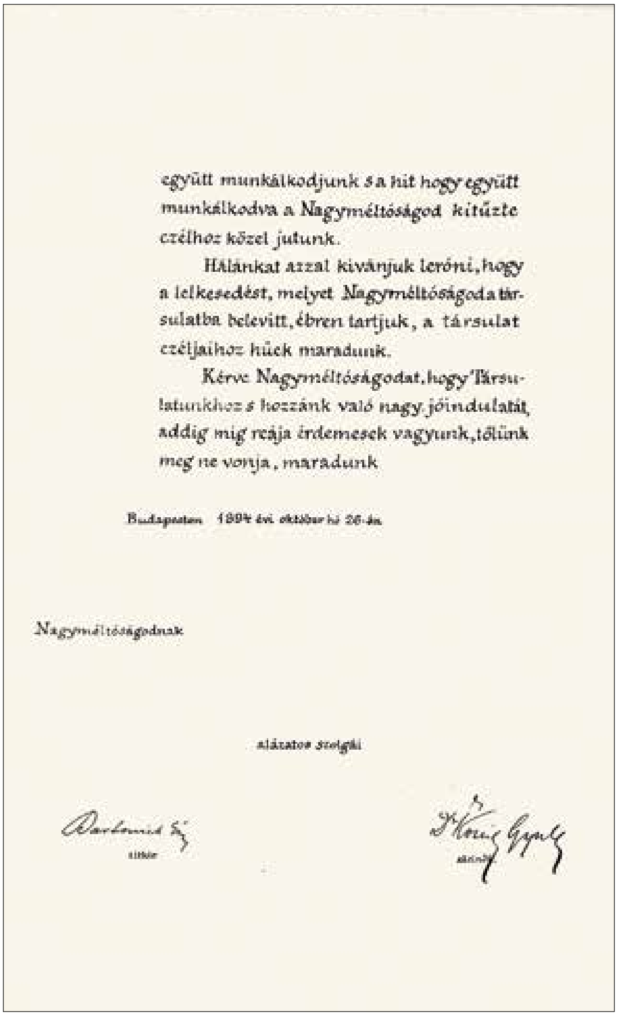


ból tekinti és életföltételeiket ennek megfelelőleg itéli meg: ez forrása örömünknek, reménységeinknek.

Nem tagadhatjuk meg magunktól, hogy legmélyebb hálánkat is ki ne fejezzük Nagyméltóságod előtt, hálánkat azért, hogy Nagyméltóságod megalakitotta, munkásságát folyamatba hozta és haladásának útját s a czélhoz vezető eszközöket hosszú időre helyesnek igérkező módon megjelölte: „Tanuljunk, hogy annál jobban tanithassunk!“ ezekkel a szavakkal szólitott minket Nagyméltóságod a közös munkára, a munkából mindjárt kezdetben az oroszlán részét foglalván le magának.

Társulatunk élete még rövid, olyan rövid, hogy történetét elmondani alig lehet. A kezdet kezdetén vagyunk csak, de tele bizalommal a jövőben s lelkesedéssel sz elénk tűzött czélért.

Egy eredménye s az eredmény fontossága miatt nagynak mondható eredménye már is van társulati működésünknek: a szaktársak tömörültek és soraink mind jobban tömörülnek; általánossá vált a kivánság, hogy



együtt munkálkodjunk s a hit hogy együtt munkálkodva a Nagyméltóságod kitűzte czélhoz közel jutunk.

Hálánkat azzal kivánjuk leróni, hogy a lelkesedést, melyet Nagyméltóságod a társulatba belevitt, ébren tartjuk, a társulat czéljaihoz hűek maradunk.

Kérve Nagyméltóságodat, hogy Társulatunkhoz s hozzánk való nagy jóindulatát, addig mig reája érdemesek vagyunk, tőlünk meg ne vonja, maradunk

Budapesten 1894 évi október hó 26-án

Nagyméltóságodnak

alázatos szolgái

titkár

elnök

The new, 20th-century bronze medal for the Eötvös Physics Competition. From 2002 onwards, the winning student has been presented with this work by sculptor György Várhelyi (1942–) along with the prize money.

was Eötvös, and the jury members included Géza Bartoniek and Sándor Mikola. The first Irén Károly prize was won by György Jendrassik, who later became a mechanical engineer, inventor and academician, and who was a student of Dénes Koren. The second Irén Károly prize went to Leó Szilárd, a student of Mór Balog.

Epilogue

Roland Eötvös participated actively in the work of the MPS until the end of his life. On 10 May 1917, for example, he gave a presentation on the gravity of the bodies moving on the Earth. He also presented to the members of the Society the device he had constructed to demonstrate the Eötvös effect in auditoriums. On 16 May 1918, he presided at the XXVth general meeting.

"The Society devoted its session on 12 December 1918 to its prestigious president and founder, Baron Roland Eötvös, in humble homage to the figure and works of the great physicist. Vice President Gusztáv Rados mentioned in his opening speech that our beloved president celebrated his 70th birthday in 1918, and to honour the event the Mathematical and Physical Journal issued a booklet dedicated to Baron Roland Eötvös. We were hoping to present him with the celebratory booklet at this session, but unfortunately he is unable to be present due to illness, thus fellow member Izidor Fröhlich will visit him on his sickbed to give him a copy of our Eötvös booklet and to express the Society's love and respect", as the journal reported the event.

The booklet that was presented to him was in manuscript form, thus the seriously ill Eötvös still got to see the work, even though it was not printed until 1921. The same year, the newly formed Society adopted the name of Roland Eötvös. Much later, in 1950, the mathematics and physics sections of the Society separated: the former now operates under the name the Bolyai János Mathematical Society, while the latter, the Eötvös Loránd Physical Society, preserves its great founder's name and keeps his memory alive.

CSABA BORSODI

Roland Eötvös, university rector

Introduction

The universities that were established at the dawn of the early modern age, such as the Jesuit University founded in 1635 in Nagyszombat (Trnava) by Péter Pázmány, archbishop of Esztergom, were headed by rectors. This university initially had two faculties – Humanities (1635) and Theology (1638). A third was added in 1667, when the Faculty of Law was founded, and a fourth in 1769, with the establishment of the Faculty of Medicine. During the Jesuit period, the rector's duties were performed by Jesuit priests, most of whom were teachers in the Faculty of Theology. They were appointed by the Jesuit provincials. However, in the second half of the 18th century, during the reign of the enlightened absolutist Queen Maria Theresa, significant reforms took place and the state began to intervene significantly in the life of the universities in the Habsburg Empire. This was also the case in Nagyszombat. Beginning in 1753, the reform efforts had profoundly changed the content of university education by the early 1770s, and it was inevitable that the university's upper management would also be transformed. The deed of gift issued by Maria Theresa, dated 17 July 1769, placed Nagyszombat University under the protection and administration of the monarch and her successors. The final phase in the transformation of the Jesuit University into a state university was the *Diploma Inaugurale*, the diploma of re-establishment, dated 25 March 1780. With this document, the monarch confirmed the assets of the university, thereby ensuring its operation. In 1777, as stated in its deed of foundation, the university moved to Buda, in the centre of the country. After a brief time in Buda, it moved to its final location in Pest in 1784. In 1773, Pope Clement XIV had disbanded the Jesuit order, and Queen Maria Theresa implemented his brief the following year. This marked the end of the university's Jesuit era. The reforms also led to changes in the role of the rector and in the way he took office. Until 1771, rectors spent not just one year, but three or sometimes even four years in office.

The 1771/1772 academic year brought with it a radical change in the institution of rector: from that time on, he was not appointed, but elected. With the exception of the period of neo-absolutism (1849–1860), the university elected a rector for a term of one year, according to the defined order of the faculties. The first elected rector of the university was Zsigmond Keglevich, a professor in the Faculty of Theology, who was succeeded by law professor Zsigmond György Lakits, professor of medicine Ignác Prandt, and humanities professor Ferenc Weisz. The next rector was once again a teacher of theology. Sometimes the order was changed, and in some rare cases two teachers from the same faculty were made rector in consecutive years. This system was in operation until the 1949/1950 academic year, after which the rector was elected for a three-year cycle.

Since 1771, the election and inauguration of a new rector has always had the purpose of demonstrating both the weight of the University Council, and the prestige of the rector. Since, in the more distant past, a new rector took office each year, the start of the academic year was subject to extremely strict rules. These rules acquired particular importance in the 1860s, after the university gained its autonomy: "*The retiring rector reported on the* *events of the year, and, at the end of his speech, placed the university's diploma, the Diploma Inaugurale, as well as the seals donated by Maria Theresa, onto the great table in the university hall; then, along with the deans who were also leaving office, he stepped down from his place. The new deans, who had been elected in advance by the faculty councils, processed into a side room, where they elected the new rector. On returning to the hall, the result was announced by the dean of the faculty from which the rector had been chosen. The ceremony ended with a lunch hosted by the new rector."* (József Papp, 1982)

The monarch (Francis I) donated so-called chains of office (rector, dean) to the University of Vienna in 1805 and to the University of Lemberg (Lviv, Ukraine today) in 1817. The rector of the Royal University of Pest approached the ruler with a request that his university should also receive chains of office. These were finally commissioned in 1819, and on 18 May 1820, the chains were worn for the first time by the rector and the four deans. From this point on, it became a custom to hand over the chains of office. According to the protocol for the ceremony, the newly elected office holders sat behind those who were still in office, and the chains were hung around the necks of the new office holders by those who were stepping down. With this act, the position was handed over, and the tradition was observed without fail until 1849.

The 1848 Revolution resulted in the creation of a constitutional monarchy. Baron József Eötvös became minister of religion and public education in the so-called independent Hungarian responsible ministry. At the initiative of Eötvös, Parliament enacted a university law, although a more detailed law and decree governing the operation of the university could not come into force. In September 1848, Eötvös resigned and emigrated. At the same time, education was interrupted during the War of Independence.

Between 1849 and 1860, during the period of neo-absolutism, when the rector and deans were appointed rather than elected, professor of law Antal Virozsil filled the position of rector. From among the four faculties, János Reisinger was dean of the Faculty of Humanities, likewise for eleven years, while the deans of the other faculties were appointed for shorter periods. The language of instruction was German.

Following defeat in the Italian war, the [Habsburg] neo-absolutist regime was forced to make concessions. This is how the Royal University of Pest was able to regain its freedom and once again elect its officials. The 1860/1861 academic year marked a new beginning: Samuel Márkfy, professor of theology, was elected rector, although his early death (in July 1861) led to the brief appointment of Virozsil as rector. The next rector came from the Faculty of Law – in keeping with the order of rotation that had been in force since 1771.

From 1860, a new method of electing the rector was introduced. Chaired by the incumbent rector, a panel of 16 voters, 4 from each faculty, elected the new rector on the last day of the academic year. At the same time, the inauguration procedure for the post of rector was divided. At the closing session of the University Council, the new rector first took an oath, with his hand placed on the rector's mace, then, in the presence of two members of the council, he assumed office in place of his predecessor, along with the handing over of the official inventory and acknowledgement of receipt. This demonstrates how the university's administrative structure had become somewhat professionalised by this time. The ceremonial inauguration of the new rector took place on the day of the opening of the new academic year, usually on 15 September. According to the regulations, the new deans were also inaugurated at this time, although, from the second half of the 19th century, the faculty deans did not change annually: the tenure of some deans lasted three or four years in some faculties. Likewise from 1860, it also became customary not only for the outgoing rector to report on the previous academic year, but also for the new rector to give an inaugural speech. This custom, with some minor changes, was in effect right up until the socialist reorganisation of the university in the 1949/1950 academic year. In addition, it was the task of the new dean of the faculty from which the rector had been elected to welcome the students. (From 1860 to 1948, these speeches were also published in printed form.)

The rectorship of Professor Baron Roland Eötvös

Roland Eötvös became rector of the Royal University of Budapest in 1891. In 1871, he was made associate professor; on 10 May 1872 he was made full professor of theoretical science; and from 1878, besides teaching experimental science, he also became the director of the Institute of Natural Sciences. In addition, as described in the other articles in the present volume, Roland Eötvös was a member of the Hungarian Upper House, president of the Hungarian Academy of Sciences for many years, and a member of the Secondary School Teachers Review Committee and the National Public Education Council, among others. Despite being a natural scientist, he was also a renowned professor in the Faculty of Humanities, since the sciences and humanities both belonged within the same faculty at the time. Eötvös's authority within the faculty cannot be overemphasised, and was due to his exceptional knowledge. Unsurprisingly, everyone was delighted when he accepted the faculty's nomination for the position of rector. Roland Eötvös had earlier refused a deanship, as he regarded the service of science to be more important than administrative tasks. His inaugural address as rector thus focused on science and the teaching of science. At the same time, he objected to the fact that the position of rector – according to tradition – could be held for one year only, because a year did not give the incumbent sufficient time to think from a long-term perspective. (Even so, he did not necessarily want to be distracted from his research by a multi-year tenure.) The Faculty of Humanities and Medicine had already broken with tradition, and, while Eötvös held the post of rector, between 1890 and 1895, Zsolt Beöthy fulfilled the position of dean.

The 1891/1892 academic year was a quiet period in the life of the university. By this time, the large-scale construction work on the natural sciences building was finished, and the buildings of the University of Applied Sciences and the clinical block of the Faculty of Medicine had been completed. Work on the wing of the main building in Egyetem Square, which has since been demolished, had not yet started. This is why Roland Eötvös could report on the 1891/1892 academic year as "a quiet year" on relinquishing the post to his successor, Béla Breznay, professor of theology.

Roland Eötvös's university mission is clearly reflected in the speech he delivered at the opening ceremony of the academic year on 15 September 1891. The report had to follow a defined form, although the attached tables were not compiled by Roland Eötvös, but by the academic and economic apparatus.

Since most of the records of the university and the Ministry of Religion and Education from the Age of Dualism were destroyed in a fire at the Hungarian National Archives in November 1956, a more comprehensive presentation of Roland Eötvös's activities as university rector is now an impossible task.

SPEECH
by means of which
BARON ROLAND EÖTVÖS
Scholar of Fine Arts, Member of the Hungarian Upper House, President of the Hungarian Academy of Sciences, Full Professor of Higher Natural Sciences, Member of the National Board of Public Education, Member of the Secondary School Teachers Examination Committee, Director of the Institute of Natural Sciences, Vice President of the Royal Hungarian Society of Natural Sciences, etc.
CEREMONIALLY ASSUMED THE CHAIR OF RECTOR
OF THE ROYAL UNIVERSITY OF BUDAPEST
on 15 September 1891.

Esteemed Assembly,

In this moment, as I take over the century-old regalia that represents the honourable position of rector, and, at the same time, as I dedicate myself to the punctilious and faithful fulfilment of all those duties that fall to me with its assumption, I am overwhelmed by a sense of gratitude not only for the honour bestowed upon me, but perhaps even more for all those benefits for which I am indebted to the university. It was in its halls that I first heard the word of science, it welcomed me with open arms when I aspired to join the ranks of professors of science, it gave me tools with which to cultivate the field of science, and it conferred on me duties, the fulfilment of which was a source of the purest pleasure. My first words are therefore words of gratitude.

I express my thanks to my former teachers, who inspired me to follow in their footsteps; I thank my fellow teachers, who have supported every step of my way with friendship, trust and affection; and I thank my dear students, whose ranks, renewed with each passing year, are a source of pleasant memories of the valuable hours we spent together. Without wishing to boast, I might claim there is not one of us who owes more to our university than I – and even if there were, I would crave your indulgence: Should not the child of a worthy mother be forgiven for considering himself his mother's favourite? I promise that I will remain a faithful son to this good mother, our alma mater, as I have always aspired to be.

I am aware of the difficult task that lies ahead of me. My excellent predecessor has passed on to me the torch of science blazing bright, and it is now my duty not to let the flame die out; I take up the meticulously ordered threads of a hundred obligations from his diligent hands and must take care not to entangle them. Nevertheless, as I assume this responsibility, despite its difficulty, I am emboldened by the knowledge that the University Council will be a benevolent advisor, and that my esteemed predecessor will stand as an example before me.

So why should he not continue to manage the affairs of the university? Why are our regulations so vehemently opposed to a man such as my predecessor holding the office of rector for more than one year, despite the fact that he has won the trust and love of all of us through his percipience in great issues and his never-ending zeal in minor ones?

Approached from a bureaucratic perspective, it may indeed appear curious that the rector, being appointed from year to year, is obliged to leave his post just as he becomes familiar with all the ins and outs of management. However, anyone imbued by the same spirit of science that brought this university, as well as its seemingly obsolete institutions, into existence, will be convinced of its usefulness: after all, a true worker and promoter of science would be unable to fulfil this honourable position for long years at a time. It is more important for the rector to remain the guardian of the *academic* spirit of the university, rather than becoming an excellent and painstaking administrative official.

Indeed, it remains the task of the university to cultivate and propagate science, a task entrusted to it by the state, under the auspices of which it educates individuals worthy to enter its service and participate in public life.

Allow me some brief reflections on this point.

The power of science is recognised today by all educated people; its truths are regarded as laws, and its recommendations are received as commands by both individuals and the state itself. But it has not always been so. It has taken centuries of unwavering work, once supported by the authority of the state and the church, other times struggling against these powers, for this viewpoint to become a generally accepted conviction. To recount how this took place would be to recount the very history of the universities, since recognition of this new power first took shape with the emergence of the universities, while it was thanks to the universities that science, although not nurtured and strengthened exclusively by them, was spread throughout the world.

History, as it shines its light on the past, also illuminates the present, and I am convinced that there is no keen intellect better able to portray the essence and mission of the university than the history of the establishment of the university itself and the accompanying assumption of power by the world of science. While it may not be my task to tell this story, and while recalling it would exceed the scope of my short speech, allow me at least to mention the accompanying achievements.

The first universities, and the institution of the university in general, were established far more naturally than is the case for such institutions today. If we were to found a new type of school today, we would first establish its regulations, then look for teachers, and then find students for the teachers to teach. When the universities emerged, things happened differently: teachers and students came first, and the regulations followed later. The establishment of this institution is not therefore the deed of a specific person, nation or state; its founders, as far as they exist, were those eager students who gathered around certain famous masters and formed student bodies.

In the 12th and 13th centuries, there were thousands of such students in cities like Bologna and Paris, where it soon became necessary to regulate the status of the population, especially because it involved the financial interests of the students, teachers and cities themselves. Such order was established by the church and the state in competition, in the form of privileges granted to certain teaching bodies in the cities, and, under the protection of these privileges, the schools of individual masters were then consolidated into universities.

The scholarly trend that launched this vibrant movement was the subsequently greatly disparaged scholasticism. No matter what we think of it, it is noteworthy that science assumed its rightful place in society, and founded its school, precisely when it was addressing issues that were entirely beyond the realm of practice. Students thronged to the first university not so much to study certain disciplines that would be of importance in their future careers, but rather with the goal of acquiring encyclopaedic knowledge. At that time, it was not unusual for a student to attend all four faculties.

Perhaps the selfless love of science was greater in those days, or perhaps the more generalised religious sentiment fuelled the quest for ideals to a greater extent than today. Nevertheless, the fact that the number of students attending some of the first universities was so high (over 10,000 in Bologna), a figure unparalleled today, demonstrates without a doubt that mastering the science of the scholastics offered benefits that went beyond intellectual pleasure. Indeed, science-loving popes elevated many renowned scholars to the ranks of bishop, investing them with purple robes, while emperors and other worldly princes entrusted them with important duties and offices. Add to this the public respect generally afforded to university graduates, which opened every career path before them.

In this era of beginnings, the uncomplicated relationship between university and society and other aspects of life is clearly apparent. The university taught anything it considered worthy of knowledge, and society benefited from educated people – even if not from all their knowledge.

Such a relationship, which guarantees a university's reputation and educational freedom, remains unchanged to the present day.

However, much else has changed since then, in both science and life. The unbounded expansion of science has led to the replacement of encyclopaedic studies with specialist studies, and, with the increasing demands of life, practical jobs have been professionalised.

Today, little respect is shown for the knowledge of a person who knows everything in equal measure – just as we tend to have little faith in the work of someone who undertakes all tasks indiscriminately.

The university educates specialist scientists, everyday life requires professionals, and as those who cultivate a science can become more erudite in it, and because someone who focuses on one kind of work will become more skilled in it, this professionalism that characterises our era has benefited us in every respect. Although a practical individual is now able to utilise more of the knowledge acquired through proficient university teaching, the universities have not, and I hope never will, become practical vocational schools. They will always remain the schools of science they once were; their relationship to life has not changed, it has merely became closer – close, but not restrictive.

Yet today, when every stratum of society is enjoying the fruits ripened by the warmth of the universities' scientific life, we are aware of both concealed and open attacks by those who claim that a university, whose students become priests, lawyers and doctors, is no more than a school for clerical, legal or medical education, which, with the remnants of its ancient traditions, is unable to meet the demands of the present.

In the superficial opinion of those who promote such a view, science should be preserved in the universities like some precious relic kept in a shrine, accessible to a chosen few but not to be revealed to the masses, who will find in the outer halls whatever they are able to make use of more immediately. Unfortunately, such views attract followers far more easily here than among our western and certain of our eastern neighbours. While sad, it is at the same time understandable, bearing in mind that science has gained terrain in our country as an alien power, and many of us are very much afraid of what is alien.

It is thus the duty of our university to stand up against such superficial judgments, wherever and whenever it can.

We are well aware that we have a duty to develop the scientific competences of our students, such that they will not be lacking later on in their practical careers. However, practice itself has never been part of these activities, nor is it our task today. If the general standard of scientific education is inadequate, it is a fault attributable to the university, but the university should not be blamed if a certain novice official, lawyer or doctor lacks some practical skills. In terms of practical life, no school is able to teach such skills; the school for this can be nothing other than life itself.

Yet another form of attack is being launched against universities as schools of science: while many people generally recognise the need for scientific education, they consider that young people dedicate too much time to it.

Their argument is that the pace of life in the 19th century is pulsing faster than in the Middle Ages, and that nowadays not only our bodies but also our minds are moving more rapidly in all directions, thus they consider it a requirement of our era to be prepared more quickly for a life that makes such rapid and forceful demands on us. This is a vain aspiration, since the harder life is, the greater the mental strength it requires, and it becomes ever more necessary to pursue intellectual tasks with the utmost integrity and to the greatest extent possible as one enters the battlefield of life.

This takes time: driven artificially, the intellect cannot flourish. It would be nice, would it not, if the promises of Ramon Llull's *Ars Magna* were to become reality.

"Since a man's life is short", he says, "and law is voluminous, this method *(ars magna)* serves to teach the law to everyone in this short booklet."

He is quite serious when he then claims that, using this method, he would be able to turn the average student into a doctor of law in three months, a better student in two months, and an excellent student in just four weeks.

There are plenty of such booklets to be found today, and there are still many who attempt the craft of rapid learning – some of them even manage to meet the requirements for their examinations in this way, while leaving their intellectual powers to slumber in infantile inertia in the midst of their mindless activity.

A young person with serious aspirations rejects such artifice, choosing the longer but more secure path to scientific learning, and because such knowledge is opened up before them by the university, they will have need of this school of science for as long as there are nations that count on the zeal of the serious-minded younger generation in the struggle for intellectual authority.

In the course of my speech thus far, I have used the terms school of science and scientific teaching so many times that I consider it useful to explain briefly what I mean by them.

A *school* and its teaching are *scientific* only if it is a place in which scientists teach. I might add that by scientist I do not mean a person who knows a great deal, but rather a scientific researcher.

The teaching of scientists can take as many forms as there are sciences and scientists; one might become immersed in details while another deals with general propositions; one might orate while another dictates; one might experiment while another deduces – they are never cut from the same cloth, and nor should they be, since it is precisely the *individual character* of the teaching that vouches for its value.

A scientist who repeatedly rediscovers the truth of science as he stands before his students, and who gathers together individual theses into one building in his own way, is all the more certain to awaken interest among his students the more he pursues his own train of thoughts. While such lectures may not cover every point in detail, and are therefore unable to convey as much as the reading of a large handbook or encyclopaedia, they nevertheless create an opportunity for something far more important, something that the dead letters of a book can never achieve: they allow even a beginner a glimpse into the very essence of science, and, rather than merely admiring its results, they allow him to acquire an understanding of research methodology.

A traveller, who, in the company of an experienced guide, visits some of the most interesting regions of a country following carefully chosen *trails* will see more of the natural beauties of that country than one who sticks to its well-trodden *highways*.

Only the teaching of a teacher who thinks independently can transmit the kind of independent thinking that is vital for both the scientist and the practitioner.

Just as no two leaves on this earth are identical, so there are no two identical patients and no two identical legal cases, thus we must require from doctors and lawyers more than the simple use of clichés borrowed from another's science; they must bring something of their own.

Perhaps I have spoken at greater length on this subject than was necessary, and perhaps it was futile to expound before the university a notion that its every zealous worker already holds not only in their mind but also in their heart. But we would not be doing enough for that notion if we were to conceal it as our own treasure: we should rather ensure that it becomes the general opinion of our nation as a whole, because its realisation is not the task of the few, but the task of every one of us. Perhaps my voice will be amplified by the position that I am accepting today, and my words will not be in vain if we win only a few new supporters to our cause.

It follows from what I have said above, that the standard of scientific teaching at a university is determined solely by the character of its teachers. The university question is therefore first and foremost a personal question, while its organisation and regulations are merely of secondary importance. In other countries, this personal aspect does indeed stand at the forefront, with the good or bad reputation of some universities, and the increase or decline in student numbers, being closely linked to individual teachers.

In our country, it is not yet customary to attach to a teacher's personal qualities the kind of importance it deserves. We are usually content to operate regular departments, or occasionally establish new ones, but we do nothing for those scientists who are setting out on their careers just at the time when the quotas have been filled, or who work in a discipline that is considered of minor importance.

This is not enough. If we sincerely want Hungarian universities to become schools of science, we need to do more for Hungarian *scientists*.

In the field of science, affluence is just as much a condition of life as it is in the arts: in one as in the other, the only thing that is of value is what stands out from the crowd. Their needs cannot and should not be tailored according to the standard measures of parsimonious public finances.

I am not arguing that the cultivation and teaching of science is more worthy, but it is an entirely different undertaking from the regular handling of so-called official affairs. It may be perfectly possible to calculate precisely how many hours it should take a certain number of officials to process a particular pile of papers, but I deem it an impossible task to determine how many scientists and how many hours of work are required by a nation in order to attain the blessings of science.

One thing is certain, that while practitioners in a particular discipline can count on just three or four jobs to provide them to some extent with a material and scientific livelihood, in the meantime scientific life in our country will have no vigour, and science will indeed remain a foreign power among us. Can we expect our talented young people – of whom, speaking from my experience as a teacher, we have no shortage – to opt for a career in teaching with no sense of trepidation when there is as little hope of prosperity as there is in a lottery, where winning numbers are extremely rare.

It is not hard to find a remedy to this great problem. We need to increase, maybe even double, the number of teaching posts at our universities.

I am not referring to the establishment of new departments, and nor should we always be looking for scientists exclusively for regular departments – rather we should be setting up departments for the sake of the meritorious scientists. If, for example, Hungary has, or will have, ten outstanding Romanists or ten excellent physicists, which is certainly not that many, then we must ensure that these ten Romanists or ten physicists are not only able to make ends meet, but that they live in the kind of conditions that make possible their undisturbed scientific research and teaching.

The scientist's home is the world, we are wont to say, but let us not forget that Hungary belongs to that world. The fact that we now have two universities, an applied university and an academy should not beguile us into believing that we have already done enough to establish science in our country. If we want science to find in our country not only a place of residence but a true home, where its strengths can freely develop and evolve so as to be bound inextricably with the authority of the nation, we must make great sacrifices that far surpass those we have made thus far.

From distant countries, from the other side of the Carpathians, from the far shores of the Oceans, we often hear fabulous news. Great lords who have spent the best hours of their lives occupied in science, and industrialists whose wealth is rooted in the application of science, have made donations worth millions, creating new universities or instilling new life into the old as if by a magic wand.

Such beautiful deeds have so far been few in our country, but we have proved that we can do great things, although our strength lies not in the millions of a few, but in the love of millions for their homeland.

What the individual cannot do can be done by the whole nation, under the leadership of its government.

The Hungarian nation is not in the habit of ridiculing a son that asks a great favour; such a wish may sometimes be considered at length, but, however slowly, it is fulfilled once it has been found to be just. May this be the fate of my own wish.

And now, after expressing my thoughts on university teaching, I would like to say a few words about university education. For indeed, the university must not only teach, but also educate. The nation entrusts to us the very best of its sons: she sends them to us as young men and, after years in our company, rightly expects them to return home as men. But it is one thing to educate a child, and quite another to educate a man; the former can be influenced by his teacher's admonitions and reprimands, while the latter is moved only by example, and especially by the encouragement of his fellows.

University education is thus primarily the responsibility of the young university students themselves.

In earlier times, as we are now aware, the educational role of the university, and especially of young university students, was manifested in harsh ways. A newly arriving university student, the "beanus", or "bec jaune", was admitted into university life only after enduring the "depositio" ritual. The details of this initiation ritual deserve special attention, since, despite their oddity, they clearly illustrate the concept that once dominated the educational mission of the university. Fricksel wrote a fascinating description of one such deposition ceremony, which he witnessed in Uppsala, Sweden, in 1716.

"The master of ceremonies, the depositor, first ordered the young men who wished to be admitted as students to wear gaudy garments stitched together from many different pieces of cloth. They smeared their faces with dirt, affixed long ears and horns to their hats, and stuck tusks into the corners of their mouths, which they were obliged to hold like a small pipe, with their lips pressed together. A long black cloak was hung from their shoulders. After being thus clothed more obnoxiously and bizarrely than those sent by the Inquisition to the stake, the depositor herded them into the hall using a stick, like so many oxen or donkeys, where an eager crowd awaited them. They were then made to stand in a circle, while the depositor, in the centre, mocked them with words and gestures for their strange appearance, before finally delivering a speech in which serious words took the place of jesting."

"He talked of the sins and errors of youth and emphasised their need for betterment through their studies. He then asked them questions, which they were obliged to answer, although the tusks, which were not permitted to fall from their mouths, prevented them from speaking, thus they could do no more than grunt, at which the depositor called them pigs and rebuked them. He explained that the tusks represented greed, and in order to prevent overeating and drinking from obscuring the minds of the young men, he attached a wooden clip to their necks and shook their heads until the tusks fell out. He then pulled off their long ears, explaining that they would have to study diligently if they did not want to remain donkeys. Lastly, he removed their horns, a symbol of coarseness, and, taking a plane, he smoothed the beanus on all sides, as an illustration of how science and the arts hone the mind. After further farcical ceremonies, the depositor poured a large tub of water over the initiates and scrubbed them with coarse rags. The company that had been thus planed, washed and scrubbed was finally released, having been admonished to begin new and better lives and to reject the base inclinations and bad habits that disfigure the soul just as their outfits had made their appearance repulsive."

The beanus then became a free student, although he had to wear a black cloak for another half a year, during which time he was obliged to serve the older students in their homes, as if in an inn, patiently tolerating every kind of ridicule and rebuke. They were known as *pennales*, and they still exist today, although in a more sophisticated form, in the *Fuchs* of Germany and the fags of English colleges.

It would be unimaginable for us to wish to restore such barbaric customs. Our youngsters would not subject themselves to such things, nor do I believe we could ever carve a *Fuchs* from a young Hungarian.

Our young people do not need to be admonished about the harmful effects of immoderation, or about the merits of learning; there is no lack of good intention. Our failing, our huge failing, is a lack of perseverance, the weakness of the will. Any one of us would be happy do something pleasant and nice, as long as no effort is involved.

I often think of Maupertuis, the French astronomer, who, on being asked what he was doing by a friend who came across him lying on a couch, replied: *"Je voudrais résoudre un beau problème, qui ne serait pas difficile."* (I would like to solve a nice problem that doesn't involve too much difficulty.) How many more like Maupertuis have spent their lives lying on the couch? Is there any one of us who does not recall imagining himself saving his country or bringing it glory by some great deed performed in half an hour, involving the sacrifice of his own good, or perhaps even his life? These are beautiful visions, because they remind us of our childhood, but they are worthy of a man only if we can draw from them inspiration to achieve through long years of hard work what we are unable to achieve in half an hour. The imaginings of the child must develop into the will of the man, and constant effort is the lifeblood of this development.

"Pluck the flower every hour!" The university should be a flower garden in which each one of its citizens obtains the flower every hour. If a lecture or an experiment is such a flower as my young friends perhaps believe, they will have their share of it every minute of the year. But I am thinking here not only of the plants that grow in the expansive atmosphere of the classroom, the blossoming of which is a task of us, the teachers, but also of the fragrant flowers that bloom in the open meadow of student life.

I would wish no shortage of pleasure alongside studying.

In other countries, and especially in England and Germany, university students have more fun than anyone else. In the big universities located in small towns, this is little wonder, since, where students are first in every other respect, they will naturally be the first in revels.

But the same is true in big cities, where students seek amusement not so much in so-called metropolitan pleasures, where they cannot take priority, but where, as far as possible, they stay connected with the natural world, seeking and finding pleasure in games that develop their physical skills and strength.

Indeed, our own city of Budapest has become a metropolis, and there is no shortage of metropolitan amusements: the balls, theatres and cafes are open to all, including students. But the student cannot really feel at home in any of these shared amusements. There is not one of them about which he can truly say: This is *mine*. Yet our city is surrounded by rugged hills on one side, and almost boundless plains on the other, while the Danube, the pride of our city and our country, flows between. It is here, and not on Váci Street, that our young students in search of pleasure will find themselves at home; they should set off to the hills for excursions, as far as the Bakony; they should occupy the Rákos field for their sports; and they should take to the waves of the Danube for rowing competitions. It is here, where not just anyone can follow, in masculine games, in friendly competitions, that our young students will discover the treasures that will make men of them and give them strength of will and endurance in the fight.

Indeed, such masculine pleasures are the most powerful means of fulfilling our responsibility for the education of each and every young university student. So alongside the question of university teaching, let us not neglect the question of university entertainment. Young people, whose primary responsibility is to find a good solution to this question, can certainly count on the support of their teachers and their rector in this respect.

The students in Bologna once elected their rector by popular vote – I hereby ask my young friends if they will allow me to consider myself, even without their vote, their *own rector of choice.*

May God give us the strength to fulfil our responsibilities in the new university year!

SPEECH
BY MEANS OF WHICH
BARON ROLAND EÖTVÖS
Doctor of Fine Arts, Member of the Hungarian Upper House, President of the Hungarian Academy of Sciences, Full Professor of Higher Natural Sciences and Director of the Institute of Natural Sciences and its Permanent Collection, Member of the National Board of Public Education, Member of the Secondary School Teachers Examination Committee, Vice President of the Royal Hungarian Society of Natural Sciences, Rector of the Royal University of Sciences
RESIGNED FROM THE DIRECTORSHIP OF THE ROYAL UNIVERSITY OF SCIENCES OF BUDAPEST

"Esteemed Assembly!

Today, as we celebrate the beginning of a new academic year, I, and my fellow officers who are retiring along with me, stand here as representatives of the past. This alone will be the subject of my few words.

It has been a quiet year.

The events that the chronicler of university affairs will record for this year, and about which I report below, are scarcely distinguishable from the uniformity of daily life. It was a quiet year, but a year of unrelenting work.

A quiet year yet memorable, and not only for me – who, as rector, have been able to repay through my official service a little of the debt of gratitude I owe as a teacher to the university for its generous support – but for all of us who cannot but recall that this year marks the twenty-fifth anniversary, celebrated throughout the nation, of the coronation of His Majesty as king of Hungary, and of the restoration of our constitutional freedom.

Political events have little influence on everyday university affairs, and those issues that continually inflame and polarise a nation's politicians, both the involved and the uninvolved, do not and should not disturb the academic work of the university. The university is neither pro-government nor pro-opposition.

Even the major transformation that restored our state twenty-five years ago left the structure of the university almost untouched. It had earlier professed science, and it continued to profess the same science afterwards, using almost the same means. If we search through the university annals of that period, we find scarcely anything indicative of the beginnings of a new era among the list of lectures, the statements by teachers and students, or the regulations governing studies and examinations. Nevertheless, that period truly was the dawn of a new era, when our elders in their teachers' chairs and we members of the younger generation on the students' benches alike sensed the warmth of the rising sun.

The work continued undisturbed and the task remained the same, only we had greater delight in fulfilling it. The university, which from that time entered the service of the Hungarian state, was able to hang the Hungarian flag from its facade and pursue patriotic goals through its scientific work. Theology, Roman law, anatomy, mathematics, and every other branch of study seemed to us more beautiful and worthy of study, since, with their assistance, we were endeavouring to serve the Hungarian king and the Hungarian homeland.

This past year has thus been memorable for us as one in which we, along with the nation as a whole, have offered up prayers of gratitude for the infinite goodness of the Almighty, who once again gave us Hungarians a king, a glorious Hungarian king, and who has renewed our hearts with the memories of what took place a quarter of a century ago.

While other bodies that are more closely associated with political life commemorated the radical reform of their organisational structure on the anniversary of the coronation, for us this was a day of patriotic fervour in the midst of our regular scholarly pursuits.

This fervour should never be diminished. We should be proud and happy to know that we can offer knowledge to the king of Hungary, and to the children of our Hungarian homeland – knowledge as great as possible.

I step down from the office of rector with full confidence in the future, since I am handing over my position to a man who is strong in terms of patriotism, learning and faith.

I pass on to him the ancient chain that has adorned the breasts of so many of our dedicated predecessors, the badge of patriotic and scientific zeal.

IMRE GARAI

The Eötvös József Collegium and Roland Eötvös's ideal of the "scholar teacher"

Introduction

The development of the profession of secondary school teacher in Hungary and the institutionalisation of teacher training can be associated with greater transformations in the history of ideas, social development and economic restructuring. In the various sectors of the economy, as well as in the state bureaucracy, the need emerged for highly qualified intellectuals with specific expertise. These processes of professionalisation have been researched according to various trends. One such critical trend is based on the theory of power and explores how the activities of groups of experts is organised, and which waves of thinking and which ideological elements influence their operation. This approach is applied in the present article to investigate the ideological foundations on which the institutionalised form of one of the most important elements of Roland Eötvös's intellectual legacy, the Eötvös József Collegium, was built, and the impact of its operation on the development of teacher training.

In Western Europe, an elite group of experts, including secondary school teachers, began to emerge in the 18th century. In England, teachers at the elite public schools, who were mostly graduates of Oxford and Cambridge, had a significant impact on the shaping of the teaching profession and teachers' self-identity. The emergence of the occupation was regulated primarily by the needs of society and the examination systems of the big universities, and the state began to influence the development of the profession by the passing of laws only in the 20th century. In Continental Europe, by contrast, the elite groups of experts were organised by the state. In France and Prussia, the state regulated the development of the teaching profession by means of regulations and laws governing the examination system. In Hungary, the training of secondary school teachers followed the continental models in terms of the development of both institutions and concepts.

Baron Roland Eötvös, full professor at the Hungarian Royal University of Budapest, teacher at the Secondary School Teacher Training Institute, and member of the Secondary School Teachers Examination Committee in 1875.

The development of secondary school teacher training institutions between 1862 and 1895

The institutional development of the secondary school teaching profession and teacher training in Hungary began in the last third of the 18th century. However, unlike in Western European countries, this progress was uneven, and no substantial steps were taken to establish a uniformly trained group of expert teachers until the middle of the 19th century. This can be explained by the fact that the different levels of schools were not separated from one another, and that the state played only a minor role in school patronage. Thus efforts to unify the teaching profession were highly problematic in practice.

During the 1848/1849 revolution and war of independence, József Eötvös submitted a reform package that included "Hungarian University Statutes", comprising 295 points, in which he proposed setting up independent secondary school teacher training institutes besides the Faculty of Liberal Arts at the University of Pest.

The neo-absolutist government that came to power following the revolution implemented some of his initiatives and achievements among other social reforms aimed at modernising the Habsburg Empire; the Austrian-style reorganisation of secondary education was an element of these reforms, which brought into being the classic knowledge-based grammar schools, as well as secondary schools specialising in science and modern languages. The emergence of these new types of high schools generated a demand for qualified teachers. The imperial minister of religion and education, Leo von Thun Hohenstein, attempted to enforce the principle of unified qualification via the temporary Austrian Law on Teaching Certification, which was passed in 1849, and the amendment of the regulations in 1856. The organisational changes at the University of Pest between 1850 and 1855 created the conditions for the professional training of secondary school teachers. However, teachers could take their exams in only five imperial cities, which deterred many people from becoming secondary school teachers due to financial reasons.

Following the publication of the October Diploma on 20 October 1860, the establishment of the first independent teacher training bodies was considered along with the re-establishment of Hungarian government departments. On 31 July 1862, the Hungarian Court Chancellery, supplementing the proposals of the Locotential Council, established the Secondary School Teachers Examination Committee and appointed József Purgstaller, principal of the Hungarian Piarist province, as its president. One year later, the Examination Committee for Teachers at Scientific Secondary Schools, headed by the director of the Technical University, József Sztoczek, was established.

The conditions for unified teaching qualifications were created by the setting up of the teacher examination committees, although the Faculty of Humanities was unable to provide the appropriate preparation for the examinations due to its unsystematic training. The reform of the Faculty of Humanities followed the neo-Humanist concept that research, education and free attendance are the main guarantees of the university's autonomy. Thus university teachers needed to pay little attention to demands for teacher training. In response to this situation, József Eötvös established training for grammar school teachers alongside the Faculty of Philosophy, and training for teachers at scientific secondary schools at the University of Technology following the Compromise of 1867. Despite the fact that the curriculum at the universities changed each semester, the two teacher training institutions were both responsible for preparing trainee teachers for the examinations for grammar school and scientific secondary school teachers, and for the successful practice of their profession. As attendance was not compulsory, the minister of education tried to encourage trainee teachers to attend by providing scholarships. The student teachers received additional training in small group seminars that complemented the university curriculum, or explanatory university lectures, in both institutions. In October 1872, in addition to grammar school teacher training, a teacher training grammar school opened as part of the Department of Pedagogy in order to provide practical preparation for some of the trainees, combined with their scholarship. This resulted in the establishment of institutes for the theoretical and practical training of teachers, as well as training in phases.

In as early as 1871, Roland Eötvös's name appears in the list of professors at the grammar school teachers' training institute, as the Faculty of Humanities entrusted him with the supervision of physics training. Teacher training was a cause that played a key role throughout his academic career. After his appointment as a regular public university teacher in 1872, he became a member of the teachers examination committee from the academic year of 1874/1875. In 1874, he travelled to France to study the elite teacher training institution, the École Normale Supérieure. His visit coincided with reform processes in teacher training, which generated serious conflicts among interest groups representing different training concepts. In 1873, the minister of education merged the scientific secondary school and grammar school teacher training colleges and amalgamated the teachers examination committees in 1875. Based on the experiences acquired by Eötvös during his visit, the minister of education Ágoston Trefort proposed in a memorandum to the National Public Education Council the establishment of a residential college modelled after the École Normale to remedy the organisational inefficiencies in teacher training. This idea was fiercely criticised by one of the fathers of the teacher training grammar schools, Mór Kármán, both in a written statement and also via the Public Education Council. In 1879, the Faculty of Humanities submitted its own proposal to the minister to set up seminars for teacher training from the budget of the teacher training colleges following the German model. Roland Eötvös, who remained convinced until the end of his life that teacher training was the task of the Faculty of Humanities, played an important role in the birth of the proposal.

On 3 January 1880, Ágoston Trefort, as competent minister, convened a meeting at his own apartment to discuss the necessary reforms, at which, with the exception of Kármán, all the major organisations and professionals were represented – including Roland Eötvös – who had earlier taken part in the debate on training reform. Several key issues were agreed at the meeting, which later appeared in various parts of Law 1883: XXX on Teacher Training. Thus the specialist training of teachers was increased from three to four years, and a compulsory practice year was also introduced. One serious deficiency in the law was that it failed to regulate relations among the established teacher training institutes.

By the mid-1890s, a serious shortage of teachers had emerged, which Roland Eötvös sought to address by a compromise in order to resolve the decades-long conceptual debate on teacher training. To this end, he began to prepare for the establishment of the Eötvös Collegium during his short stint as minister of education in 1894–1895.

The establishment of the Eötvös Collegium and Roland Eötvös's ideal of the "scholar teacher"

The first students at the Eötvös Collegium moved into the Kerkápoly House, the designated seat of the residential institution, on 21 September 1895. However, the actual operation of the Collegium was preceded by extensive preparatory work with the involvement of teacher training experts and the minister of religion and education. The preparatory meetings outlined the scholarly concept for teacher training that was at the focus of the institute, and which can be divided into two components in terms of its ideals. One was the Central European concept of *Bildung* and the related philosophy of neo-humanism.

The first decades of the 19th century were defined by the coalition wars against revolutionary France, and their consequences in Prussia. Humiliated by the 1807 Treaties of Tilsit, Prussia implemented a social and state reform that included the transformation of its universities and secondary schools. These were based on the concept of *Bildung,* the meaning of which was modified in the 19th century to include self-education focusing on the aesthetic and educational impacts of the cultural heritage of Ancient Greek civilisation, in which self-examination also played an important part. The first training centre for the new type of

The new building of the Baron Eötvös József Collegium on Ménesi Road, on the southern side of Gellért Hill.

intellectual was the Faculty of Humanities of the reformed University of Berlin. The ideal was linked to a philosophical trend, the followers of which believed that new secondary school teachers trained at the Faculty of Humanities would be able to encourage an interest in science among their students as a result of their own training, and would encourage them towards self-examination based on self-education. Thus secondary school teachers not only carried out their task of teaching, but also implemented social reforms by educating citizens to hold a new world view. In historiography, this community of new citizens is referred to as the *Bildungsbürgertum*, an educated bourgeois middle class that defined itself in comparison to the prerogative-based leading social strata and groups holding positions in the economic elite.

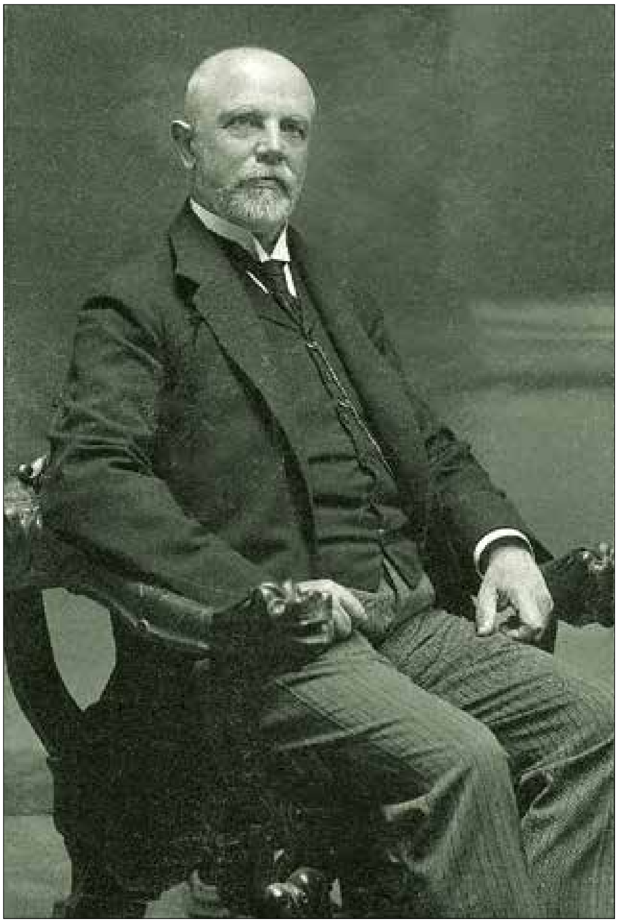
The second component in the concept can be traced back to the French ideal of *culture générale*, which began to emerge in the Napoleonic Era, with the consolidation of the achievements of the French Revolution. Lyceums, and the academically educated lyceum teachers, were given a key role in maintaining French erudition. In addition to knowledge of the classics and medieval Latin, their training increasingly featured French language and literature as a result of the curriculum-related debates in the 1880s. Lyceum teachers were appointed on the basis of the results they achieved in the civil service examination *(aggrégation),* in which the top places were typically won by graduates of the École Normale Supérieure. The success of the residential teacher training college was due to the highly advanced scientific infrastructure (libraries, laboratories) on the one hand, and the combination of methods based on the individual guidance of students and lectures on the other. During the lectures, teachers examined problems with their students, introducing them to the foundations of scientific understanding and thinking. In this way, the students' teacher-supported self-training was supplemented by joint training sessions that were of a strongly disciplinary nature. Besides obtaining specialist knowledge, it was also important for trainees to develop loyalty to the existing political system.

The "ideology" of the scholar teacher corresponded to Hungarian educational policy in two respects. On the one hand, it meant the training of a new type of teacher who would be successful in the teachers' state examinations as a result of their in-depth specialist knowledge, and who, through their high school activities, could trigger social reform in a way that did not fundamentally subvert the existing social and political system. On the other hand, the newly qualified teachers were also considered as loyal state officials, since, regardless of their specialist area, knowledge of Hungarian language and literature was an important aspect of their erudition. The latter essentially became an educational political programme to strengthen the "Hungarian" character of the state and accentuate the secular character of the state administration – the partial separation of the state and the Catholic Church – in the mid-1890s. The Eötvös Collegium was regularly referred to as a public institution and its members as state-trained students, when graduates applied for teaching jobs.

The training of scholar teachers on Ménesi Road (1895–1919), teacher training reform (1899)

As the trustee of the new institution, Roland Eötvös represented the Collegium as a whole before the minister of religion and education, while having the right to propose to the ministry the admission or dismissal of students. In addition to his representative role, however, he regularly attended meetings of teachers, as well as the "beer dinners" after significant events at the residential institute, where he participated in informal exchanges of views with members of the teaching staff as well as students. Daily administrative affairs were handled by one of his former students, Géza Bartoniek, as director.

Similar to its French parent institution, the Collegium selected its members from among those students who had left school with top grades, and university students who showed good academic progress. However, due to the postponement of the examinations for teachers, the recruitment policies had changed by the 1900s, and it was largely high school graduates and first-year university students who were admitted in order to optimise the educational impact of the residential institution. Specialist studies were conducted in small seminar groups in the afternoon, following university lectures. On these occasions, the university curriculum was studied, or a scientific problem was investigated under the guidance of a teacher. The training was complemented by a European-standard open-shelf library, which comprised over 30,000 volumes by 1919. Studies by members of the Collegium were evaluated at teachers' conferences, at which the opinion was expressed first in the field of classical philology, then in the field of history from 1904/1905, that the training at the Collegium – which was based on the teacher



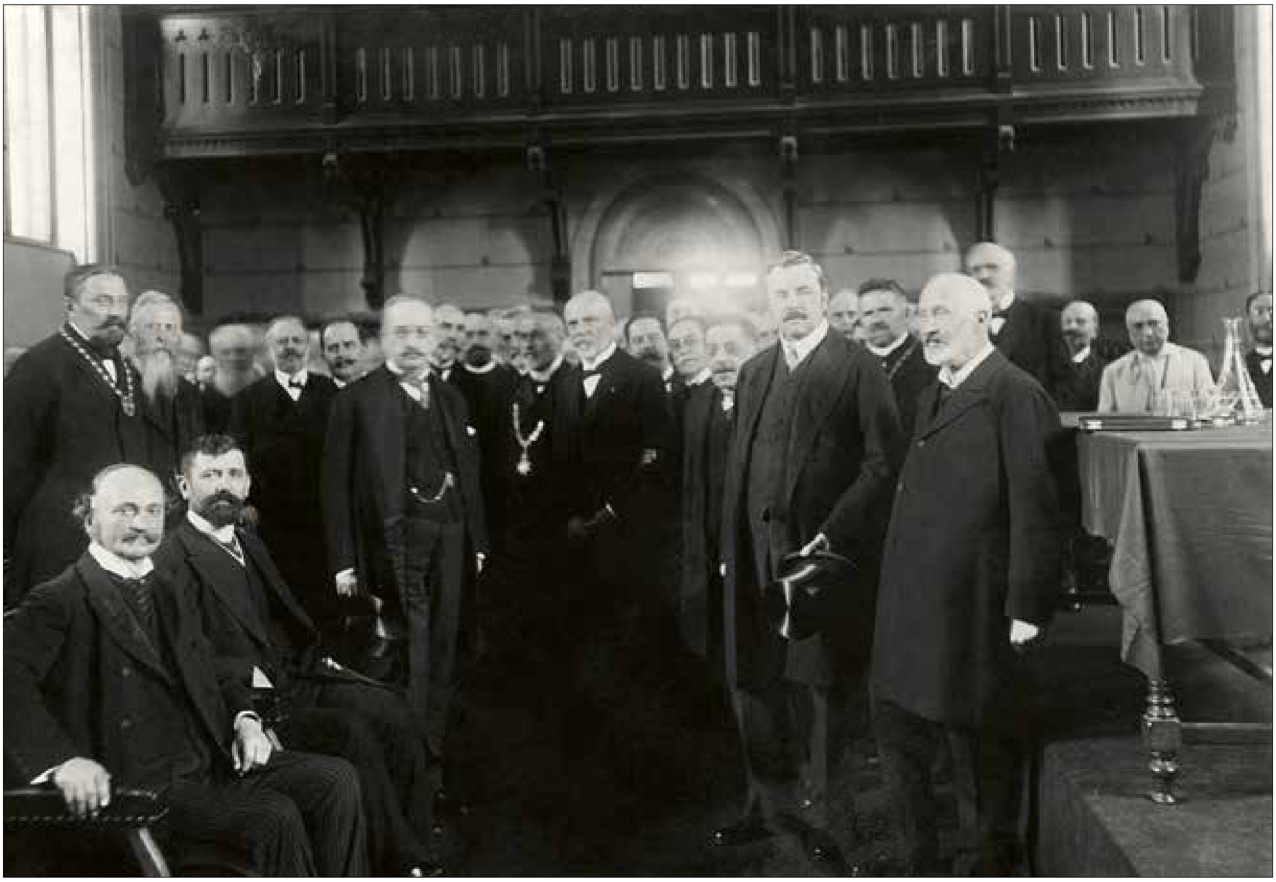
Géza Bartoniek, first director of the Eötvös József Collegium

"Orders" of the training institute (including the preparatory requirements for the teachers' examination) – should increasingly prepare its students for the basic and specialist examinations. As an important element in the training, the French parent institute sent a French student to Budapest as a language instructor from February 1896. The

Aurelion Diegon, French language tutor at the Collegium in May 1913

specific form in which the students lived together, the "family system", also played a significant role in the system of education at the residential institute. Four students shared a room: from first-year freshers to fourth-grade students preparing for their specialist exams. Older students supervised their younger fellow students in moral affairs as well as professionally. Thus the elements of individual work and collective supervision were combined in the educational system for residents of the Collegium.

Roland Eötvös proposed the systematic development of the Collegium to the Ministry of Education in both 1896 and 1898. In these proposals, he also suggested that, in place of the teacher training institute, there should be a residential institute, or a set of institutions founded on the model of the Baron Eötvös József Collegium. Due to the effectiveness of the training, the ministry was open to the proposal, thus a plot of land was purchased on the south side of Gellért Hill in 1901, where the Collegium's new building was constructed in 1910. In addition, several leading specialist teachers were appointed by the ministry in 1906. The inauguration ceremony on 26 October 1911, which was attended not only by the Hungarian cultural-political elite, but also by envoys from France, symbolically ended the experimental period of the institute. The representative character of the building was an expression of the fact that, besides teacher training, the achievement of higher goals was expected from the Collegium. At the ceremony, Eötvös promised the minister that the institute would accept Bosnian and Turkish students, in order to train them as teachers, or as Pro-Hungary intellec-



Guests at the inaugural ceremony for the new building of the Collegium on 26 October 1911

tuals, to coincide with the Monarchy's ambitions in the Balkans.

In 1899, besides the completion of the Collegium's experimental period, significant transformations took place in the teacher training institute that Eötvös directed from 1896. At the time of his appointment, the ministry commissioned him to reorganise the operations of the institute on the basis of his preliminary ideas. Following Eötvös's guidelines, the training institute's teaching body had developed the new organisational regulations by 1899. The main changes concerned three elements: firstly, the regulations aimed to systematise the highly fragmented teacher training institutions. The goals of teacher training were being met by the university and teacher training institutions, the Eötvös Collegium and the practice schools. The second element was the concept that all students that wished to obtain a teaching qualification should be a member of the teacher training institution. Finally, a seven-member council of practising teachers complemented the president and the director at the head of the institution. Through their knowledge of their own discipline and related areas, the members of the council covered all specialist areas of teaching. The earlier individual decision making was replaced by joint deliberations, and joint decisions based on individual proposals were always preceded by professional discussions. In this way, the institute was able to adapt to social and academic demands with respect to teacher training more efficiently than in its previous form.

Closing thoughts

Roland Eötvös was involved in the operation of all institutions connected to the issue of secondary school teacher training from the beginning of his scientific career.
He can be considered as having a significant influence on the discourse that emerged in the second half of the 1870s concerning the directions of the reform, and was the first to suggest the idea of creating a residential teacher training college based on his experience in France. By establishing the new institute, he did not wish to deepen the divide between teacher training institutions, but, on the contrary, he sought to form the different institutions into an institutional system. He aimed to promote this by, on the one hand, establishing the concept of scholar teachers, in which training experts with different views participated in the first stage of the establishment of the Collegium. On the other hand, by renewing the organisational regulations of the teacher training institute, he wished to systematise the separate teacher training institutions. This attempt grew from his conviction that teacher training is the task of the Faculty of Humanities, since, according to the 1899 organisational regulation of the teacher training institute, the institutions of teacher training chiefly complemented the university lectures and practical training, besides providing a systematic framework for the preparation of teachers.

The sustainability of his ideas and their role in the development of the teaching profession is well represented by the fact that the new organisational and ideological framework for secondary school teacher training, as established in 1899 at the University of Budapest, had a significant impact on Law 1924:XXVII, which defined the training of teachers in Hungary until 1949. As a result of the law, teacher training institutions and residential institutions following the Budapest model emerged alongside the Faculty of Humanities at all universities in Hungary. In the case of residential institutes, the legislator specifically noted that the codification of their establishment was justified by the effectiveness of the Eötvös József Collegium, which had been operating for nearly three decades by that time.

ANDREA MOLNÁR

Roland Eötvös, the public figure

An interest in public affairs and active involvement in public life were among the most important qualities that Roland Eötvös inherited from his father. His father, József Eötvös (1813–1871), was regarded as one of the most eminent politicians of his day, and it is well known that his wider family and his father's circle of friends included the most outstanding personalities of the era, whose example and endeavours greatly influenced the young Roland. Throughout his life, he adhered to the ideal of acting for the advancement of the nation and of humanity as a whole as his principal moral duty. It was this that persuaded the somewhat reserved scientist, who regarded as indispensable the intellectual independence of science, to fulfil the often difficult role of president of the Hungarian Academy of Sciences for over 16 years, to be a member of the Upper House of Parliament, and to serve his country as minister of religion and education.

Roland Eötvös was just seventeen when he decided to pursue a scientific career. His father supported his wish to study at a foreign university, although in order to achieve success in public life, he asked his son to "complete the first two years of law in Pest. The studies necessary for the examinations at the end of two years are those required by any educated person, whatever career they may pursue [...] If you have completed these two years, [...] I, too, wish you to go to Berlin or another German university to finish your education" (Letter from József Eötvös to his son, Szent-Tornya, 28 March 1866). Roland followed his father's advice, although he attended lectures in the sciences alongside his studies in law. From 1867, he continued his scientific studies at the University of Heidelberg, where, in July 1870, he obtained a doctorate in the natural sciences, with mathematics and chemistry as secondary subjects. Following his examinations, he returned home and joined the Society of Natural Sciences, where he was elected as a member of the board in the autumn, and as a member of the editorial board of the Society's journal. His father died on 2 February 1871, thus did not live to see his son make his first appearance in the Academy of Sciences. In May 1871, the organisation's assembly voted to invite Baron Roland Eötvös to give a guest lecture. His presentation, "The Law of Action-at-a-Disctance as Deduced from Vibration Theory", took place in Mathematics and Science Section III on 19 July.

Alongside his own merits and good fortune, respect for his father, whom he had lost at a young age, also contributed to the spectacular advancement of his career. In 1871, with the expansion of scientific education at the University of Pest on the agenda, he successfully applied for the post of associate professor. One year later, at the age of 23, he was made a full professor in the Department of Theoretical Physical Science by special permission of the monarch. Three years later, his dream was realised: he was able to give lectures on experimental physical science.

József Eötvös – painting by Viktor Madarász (1874)

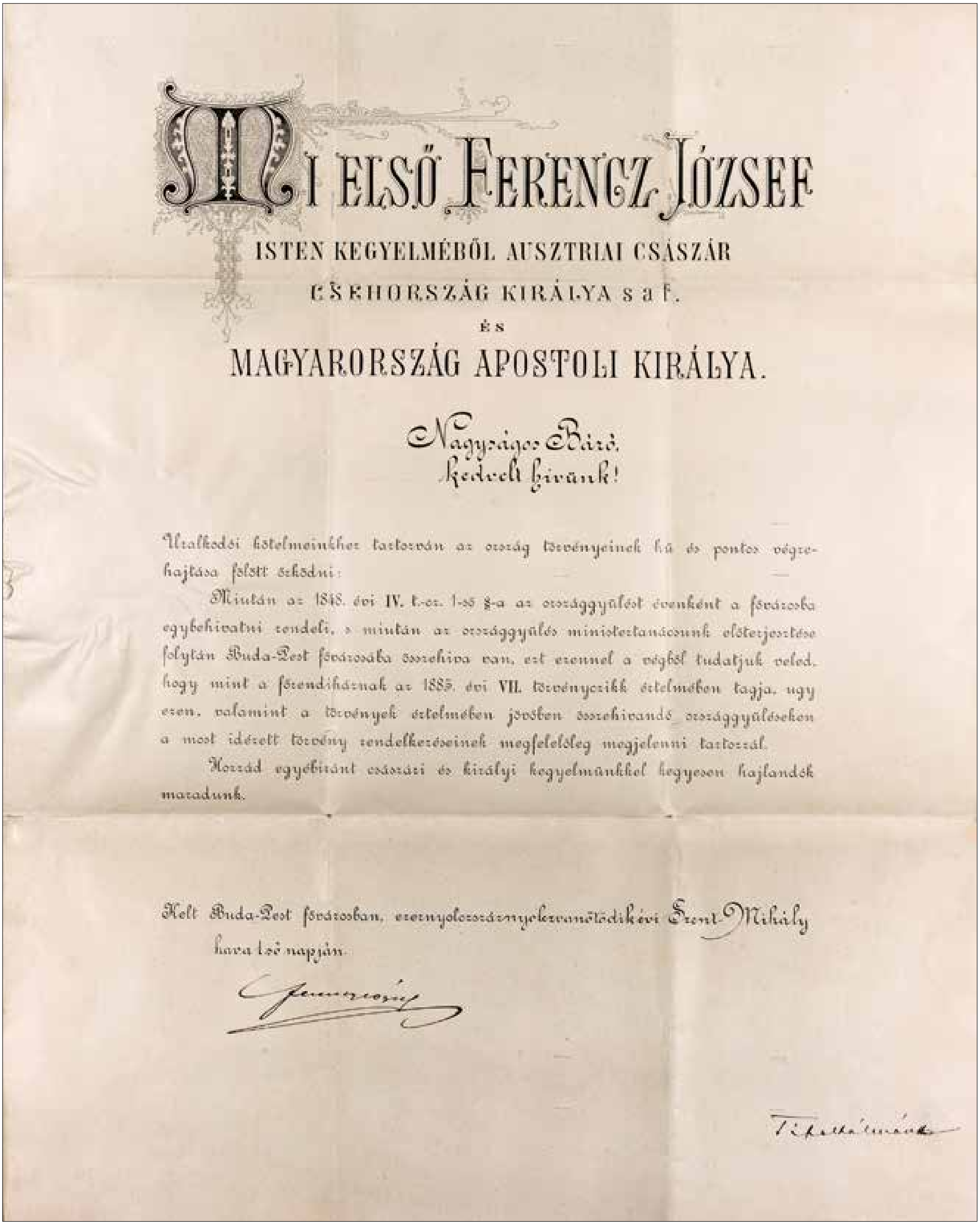
Scientific public life

In parallel with his university successes, he also progressed rapidly at the Hungarian Academy of Sciences. He was not yet 25 when, on 21 May 1873, he was elected as a corresponding member of the Academy at its 33rd General Assembly by 30 votes to 4, obtaining well over the two-thirds required. However, his inaugural address, "Data towards the Theory of Electro-statics", was not delivered until 19 January 1880. In the introduction to his speech, he paid tribute to his father: "I attempted to enter the field of science in our country at a young age, full of genuine ambition but with no personal merit, and I found that every door opened before me, as if by a magic word, and I encountered helping hands on all sides, offering to support my initial steps. That magic word was the name of my late father, my most valuable inheritance, which is a constant reminder to me that I must live up to it through my work." Although Eötvös postponed his inaugural address for some time, he was nevertheless present in scientific public life: he regularly attended the sessions of Mathematics and Science Section III following his election, and reported on his research findings each year. In 1881, the year after his inaugural address, he was nominated as a full member of Mathematics and Science Section III, although he received a sufficient number of votes from the General Assembly only on the third occasion, in 1883. He delivered his inaugural lecture on 19 January 1885: *"The Relationship between the Surface Tension of Liquids and Critical Temperature."*

By the early 1880s, Roland Eötvös had earned international recognition for his scientific achievements. In 1881, he represented Hungary at the first International Electrical Congress in Paris, and was awarded the Légion d'honneur by the Government of France. During his visit to Paris, he undertook research into the French educational system at the request of the minister of religion and education, Ágoston Trefort. He was to profit from this when establishing the Eötvös József Collegium a decade and a half later.

The death of Ágoston Trefort on 22 August 1888 meant not only the loss of a respected, experienced and wise figure from the head of the Academy and the government: for Eötvös, it also meant the loss of an uncle and a good friend of his father. There was an unusual degree of uncertainty surrounding the election of his successor as president of the Academy. At that time, the Academy was the target of severe criticism, which is why the choice of the new president was particularly important. Unprecedentedly, a combined session was not convened for the election of the secretary-general and president directly after the death of the president. Instead, the election of the president was postponed until the General Assembly in May, leaving the institution without a president for almost nine months. The list of candidates for the post included the conservative Antal Széchen, minister of finance Béni Kállay, and the most prestigious candidate, prime minister Gyula Andrássy, but none of them accepted the nomination. This was how attention turned to the young Roland Eötvös, a scientist who had already achieved renown throughout Europe. At the General Assembly held on 3 May 1889, the outcome of the election for president was not clear cut. The members of the board voted for a total of four candidates: of the 48 votes, Eötvös won 27 in the end, Antal Zichy 18, Béla Széchenyi 2, and Ernő Hollán 1.

Roland Eötvös thus took office as the sixth president of the Hungarian Academy of Sciences. He differed from his predecessors in many respects: first and foremost, he was a scientist and only then a politician; the first president to specialise in the natural sciences. In terms of his world-view and liberal principles, he clearly followed in the footsteps of József Eötvös and Ágoston Trefort, and he



MI ELSŐ FERENCZ JÓZSEF
ISTEN KEGYELMÉBŐL AUSZTRIAI CSÁSZÁR
CSEHORSZÁG KIRÁLYA s a t.
ÉS
MAGYARORSZÁG APOSTOLI KIRÁLYA.

Nagyságos Báró,
kedvelt hivünk!

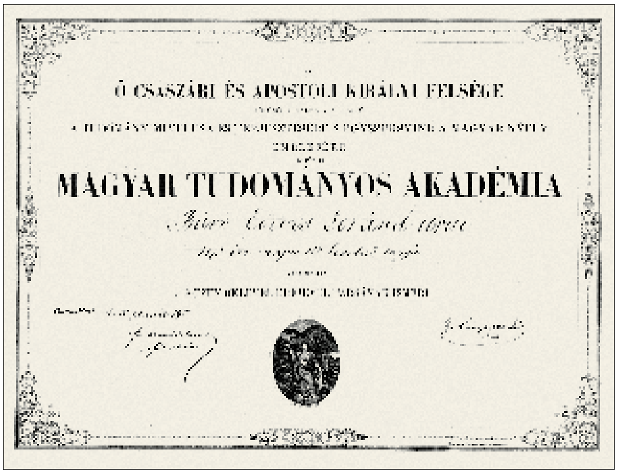
Uralkodói kötelmeinkhez tartozván az ország törvényeinek hű és pontos végrehajtása fölött őrködni:

Miután az 1848. évi IV. t.-cz. 1-ső §-a az országgyűlést évenként a fővárosba egybehivatni rendeli, s miután az országgyűlés ministertanácsunk előterjesztése folytán Buda-Pest fővárosába összehiva van, ezt ezennel a végből tudatjuk veled, hogy mint a főrendiháznak az 1885. évi VII. törvényczikk értelmében tagja, ugy ezen, valamint a törvények értelmében jövőben összehivandó országgyűléseken a most idézett törvény rendelkezéseinek megfelelőleg megjelenni tartozzál.

Hozzád egyébiránt császári és királyi kegyelmünkkel kegyesen hajlandók maradunk.

Kelt Buda-Pest fővárosban, ezernyolczszáznyolczvanötödikévi Szent-Mihály hava 1ső napján.

Royal announcement of Roland Eötvös's membership of the Upper House



Announcement of Roland Eötvös's election as corresponding member

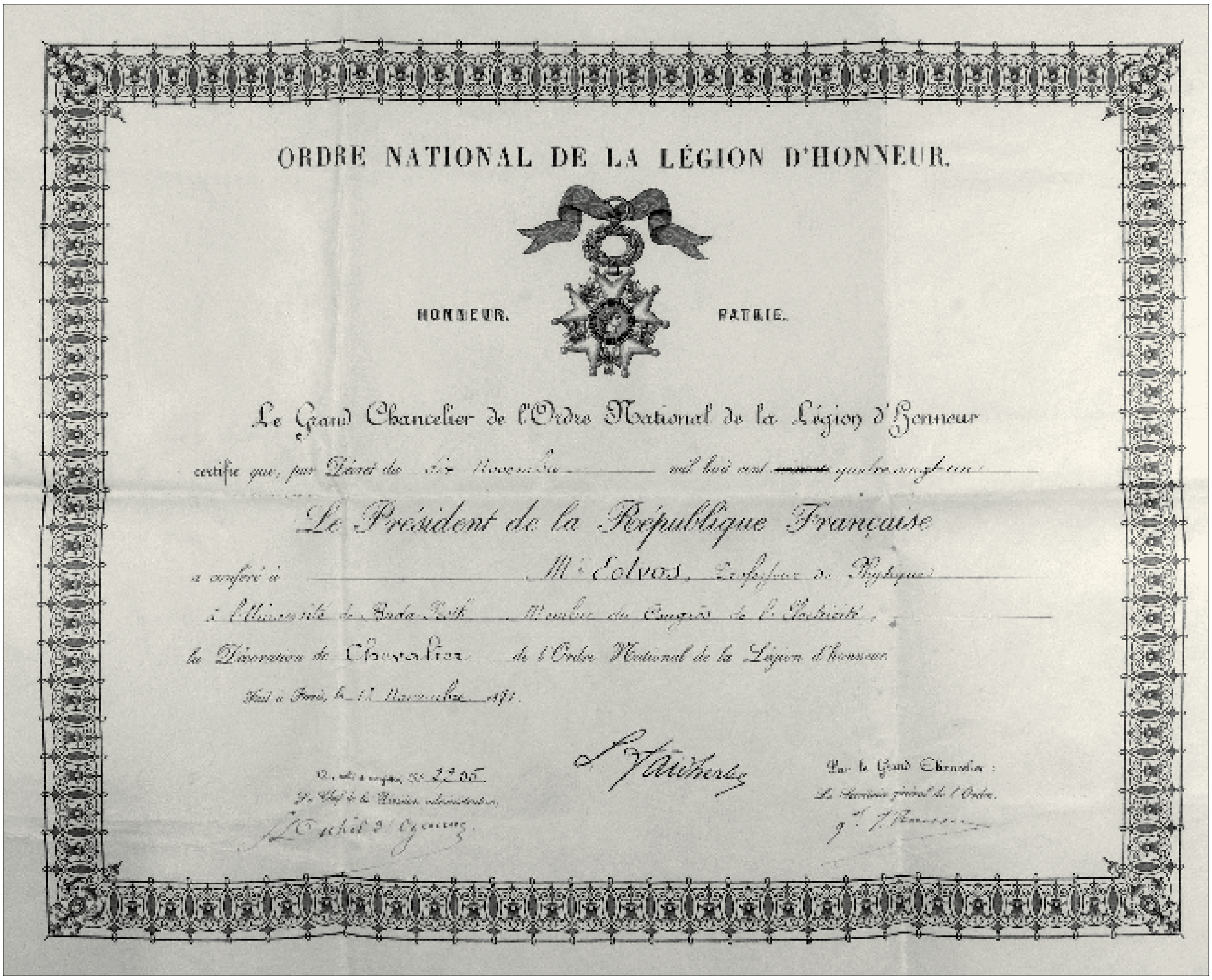
successfully curbed the politicisation of the Academy for almost a decade and a half.

The Academy also had to find new people to fill other leading positions. The former secretary-general, Vilmos Fraknói, was elected second president, and the post of secretary-general that he had vacated was not filled for five months (until October). However, the October election was followed with unusually keen interest: according to the writer Kálmán Mikszáth, who was elected as a corresponding member of the Academy in the same year, the election of county sub-lieutenants in the past could scarcely have been surrounded by greater commotion. Literary scholar Zsolt Beöthy and physicist Kálmán Szily stood as candidates for the post of secretary-general. The contest was ultimately decided by a vote at the session: the secretary-general was obliged to resign from all other positions, although in return he was paid a higher salary. This meant that, alongside the young, "popular, brown-faced president", Kálmán Szily was made secretary-general, and he proved to be the president's most important and loyal colleague for the next one and a half decades. The Eötvös–Szily leadership was eagerly anticipated by those members of the general public who were interested in the affairs of the Academy, as they were regarded as representatives of scientific professionalism.

The new leadership was in a difficult situation: the internal life of the Academy had been infiltrated by the contradictions of national political life. Ágoston Trefort himself, in his last speech as president, had sharply denounced the emergence of a climate that hampered scientific work and opinions. Amidst the increasingly conservative trends, many were expecting reforms from the new leadership. In his first speech as president, Roland Eötvös made it clear that he favoured neither romantic nationalism nor reform. "The Academy is not an institute that should be the subject of experimental reforms; its purpose and its principles should remain unchanged not for decades, but for centuries. It is not like a ship, setting sail on adventurous explorations in unknown seas: it is rather a lighthouse that guides the wandering sailor to safe harbour." Culture is the guarantee of national development: in its absence, we are no more than some "ethnographic curiosity".

The initial authority of what was formerly the Hungarian Scholarly Society had somewhat diminished by the Reform Era, something that even István Széchenyi had bemoaned in the 1840s. After the 1867 Compromise, József Eötvös, János Arany and their colleagues had lent their full prestige to making significant changes to the operating principles of the institution. With the king's approval, a new statute came into force and the responsibilities of the institution were redefined in 1869. In the decades following its foundation, literary concerns almost entirely outweighed the natural sciences, since the development of the national language was the principal goal, and the establishment of a national literature was on the agenda. After 1867, however, József Eötvös began to emphasise the equivalence between science and literature, at the same time insisting that science should be cultivated from a European perspective.

In the 1880s, attacks on the Academy escalated, targeting primarily the reclusiveness of scientists and the futility of their activities. Roland Eötvös was aware of the unpopularity of the institution and attempted to explain in his speeches the


ORDRE NATIONAL DE LA LÉGION D'HONNEUR.

HONNEUR. PATRIE.

Le Grand Chancelier de l'Ordre National de la Légion d'Honneur

Le Président de la République Française

a conféré à M. Eötvös, Professeur de Physique

la Décoration de Chevalier de l'Ordre National de la Légion d'honneur

Par le Grand Chancelier :

The French Légion d'honneur awarded to Roland Eötvös

unique role of the Academy and the tasks of science.

Eötvös and Szily introduced certain new rules at the beginning of their term, in the interest of more efficient operations. Because attendance at scientific sessions was typically low, all full members were required to attend section sessions. The president and the secretary-general set a good example: they frequently attended meetings of other sections, while regularly participating in sessions in their own section. During Eötvös's presidency, the Academy held 40 to 50 sessions a year. According to the regulations, with the exception of the two-month recess, sections held monthly meetings, at which members of the Academy read their papers. Mathematics and Science Section III operated slightly differently from the other two sections: members of the Academy who taught at the university were able to invite their students to read a short summary of their studies, in order to present as many results as possible.

Originally, the Academy had comprised six sections, although when the statutes were amended following the 1867 Compromise, the court permitted only three sections. In 1891, still during Eötvös's tenure, it became possible for each section to

The building of the Hungarian Academy of Sciences in the 1890s


HOTEL

have two subdivisions, and the number of members was determined on this basis. This structure was more appropriate for the rapidly developing disciplines, especially in the natural sciences. The sections also featured an ever-expanding system of committees. The recruitment of researchers was another key issue, and one that Eötvös, as a university professor, also followed closely. Although the Academy regulations allowed for 240 members (excluding external members), the maximum number was never reached under Eötvös's presidency.

From 1890, the new leadership managed to make the operations of the Academy far more transparent to the public. The *Akadémiai Értesítő* (Academic Bulletin) was published on a monthly basis, and the publication was expanded to include the full studies read out at the sessions, as well as an evaluation of deserving applications. Kálmán Szily published an annual secretary-general's report on the professional work of the Academy, as well as the official statement of the Hungarian Land Credit Institute on the assets of the Hungarian Academy of Sciences. The annual list of institutions purchasing the Academy's publications at the flat rate expanded continuously, and included a significant number of secondary schools and libraries.

The Academy was created by private donations and has always been proud of being a national institution. Although the independence bestowed by the foundations was impressive, the Academy nevertheless struggled almost constantly with financial difficulties. Its building was its most valuable asset, while at the same time demanding the biggest expenditure, but the Academy was unable to devote any significant sums to research. In the 1890s, there was a significant increase in the otherwise numerous small donations awarded for specific purposes, and calls for applications for these were regularly announced. The evaluation of the resulting applications demanded a great deal of work. It was commonly understood that if no applications were submitted, or if the submitted applications were of poor quality, no award would be made. Even the Academy's Grand Prize was not awarded annually, in the absence of deserving results.

In this context, it is not hard to imagine the huge significance of the announcement made by Baron Eötvös a few months after his election as president. At the same session at which the secretary-general was elected, Eötvös read aloud a letter from Andor Semsey, in which he offered one hundred thousand forints to be used for academic contests. "The room was filled again and again with cheers as the president read out the details of the ten prizes worth ten thousand forints. There was a festive mood in the distinguished Academy. Since the days of Széchenyi, no such impressive words had been heard there! One hundred thousand forints! For ten scientific papers! Royal generosity." This was how Mikszáth described the impact of the announcement. Semsey, a member of the Academy who was on good terms with Eötvös, became one of the Academy's most important patrons.

The calls were published in 1890, relating to ten different disciplines and specifically targeting Hungary and conditions in Hungary, with a first prize of 10,000 forints and a second prize of 1,500 forints for each call. The expected outcome was a handbook on the given topic, and initially five years were allowed for the completion of the work. The awards ran eventually until 1908, although the scheme did not produce the expected scientific results. Only the work on mineralogy in Hungary was completed as originally planned, while other work, on archaeology, literary history and economics, was awarded only a second prize.

The beginning of Roland Eötvös's presidency coincided with the centenary of the birth of István Széchenyi. Eötvös considered it extremely important to celebrate the anniversary appropriately. The young sculptor Barnabás Holló was commissioned to make a bronze relief depicting the scene in which the offer was made to establish the Scholarly Society. This relief, which can still be seen on the wall of the Academy building, was unveiled in January 1893. In his speech at the ceremony, Eötvös announced the launch of the annual Széchenyi Festival.

In 1894, there were two national events in which Eötvös played a significant role as president of the Academy. That year marked the 50th anniversary of Mór Jókai's career as a writer, and preparations for its celebration had begun already in 1890. The idea of a special edition of Jókai's works came from Eötvös, who was made chair of the organising committee. The national celebrations took place with rare pomp, and, after the emperor and empress, Eötvös purchased the third series of the 20-volume special edition, bound in Moroccan leather.

In the same year, the death and funeral of Lajos Kossuth stirred great public emotion. Despite governmental opposition, Roland Eötvös personally attended the funeral as a member of the official funeral procession and placed a wreath on Kossuth's coffin as president of the Academy.

A number of major research projects were also launched during Roland Eötvös's presidency: József Szinnyei's large-scale bibliographic works, as well as the 14-volume "The lives and works of Hungarian writers" were both completed. Work began on the Great Dictionary of the Hungarian Language and the Sigismund-era document archive, while the Dictionary of Medieval Latin in Hungarian Sources was completed.

Still during his tenure, the decoration of the ceremonial hall was undertaken using targeted donations, and Lotz completed the fresco on its eastern wall; the Goethe room was furnished from the collection of Gyula Elischer, and a memorial room was also dedicated to Széchenyi; finally, György Ráth donated his pre-1711 Hungarica collection to the Academy in 1895. The Hungarian Academy of Sciences also participated in the Millennial celebrations, predominantly with works on the early centuries of Hungarian history. In 1896, the General Assembly was honoured to receive a visit from the emperor in person.

At that time, the Hungarian Academy of Sciences was unable to play a leading role in the development of the natural sciences in Hungary. Rapid development in the field was hindered rather than facilitated by the Academy's sectional and committee structure.

Roland Eötvös had a serious interest in bringing scientific undertakings in Hungary to the international stage, and for this reason many scientific societies became involved in international activities. It was regarded as a great success when the Hungarian Academy of Sciences was invited to the first meeting of the International Association of Academies, held in Paris in April 1901, to which ten academies received official invitations.

One of the highlights of Eötvös's presidency of the Academy was the establishment of the Bolyai Prize, marking the centenary of the birth of the great mathematician, which was announced by the president at the Bolyai commemoration ceremony in Kolozsvár (Cluj) in 1903. According to the regulations, the prize was to be awarded every five years, and the first recipient was French mathematician Henri Poincaré, in 1905. The prize was a significant amount (10,000 crowns), and although it could not rival the Nobel Prize, it was regarded as highly prestigious in the field of international science.

An earlier and a later photograph of Roland Eötvös

Political public life

In 1872, in keeping with family tradition, Roland Eötvös became a member of the Upper House by a royal letter of invitation. He was among those aristocrats who deserved membership not because of their income, but because of their services to the nation. In 1885, when the Law on the Upper House was modified, fifty seats were filled by election, thus he was able to become a life member. He used his membership of the Upper House primarily in the service of science and education. In 1893, for example, during the budget debate, he contributed to creating better housing conditions for the university by establishing a university campus on Üllői Road.

He was also following in his father's footsteps when he accepted the portfolio of religion and education in the second cabinet of prime minister Sándor Wekerle in the summer of 1894. Eötvös's appointment was widely commended, and he was acknowledged by the press as one of Hungary's greatest scholars. "Likeable, cheerful and friendly," is how Mikszáth described him in an introductory essay. He himself stated that he had accepted the appointment in order to pave the way for those who "wish to strive to cultivate the fields of science".

Unfortunately, his term in office lasted just seven months, as the second Wekerle government was overthrown on 15 January 1895. During this time, several important bills were passed by the Parliament, which were submitted by Eötvös but had been elaborated by his predecessor. These included a bill on pension rights for teachers in non-state institutions, civil marriage, and the construction of a major new art exhibition hall. Also in June, he delivered a speech in the Parliament on a bill on freedom of religious practice and denominational equality. Eötvös pressed for the passing of this bill, which had already been drafted earlier, because he felt it represented the ideas held by his father.

During his tenure, he also fulfilled a number of protocol duties, and in addition dealt with the question of Catholic autonomy, enacted a law on children's education, established over four hundred new elementary schools, laid the foundations of the Museum of Applied Arts, and devoted particular attention to teachers' issues. He also opened a fine art exhibition, purchased Otto Hermann's valuable data collection on the transit routes of migratory birds – and the list could go on. Last but not least, he took the initial steps towards the realisation of his old dream by proposing the establishment of the Baron Eötvös József Collegium, which was created in 1895.

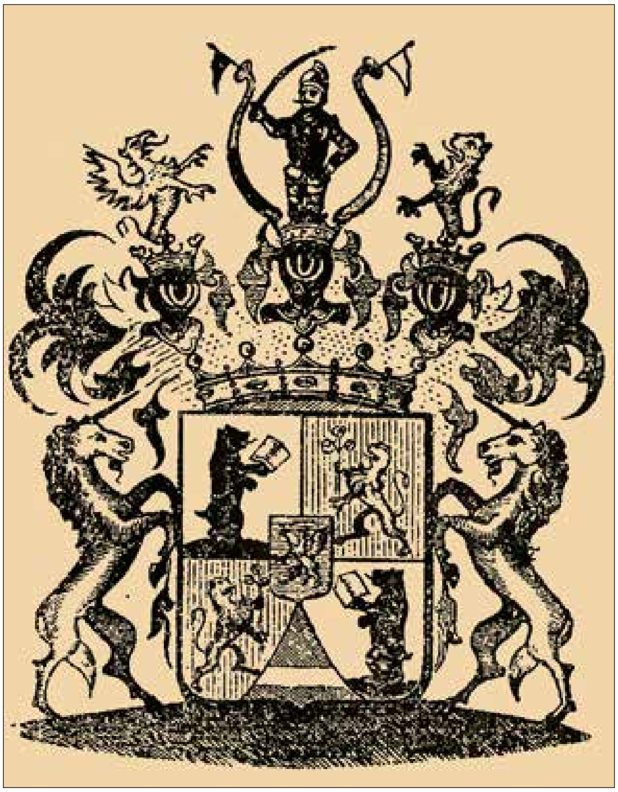
We know little about how he took the forced termination of his post as minister: presumably, complete retirement to the world of science was very strongly on his mind. In a letter to Kálmán Szily dated spring 1895, he wrote of his intention to resign if he were re-elected as president of the Academy, as he preferred research and teaching. In the end, he remained president of the Academy, although it is little surprise that the president's address he delivered in 1895 was perhaps one of the most critical of all.

Roland Eötvös was elected president of the Academy on six occasions. Likewise after a serious domestic political crisis, and half a year after his loyal secretary-general had retired, he resigned in a letter dated 5 October 1905, despite being requested by a special committee to reverse his decision. Eötvös was the first president not to retain his position until the end of his life. As the reason for his resignation, he stated that he wished to do more scientific work, and this was not merely an excuse: he completed some hugely successful research in the remaining decade and a half of his life. As a member of the Board of the Hungarian Academy of Sciences, and as a scientist, he served the Academy until the end of his life.

BALÁZS DEVESCOVI

The Eötvös family in the age of the bourgeois transformation

Literary historian Pál Gyulai called József Eötvös one of the most outstanding representatives of Hungary during the era of the bourgeois transformation, "as an individual, as a statesman, and as a poet." Roland Eötvös was likewise an outstanding figure in the process of embourgeoisement in Hungary, both as a scientist and as a man. The Eötvös family, whose journey led from aristocratic forebears to their bourgeois descendants, can indeed be regarded as representatives of the increasingly bourgeois Hungary.



The coat of arms of the baronial branch of the Eötvös de Vásárosnamény family

The story of Baron Eötvös de Vásáros-Namény family is best known from the genealogical study by Iván Nagy, *Magyarország családai* (The Families of Hungary), a work that relies entirely on printed sources and publicly available data in the absence of family testimonies. According to Nagy, the family came originally from Bereg County and moved to Szatmár in the 17th century. Miklós Eötvös was the first to make a name for himself: in 1696, he was district administrator of Szatmár County, and three years later a tax officer for the county. The title of baron was bestowed on another member of the family by the name of Miklós during the reign of Maria Theresa in recognition of his merits as imperial royal general in 1768.

The family achieved national recognition through József Eötvös's grandfather and father. They were both high-ranking officials loyal to the Habsburgs, and imperial privy councillors: Ignác Eötvös the elder was master of the cupbearers, while the younger was master of the treasury. Our knowledge of the family is based not only on Iván Nagy's book, but also on Ferenc Szinnyei's study *Magyar írók élete és munkái* (The lives and works of Hungarian writers).

Born in 1763, Ignác Eötvös was made doctor of humanities at the University of Nagyszombat (Trnava) in 1779, and was appointed an official and secretary in the district courts west of the river Tisza in 1786. When this position was abolished, he withdrew from public affairs in 1790, although he still participated in the 1790, 1792 and 1796 Diets. In 1797, he was appointed first honorary, then effective councillor at the Hungarian Royal Court. In 1802, he was entrusted with the administration

Baron Ignác Eötvös's wife, Anna Lilien – watercolour by Johann Ruprecht

Baron Ignác Eötvös II – etching by Sándor Ádám Ehrenreich, after a painting by Joseph Weidner

of the treasury. Between 1806 and 1812, he was vice-president of the royal "Hofkammer" (an organ of the financial administration), after which he became keeper of the crown. In 1814, he was appointed *vice-ispán* (vice lord lieutenant) of Gömör, and in 1816 of Hont County, then in 1824 he became *ispán* (lord lieutenant) of Abauj County and royal master of the cupbearers. As a reward for his loyalty and service, he was awarded the Middle Cross of the Order of St. Stephen shortly before his death in Buda on 12 June 1838.

Born on 25 February 1786 in Sály, Borsod County, Ignác Eötvös the younger followed his father in his official career. He completed secondary school in Buda, and attended university in Pest. In 1802 he earned a doctorate in humanities, and in law in 1804. He began his official career as an honorary draftsman for Pest County, later becoming secretary and executive councillor; in 1826 he was made executive councillor to the Royal Hungarian Chancellery, and in 1826 or 1827 he became *ispán* of Sáros County, following his appointment as *vice-ispán* of the county in 1823. In 1830, he was promoted to second court chancellor and internal privy councillor. In 1836, he was made master of the royal treasury, but later resigned due to bankruptcy in 1841. Having lost all his estates, he retired to Velence, where he died on 21 August 1851.

It would have been natural for József Eötvös to follow in the steps of his predecessors, but he took a different path. While we cannot know for certain why this was the case, a few reasons can be highlighted. Firstly, it is worth mentioning the sense of patriotic shame that the young Eötvös felt with respect to his contemporaries, and which he expressed during his memorial speech at the Academy for one of his greatest friends, the historian László Szalay. As a result of the speeches delivered in the 1825 Diet "the nation […] looked at its past and compared its more illustrious days with the present: its heart was filled with pain, and what it felt most bitterly was not the loss of its status. It was not that its bright star had faded, and that we believed the worthier days of our country to have been lost forever, but that the blame for this decline lay not with our fate but with ourselves, that a nation that had sunk so low and become alienated in its own country deserved no better; this was what was painful for the Hungarian; and what prompted him to act was not patriotic *hope*, but patriotic *shame*."

In the case of József Eötvös, a sense of personal shame also contributed. His father and grandfather, who were both loyal to the emperor, had stood against the feudal opposition: Ignác Eötvös I, as one of the six royal commissioners responsible for tax collection and recruitment, both of which were against the constitution, arrested two leaders of the opposition in Nyitra (Nitra). When he subsequently entered the county assembly, this act almost cost him his life. Besides, as a royal commissioner, during the cholera epidemic in 1831 Ignác Eötvös II was entrusted with the task of "settling" the uprising in the north, and he allegedly "executed so many people that the emperor himself was sick of it." Apart from them, József Pruzsinszky, the Eötvös family tutor, played an important role in the personal humiliation. In his 1871 biography, Eötvös's friend Ferenc Pulszky wrote that the father of József had "engaged a rigorous old republican as his tutor to instil in him a hatred of liberalism". According to his biographers, this altered Eötvös's way of thinking about the family's traditions and political views.

His sense of shame is well known from both Pulszky's biography and the memoirs of Miksa Falk, a journalist. The first event is related to a walk taken with his tutor to the Vérmező (Field of Blood), during which Pruzsinszky talked to his student about the Martinovics conspiracy: "Five upstanding Hungarian patriots were executed here. No one erected a memorial to them, but the feet of the people have unwittingly trodden the form of a cross into the ground. The time will come when these men will also be remembered; but this memory will comprise a gallows, on which they will hang the kind of people that you yourself will one day become." On starting secondary school, the young boy understood the meaning of this speech, when he was seated in the first bench and all the others moved away from him, except for one Jewish boy. Their explanation was that "they did not want to sit on the same bench as the grandson of a traitor." The little boy reddened with embarrassment, and, despite German being his mother tongue, he begun to study Hungarian. After a few months, "poor little Pepi climbed up to the teacher's dais – he often recounted with laughter how he was so short that he could barely see over the edge of the desk – and informed his schoolmates in a determined voice that in fact his grandfather and father were not traitors, but rather servants of the emperor; and he swore to the living God that he would serve only his homeland and would dispel the unpopularity surrounding his family name through his own patriotism." According to a more recent interpretation by Pál Bődy, "while respecting the principle of parental tradition, a gradual intellectual and emotional transformation" can be assumed "towards a commitment to Hungarian patriotism and human freedom."

Born on 3 September 1813 in a Buda mansion at 19 Úri Street, József Eötvös grew up in aristocratic surroundings. As Béla Tóth noted in his introduction to an Eötvös anecdote, "the young Eötvös rode, fenced, danced, drank champagne and courted, like any other young baron." Although he mentions Buda as his native city, his childhood was spent mostly on his mother's estate in Ercsi, where his only tutor was his German-speaking mother, Baroness Anna Lilien. In 1824, he became a public student at the Buda University High

József Eötvös as a young man – oil painting by Anton Eisle

School, then between 1825 and 1828 he studied at the Faculty of Arts of the University of Pest, before attending the Faculty of Law between 1828 and 1831. In 1833, he passed his lawyer's examinations and took his lawyer's oath in Pozsony (Bratislava). He embarked on his official career with the support of his father: from 1833 to 1835, he was honorary subnotary in Fejér County; from 1835 to 1836 he was a trainee draftsman at the Hungarian Court Chancellery before being appointed honorary draftsman; and finally, after his grand tour in Europe, he became a judge at the court of Eperjes (Prešov), moved to Sály and participated in county assemblies in Borsod County.

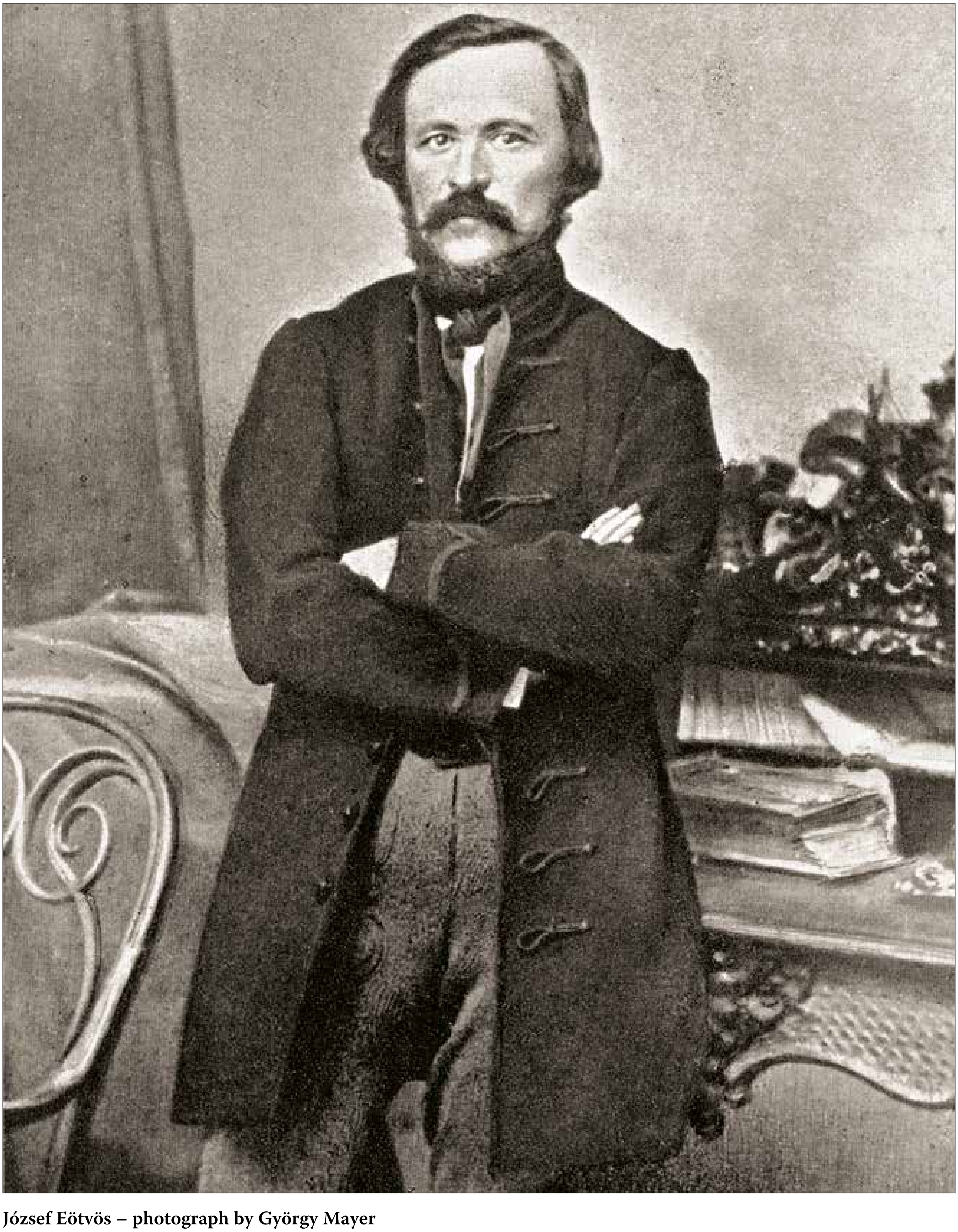
His subtle distancing from his father began with his grand tour between the summer of 1836 and the autumn of 1837, when he travelled in Italy, Switzerland, France, England, the Netherlands and Germany. Ferenc Toldy wrote that "on his return, in order to bind his son once again and more closely to his official career, his father […] appointed him […] as honorary judge of the Tiszamellék District Board. Eötvös, however, although the title featured in the Academy register for several years (1838–42) […] appeared at meetings on only a few occasions, instead living on his father's estate in Sály (Borsod County) until 1840, where he devoted his time entirely and definitively to literature; whereupon his father no longer urged him to remain in office." In addition to literature, he embarked on a career in politics. He distinguished himself by his speeches at Borsod County assemblies and he wrote his first work on prison reform. Father and son held conflicting political views, although as well as living in Sály, József Eötvös also resided in Buda, in his father's apartment in the Batthyány Palace on Dísz Square.

Greater changes were brought about when his father declared bankruptcy. Ágoston Trefort, another important close friend of Eötvös and his brother-in-law, divided Eötvös's life into two parts: "The family disaster that befell him in September 1841, and which put an end to his youth, began with the struggles and aspirations of the more mature man, marking a caesura in his life that fundamentally divided it into two distinct parts." In 1841, a financial crisis struck Vienna, which also affected the Geymüller bank along with the treasurer, Ignác Eötvös. Everything was lost in the family shipwreck, the Fejér and Borsod county estates were auctioned off, and Ignác Eötvös resigned from all his offices. András Gergely discovered in Franz Anton Kolowrat-Liebsteinsky's ministerial records how he relied on the help of the court to salvage his existence. His son considered as unacceptable either this or the financial operations suggested by the bankers, as preserved in the anecdotes, but whatever the case he abandoned his father and, as Menyhért Lónyay writes in his memoir, "with his books and some pieces of furniture that had belonged to him, he moved from the Prince Batthyány Palace in the Buda Castle to live with his faithful friend […] Ágoston Trefort, in the Wodianer House in Pest.

In keeping with the commemorative speech by Pál Gyulai on the anniversary of József Eötvös's death, we consider Eötvös's lifestyle to have been bourgeois. "As a result of misfortune, he inherited nothing from his father except the prerogatives against which he had fought throughout his life. He entered the world as a poor man, and sought to achieve new titles through his work. […] Nothing but his fine manners revealed him to be an aristocrat. He was a bourgeois in his pleasures, habits and lifestyle." On 13 September 1842, he married the seventeen-year-old Ágnes Rosty, and, as literary historian István Sőtér wrote, "their family happiness became almost proverbial among their contemporaries." Eötvös's diary frequently refers to the fact that he lived from his work, and not too well at that; while his son was studying in Germany, he repeatedly warned him that, besides the modest income for his work, he was living on an insecure ministerial salary and the income from his wife's estates in Békés County, and once the children had grown up, they lived in permanently straitened circumstances.

József Eötvös and Ágnes Rosty led a bourgeois lifestyle, as suggested by contemporary recollections.

Ágnes Rosty – photograph by György Mayer



József Eötvös – photograph by György Mayer

József Eötvös's holiday home on Svábhegy – watercolour by Gusztáv Keleti

At the time of the Pozsony Diet of 1843–44, according to Trefort "his lifestyle was the subject of a great deal of talk." The politician Menyhért Lónyay recalled: "One could not have imagined a more attractive family life […]. In his simply furnished, modest accommodation, the study was where he spent his working hours at his desk; his young wife was busy with women's work or playing the piano; when the time came to rest, his close friends gathered there."

The life of Eötvös and his family was closely intertwined with that of Ágoston Trefort and his family. Their friendship began in 1837, when, after his tour in Western Europe, Trefort passed his lawyer's exams and became a trainee draftsman in the Hungarian Royal Chamber and rented an apartment in Sándor House, Buda, where they were introduced to each other by his neighbour, Count János Serényi. Details of their lives are known from his autobiography. Together with László Szalay, Trefort made the trip to Sály to see Eötvös several times in 1839, and in April they decided to publish the journal *Budapesti Szemle* (Budapest Review). Eötvös then suggested that they should both marry the daughters of Albert Rosty. After the bankruptcy, Eötvös moved in with him, then married Ágnes Rosty. Trefort courted Ilona Rosty for longer, which is how we know about where the Eötvös couple lived. After the Pozsony Diet, they lived in the Wodianer House – on the same floor as Trefort – until

Registration of the baptism of Roland Eötvös, 5 August 1848

Baron József Eötvös with his son Roland in 1860

The Carthusian House (“Karthauzi-lak”) – watercolour by Gusztáv Keleti their emigration in October 1848, renting apartments in the Buda hills from the spring to the autumn, as was the custom among the bourgeois. They spent the summer of 1845 in the Fridvalszky Villa on Svábhegy, the summer of 1846 and 1847 in the Schreibner House in Krisztinaváros, where Trefort also lived after his wedding on 14 March 1847 and his honeymoon with Ilka Rosty. Trefort writes nothing about the colder months, although in connection with the summers he mentions readings and walks in Svábhegy and Városmajor, while Zsigmond Kemény's diary contains a description of the Schreibner House: a small building with a tiny front garden, with an entrance hall in the apartment rather like a porch, "with the baroness's rooms to the left and Pepi's [József Eötvös's] study on the right, with a cheap couch, a comfortable armchair, a few chairs, and a bookcase."

The two families returned from emigration in the autumn of 1850. The Eötvös couple were at Lake Velence during the winter before moving to their villa on Svábhegy in the spring, then, from autumn 1851, they certainly used the second-floor apartment in the Sina House overlooking Erzsébet Square at the corner of the former Fürdő and Bálvány Streets as their winter residence. The holiday home on Svábhegy deserves particular attention, since, after the birth of Ilona in 1846 and Jolán in 1847, it was here that their son Roland (in Hungarian: Loránd) was born on 27 July 1848 (their last surviving child, Mary, was born in 1851). In 1845, József Eötvös purchased a large forested estate on Svábhegy, and maps dating from 1846 show that there were two buildings on the plot: one cross-shaped building on the site of the villa, and the Carthusian House to the south. His father recalled the day on which Roland was born in a letter written on his son's 20th birthday (in the present volume see the letter cited in the article by Gyula Radnai), and the next year he again reminded Roland of how his sister Ilona gave birth in the house on Svábhegy: "On this occasion, we didn't think of anyone more often than you, who came into this world on Svábhegy 21 years ago." We cannot know for certain the exact location of Roland's birth: he may have been born in the Carthusian House, or perhaps more likely in the villa that was under reconstruction, but it must also be borne in mind that while Trefort makes no mention of his brother-in-law's residence in the spring of 1848, he does mention that his wife, Ilona, was living in the Libasinszky House near the Eötvös Villa, which makes it likely that her sister and her family were living there. We know for sure that Roland Eötvös was baptised in the Krisztinaváros Church on 27 July 1848. The third of the Rosty girls, Anna, married in September 1850, after which Trefort distributed the Rosty estates: Csabacsüd in Békés County became his, the Eötvös couple were given Szentetornya as well as the villa on Svábhegy, which Trefort claims that they started building together in 1848. Despite the division of the property, their children visited each other on several occasions over a long period of time, thus it was not merely a formality that Ágoston Trefort was Roland Eötvös's uncle and godfather, along with his godmother, Anna Rosty.

The political careers of Eötvös and Trefort were closely intertwined as well. With Szalay, they formed the core of the Centralists, and the three were to write the most influential articles in their newspaper, *Pesti Hírlap* (News from Pest), in 1844–45. Later, Trefort and Eötvös frequently occupied similar positions. In the Batthyány Government in 1848, Eötvös was given the portfolio of religion and education, while Trefort was deputy secretary of state in the Ministry of Commerce, Agriculture and Industry under Gábor Klauzál. In the post-Compromise period, after 1867, their names were linked to the establishment of public education: Eötvös was minister of religion and education in the Andrássy Government, a post that was taken after his death by Tivadar Pauler. Then, building on the foundations that had been laid by Eötvös, it was Trefort who developed the Hungarian public education system as minister between 1872 and 1888. They were both president of the Hungarian Academy of Sciences: Eötvös from 1866 until his

Roland Eötvös as a young man – watercolour by Gusztáv Keleti (1858)

death, and Trefort from 1885 to 1888 (between them the position was held by Menyhért Lónyay).

As minister, József Eötvös had some important laws passed in 1868: on public education, nationalities, and the emancipation of the Jews. He wrote political pamphlets, one on the emancipation of the Jews in as early as 1841, one on the improvement of prison conditions with Móric Lukács in 1842, and a collection of the Centralist programme in 1846 with the title *Reform*, as well as several German-language articles on the political situation in the 1850s. Many people consider his most important work to be his political-philosophical writing, the two-volume *A XIX. század uralkodó eszméinek befolyása az álladalomra* (The Influence of the Dominant Ideas of the 19th Century on the State), which was published in 1851 and 1854 in German and Hungarian.

He was also a significant writer of literature, mainly writing poems and dramas at the beginning of his career, followed by three substantial novels before the Revolution of 1848, and later publishing prose works, albeit marginally. His first success was achieved between 1839 and 1841, when his romantic novel *A karthausi* (The Carthusian) was published in the *Budapesti Árvízkönyv* (Budapest Flood Book), of which he was editor. It was thanks to this novel that he was asked to deliver the memorial speech for the poet and politician Ferenc Kölcsey at the Academy. *A falu jegyzője* (The Village Notary), a romantic picaresque novel that bitterly satirised the county system, was published in 1845. Published in 1847, his most outstanding work, according to many, was the historical novel *Magyarország 1514-ben* (Hungary in 1514). Following the War of Independence of 1848/49, as well as being president of the Academy he contributed to the shaping of literary life as president of the Kisfaludy Society, which was re-established in 1860. In 1854 and 1855, he published short stories in the journal *Magyar Nép Könyve* (The Book of the Hungarian People), while his last novel, *A nővérek* (The Sisters) appeared in 1857.

József Eötvös was reluctant to resume his position in the Ministry of Religion and Education, as the futile parliamentary debates exhausted him, and, as his health deteriorated, strenuous effort took its toll during his final years. He complained of stomach and kidney problems and frequently visited Karlsbad on the advice of his doctor. In December 1871, he took to his bed, developed a fever in January 1872, and died peacefully at 11 pm on 2 February – his real illness, and the cause of his death, was tuberculosis.

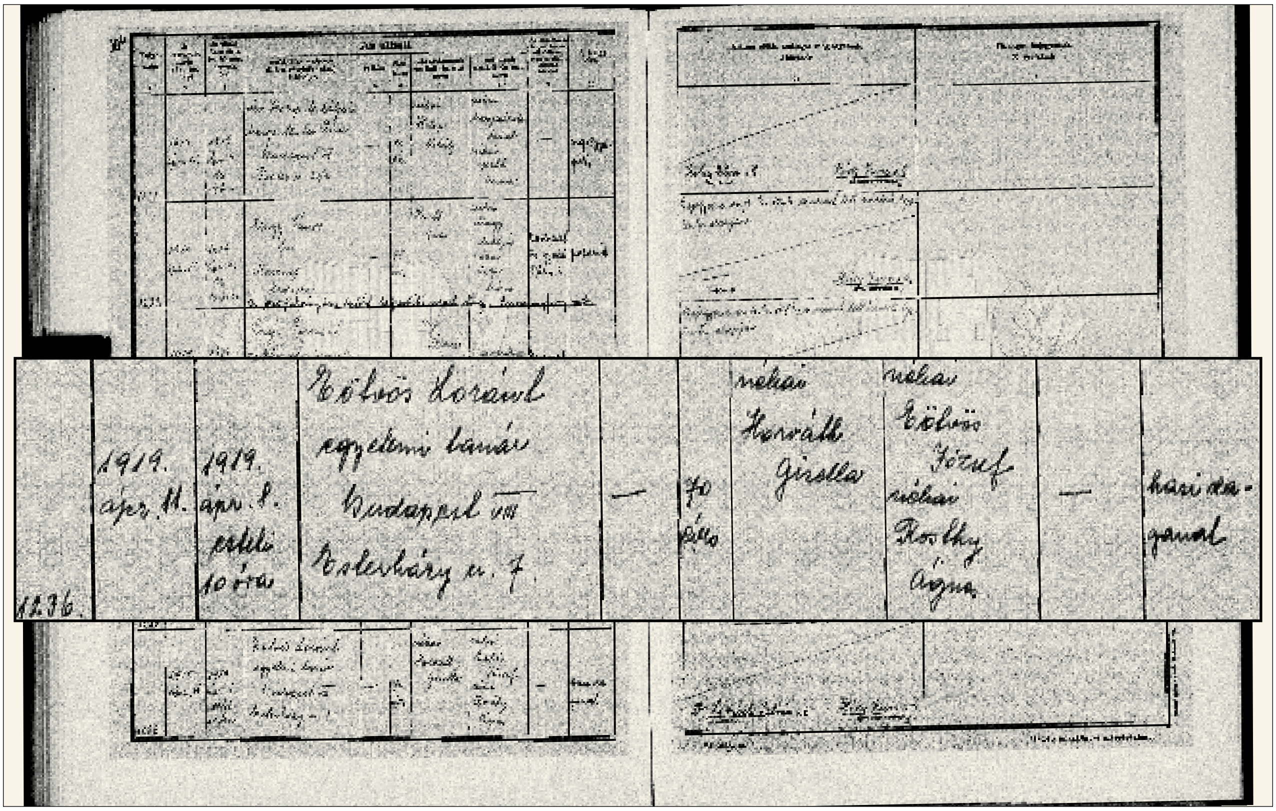
József Eötvös himself had not followed in the footsteps of his father and grandfather, and now Roland Eötvös also made an informed decision about his career. It helped that he had grown up with his sisters in a loving family atmosphere. Roland Eötvös was initially brought up in his parents' houses in Erzsébet Square and on Svábhegy. He started public secondary school in 1857/58 at the Piarist school, although in the first semester of fourth grade he was a private student and left the school due to a serious illness at the end of the fifth grade (his parents feared tuberculosis). He also completed sixth and seventh grades as a private student, eventually leaving school in 1865. Most of his biographers mention his two excellent tutors, one of whom was Gusztáv Keleti, later a well-known painter, who was director of the Art Teachers Training College that he established on the mandate of József Eötvös; the other was Tamás Vécsey, later a teacher of law at the university. Along with his former and current tutors, Keleti and József Sándor Krenner, who would later become a knowledgeable mineralogist, Roland undertook a small-scale geological tour in the Erzgebirge mountain range in Central Europe in September 1864, and subsequently visited Bihar and the Scarisoara Ice Cave with them in September 1868. (The visit was the subject of his first publication in *Vasárnapi Ujság* on 5 December 1869.)

It would have been natural for Roland Eötvös to enter state public service after obtaining his law degree, but he opted for a different direction. Izidor Fröhlich wrote that, "in keeping with the fashion of the times, and in all probability at the request of his parents, Roland began his studies in law and political sciences at the University of Pest; however, his pronounced aptitude for arithmetic and the natural sciences led him to study these subjects after graduation. His father, who had become aware of his inclinations early on and wished to promote them to some extent, did not want to stand in the way of his son's wishes, thus, alongside his studies in law, he commissioned József Sándor Krenner to tutor him in the natural sciences, especially mineralogy and petrography; however, he was also very interested in chemistry and worked diligently in the laboratory of Károly Than, a university professor in this subject." He was tutored privately in mathematics by Ottó Petzval in 1864–5 and attended the lectures by Gusztáv Kondor on astronomy. Finally, Fröhlich writes that "at his father's request, he continued to study law and politics at the university, and, according to his own written curriculum vitae, he completed his studies in these subjects."

In 1867, he went to Heidelberg to study the natural sciences in greater depth; in 1869, he spent the summer semester at the University of Königsberg; then on 8 July 1870, he completed his doctorate summa cum laude in Heidelberg, majoring in physics with mathematics and chemistry as additional subjects.

Like his father, Roland possibly came to a final decision about his career while he was abroad. The only difference was that Roland had his father's support. According to Árpád Horváth's novelistic biography, he and his father went on an Italian tour in the summer of 1867: as they looked at the Galilei manuscripts in the university library in Bologna, Roland, like his father before him, made a vow to become a physicist, just like Galilei. In a letter dated 28 March 1866, Roland Eötvös had written to his father that, besides studying law, he wanted to study the natural sciences with good teachers at foreign universities, rather than from books: his father, however, insisted that he pass his two-year law exams first. For his 18th birthday, Roland was given a trip by his father: on 1 August 1866, for the first time in his life, he travelled largely alone to Switzerland, Italy and France, returning home on 1 October. According to Domokos Dániel Kis, this "almost lonely journey to Switzerland was the first genuine experience of his life, which made him a lifelong 'lover of the mountains'", and also contributed to him "becoming a faithful researcher of one branch of the natural sciences." Roland Eötvös's sojourn abroad was a decisive moment in his journey towards adulthood, just as his father's Grand Tour had been, although it covered fewer countries and did not last as long, while mountaineering must have been its principal aspect. Nevertheless, there is something touching about the parallel, which highlights the closeness between father and son. After scaling the Dufour peak in the Monte Rosa massif, Roland visited the Great Saint Bernard Monastery on 17 September 1866, where he discovered his father's name in the guestbook, dated 9 August 1836. (For details illustrated with the two signatures see the article by Domokos Dániel Kis.) Roland's father also provided financial support for his son's studies in Heidelberg, and their correspondence during that period is a beautiful example of the intimate relationship between them: József Eötvös helped Roland by offering him advice during his difficulties in Königsberg, although he firmly dissuaded him from participating in an Arctic expedition at the end of 1869, which, apart from being expensive, was highly dubious in terms of its scientific success.

On 5 May 1889, during the gala dinner for his election as president of the Academy, Roland Eötvös recounted how, in his childhood, he had been accompanied by three guardian spirits: poetry, politics, and science. Having abandoned poetry, his further choice was made easier by the fact that his father always returned from the Parliament in a bad mood, but was always cheerful on returning from the Academy. His open letter to Ágoston Trefort on the subject of university teaching, which was published in the *Budapest Review* on 10 April 1887, began with the following words: "I chose this



Registration of the death of Roland Eötvös on 8 April 1919

career with enthusiasm, convinced that there was no job in which I would be able to do more for my country, and because of the promise of laurels, which grow sufficiently tall along this path to be plucked by the truly strong alone."

The turning point in József Eötvös's life was the financial bankruptcy of his father in 1841, while the death of his own father had a similar impact on Roland's life in 1871. After obtaining his doctoral degree and returning home, he began his experiments, was nominated as a member of the board of the Society of Natural Sciences, and was elected to the editorial board of the journal *Természettudományi Közlöny* (Communications in Natural Sciences). His scientific career began only after the unexpected death of his father, and, thanks to his father's renown, progressed rapidly. On 5 March 1871, Roland Eötvös applied for an associate professorship and was accepted on 14 March, after which he began to give university lectures. On 10 May 1872, he was appointed professor in the Department of Theoretical Physics at the University of Pest, and became a corresponding member of the Academy on 21 May 1873.

His contemporaries saw Roland Eötvös as a representative of the aristocracy and bourgeoisie at the same time, and his choice of scientific career and teaching was considered a surprise. In his biography, in which he recounts his personal memories, Izidor Fröhlich writes that at Eötvös's first university lecture on 17 April 1871, "one part of the audience comprised three students of the exact sciences; […] while most of the rest were attracted by curiosity; they were keen to see a real baron lecturing at the university, which was something that had never happened before there." He also notes that Baron Roland was a "*quiet, genuine scientist, who worked with modesty,* and who was so immersed in his experimental problems, to the exclusion of everything else, that his wife frequently complained that, when her husband's laboratory door closed behind him, he was lost to his family for days." His colleagues often refer to harmony in their descriptions of him. Dezső Pekár and István Rybár remember him as someone who took good care of himself physically, alongside his scientific work. The article by Domokos Dániel Kis in the present volume is devoted to Roland Eötvös, the sportsman and keen hiker.

Lastly, we should add a few words about the private life of Roland Eötvös. He married as a young university professor, on 29 July 1875. As the Sunday paper *Vasárnapi Ujság* reported on 8 August 1875: "B. Loránt Eötvös, university professor, son of the exceptional b. József Eötvös, celebrated his wedding in Marienbad to Miss Gizella Horváth, the highly educated daughter of former minister of justice Boldizsár Horváth. […] The young couple travelled to France." (The original mispelling of the name of Eötvös is kept.) According to the biography by Tibor Buday and his wife, "on their return from their honeymoon in Paris, the young husband took his wife to the Eötvös apartment at 10 Erzsébet Square. From here, they moved to 6 Kecskeméti Street a few months later, before taking possession of their final home, the professor's flat on the first floor of the Institute of Physics in Eszterházy (today Puskin) Street, in 1886, where they lived for the rest of their lives." After the death of József Eötvös, the family sold their property on Svábhegy to the building company that constructed the cogwheel railway in Buda. Roland's sisters got married, and he lived with his mother in Erzsébet Square for some time, and this is where he brought his new wife for a few months. In 1967, Béla Szőke discovered that between 2 June 1882 and 15 January 1918, Roland Eötvös owned two acres of land with a villa in Pestszentlőrinc; it was here that Roland Eötvös performed his first outdoor balance experiments. Roland seems to have followed his father's custom by having two residences. We should add briefly that he spent his summers in the Alps – in Schluderbach – with his daughters, a habit that he changed only on the outbreak of the First World War; by this time, he considered himself too old for mountaineering, thus stayed only in the High Tatras.

Roland Eötvös was an experimental scientist and university professor, who produced important publications. (This area of his activity, along with Eötvös's institutional positions, is dealt with extensively in the pages of this volume.)

He remained in good health until the end of 1917, but in 1918 he developed cancer and by his 70th birthday he was seriously ill. "After long suffering, but in full possession of his intellectual faculties to the end, the loving heart of this great philanthropist beat its last in the final minutes of 8 April 1919", wrote Dezső Pekár.

Roland Eötvös and his wife had three daughters: Jolán (1877), Rolanda (1878) and Ilona (1880), although only Rolanda and Ilona reached adulthood; they never married and had no children, thus with them the family of Baron Eötvös de Vásáros-Namény died out. When Roland Eötvös died in 1919, the Hungarian Soviet Republic was in power, and the great scholar was buried by the Soviet system. (The funeral itself is described at length in the article by László Törő in the present volume.)

DOMOKOS DÁNIEL KIS

Roland Eötvös the sportsman

Baron Roland Eötvös is renowned not only as a physicist, university lecturer, member of Parliament, president of the Hungarian Academy of Sciences for 16 years, and minister of religion and education, and his name is linked not only to the laws of physics and famous measuring devices that he devised: he was also celebrated in his day as a mountaineer and amateur photographer who captured images of the most hair-raising peaks.

In 1902, the well-known climber and geologist Adolf Witzenmann, who held Eötvös in high esteem, named one of the peaks in the Cadin mountain range in the Dolomites in South Tyrol in his honour: Cima di Eötvös.

As an old man, the professor said the following of his favourite mountain range: "The ever-changing view of the Cadin mountains is a source of eternal beauty."

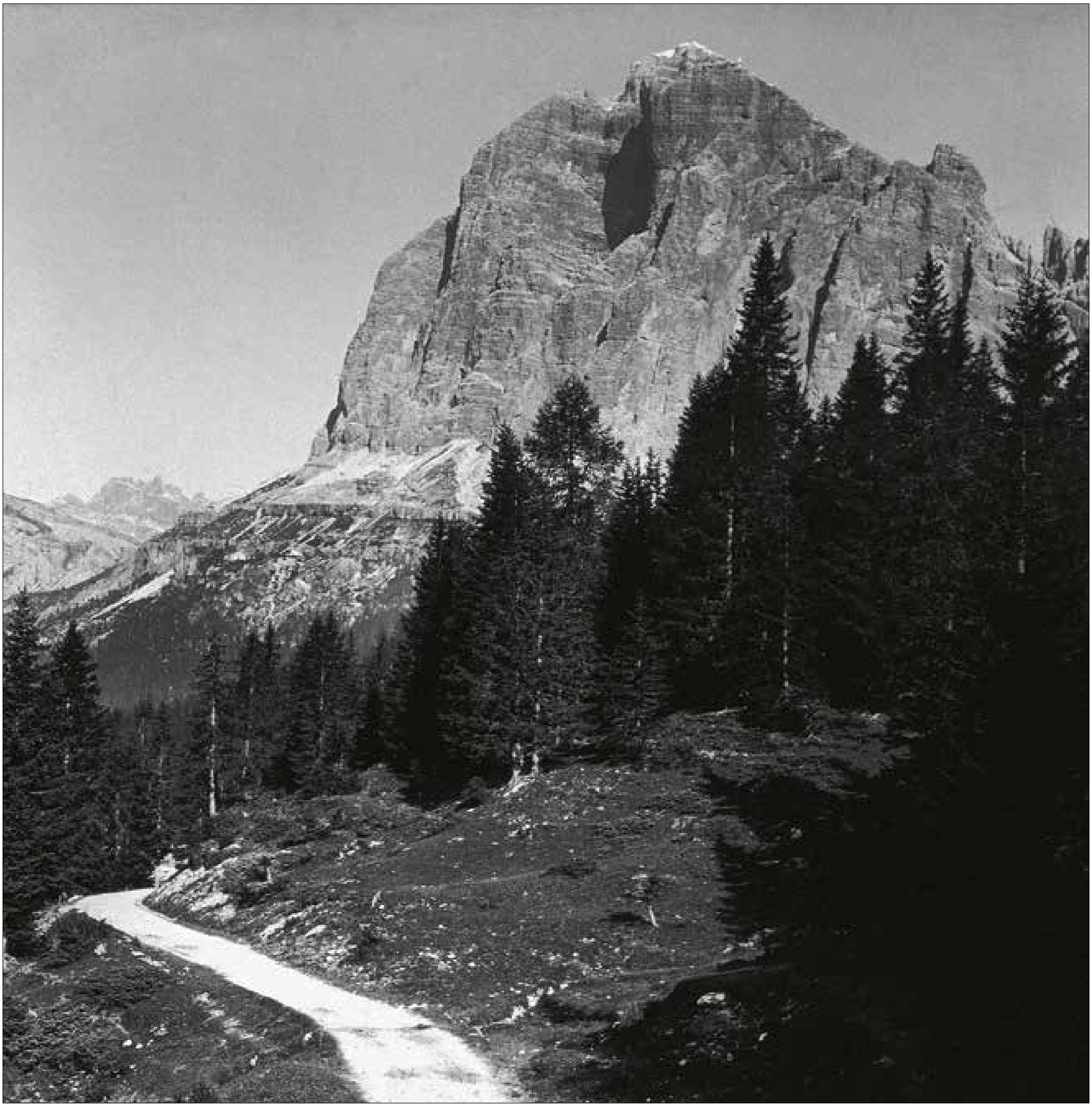
Eötvös had a well-deserved reputation among his mountaineering contemporaries. He was the first to conquer a number of peaks in the Dolomites. These daring pioneering ascents were recorded by climbers who penned recollections of their mountaineering experiences. Leone Sinigaglia, for example, the Italian author of *Climbing Reminiscences of the Dolomites*, which was published in English in London in 1898, refers to the "Hungarian baron", the "professor from Budapest", recalling the modest, physically strong and extremely skilled Hungarian scientist on the rocky summits of the giant mountains.

As his role model, Eötvös singles out his father, the writer and minister of religion and education József Eötvös, with whom he made his first visit to the Alps, along with his uncle, Pál Rosti, to whom he gave the nickname Pablo following his travels in Mexico, Cuba and Venezuela, and who was one of the pioneers of landscape photography in Hungary. He was following partly in their footsteps when he made artistic recordings of his impressions during his climbing tours. Later, it was perhaps the renowned physicist and mountaineer, and the greatest scientific researcher of glaciology and ice sheet dynamics, John Tyndall, who had the greatest influence on his passion for mountaineering. Eötvös translated the Irish physicist's climbing reminiscence *The Ascent of the Jungfrau*, and, as one of the reformers of scientific language, he recommended in a footnote that the word "ice sheet" be used in place of "glacier". And while Tyndall was one of the most prestigious members of the London Alpine Club, the world's first mountaineering association (founded in 1857), later, partly by virtue of his merits as a climber and hiker, Eötvös became president of the Budapest branch, formed in 1888 in the framework of the Hungarian Carpathian Association, the world's seventh hiking association (founded in 1873), and, still later, was president of the Hungarian Tourist Association from 1891 to 1899. With an emphasis on the importance of sport for the young, at the request of his fellow professor Jenő Klupathy he took on the role of president of the Budapest University Athletics Club, which was founded in 1898 as the sports club of what is now known as the Eötvös Loránd University.

In 1898, his Hungarian admirers named in his honour one of the first hikers' shelters constructed by the Tourist Association, which can still be seen today in Dobogókő, on one of the peaks in the Pilis-Visegrád Hills close to Budapest.

The Cadin Group and the Eötvös Peak (2,837 m) – photograph by Roland Eötvös

The conscientious, prudent scientist characteristically organised his climbing expeditions with great foresight, never acting in haste, and no serious accident ever took place during his ascents. Of course, as was usual at the time, Eötvös and his companions climbed with a guide, just like the British climber Whymper of "Matterhorn Catastrophe" fame, and just as Tyndall, the famous physicist and conqueror of the Weisshorn, generally did on his most important expeditions. During that period, perhaps the only exceptions were the Hungarian-born Zsigmondy brothers, Emil and Ottó, or the Hungarian Mór Déchy, who undertook expeditions in the Caucasus. The "ungarischer Baron", as Eötvös was known by the locals, was the first to reach the Zwölferkofel peak (in Italian the Cima Dodici, or Croda dei Toni) (3,091 m), primarily with Michael Innerkofler, the famous mountain guide known later as the "Dolomiten König" (King of the Dolomites), on 21 July 1877, followed by the Sextener Rotwand (Croda Rossa di Sesto) (2,788 m) on 20 July 1878. On 25 July 1879, a group of three climbers were the first to conquer the Elferkofel (Cima Undici) (3,115 m): along with Eötvös were Michael Innerkofler and Franz Happacher, a village notary from Sexten and a good climber, who belonged among the group of Eötvös's closest friends from Schluderbach, and



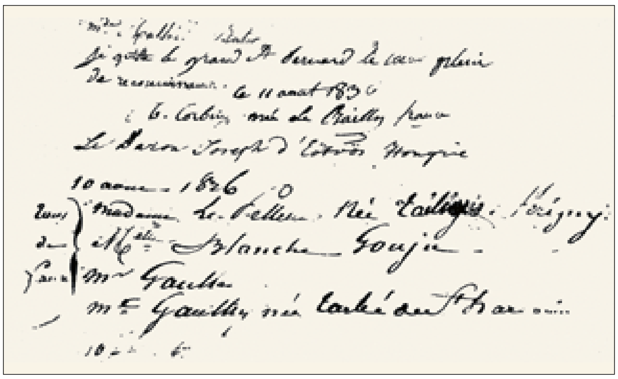
Tofana di Rozes (3,225 m) near Cortina d'Ampezzo – photograph by Roland Eötvös

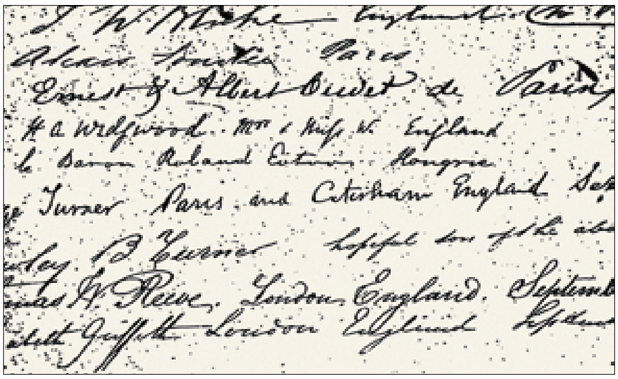
who, having paid the rather high guide's fee, had invited him to take part in the successful expedition. On another occasion, they successfully climbed the Südlicher Bullkopf (Cima Bull) (2,854 m), and on 26 July 1879 they conquered the Einserspitze (Einserkofel, Cima Una) (2,699 m). 1884. On 19 July 1884, they were the first to climb the 2,717 m isolated rocky peak of the Croda da Lago. He was also the first to climb the Schwalbenkofel (Croda dei Rondoi) and the Cresta Bianca. "The Croda has fallen", acknowledged one old mountain guide, on seeing him return with Innerkofler. Hungarian-born Emil Zsigmondy confirmed that Eötvös had been the first to reach the peak, which he himself climbed 11 days later with Ludwig Purtscheller.

The famous path leading to the Croda da Lago, which he was the first to discover in his conquest of the peak, now bears his name: Via Eötvös. However, the more famous route on the sheer southern face of the Tofana di Rozes, which also bears his name, honours the illustrious bravery of his mountain-climbing daughters: Ilona and Rolanda Eötvös were the first to reach the peak on 8 August 1901 with local guides Antonio Dimai, Agostino Verzi and Giovanni Siorpaes.

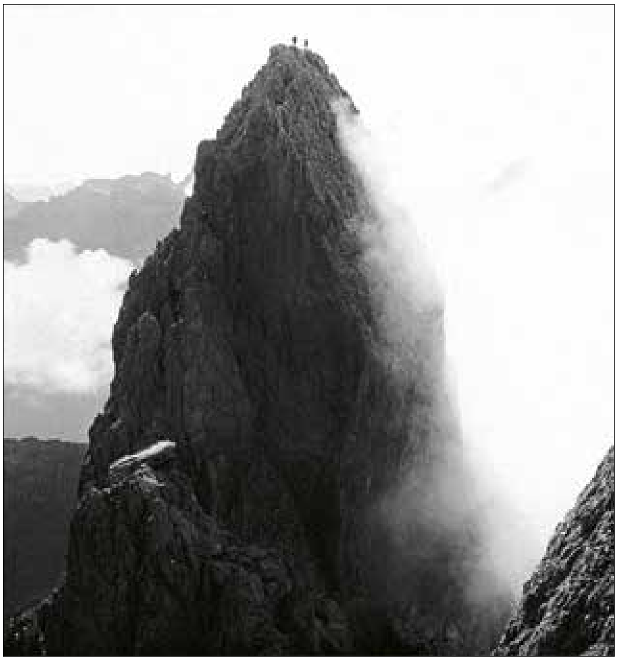
With his slightly reticent nature and the kind of prudence typical of an observer of nature, it was characteristic of Eötvös that he undertook expeditions only with guides with whom he was entirely familiar, and that the relationships he established with these unsophisticated, uneducated people evolved into what were effectively lifelong friendships. On returning from one of their rather risky joint expeditions, Eötvös wrote in the diary of climbing guide Agostino Verzi "To all the commendations that Agostino received from those who entrusted themselves to him, I would only like to add that I am 52 years old and weigh 90 kilograms. Agostino is thus deserving of praise as the guide not only of lightweights and ladies, but of heavyweights, too. 17 July 1900."

The first serious expedition that Roland Eötvös undertook with what can be regarded as a scientific purpose was in 1864, at the age of 16, in the company of his tutor, József Sándor Krenner, who was later to become a renowned mineralogist. They travelled to the valley of Stracena in northern Hungary, where they visited the famous ice caverns. Two years later, influenced by his childhood in Austria, he was already planning more ambitious trips. On 1 August 1866, at barely 18 years old, Eötvös left Hungary alone for the first time to undertake a longer journey to Switzerland, to the genuinely high mountains. The expedition may have been by way of a birthday gift. He returned from the long, two-month tour on 1 October. He reached Switzerland having crossed through Austria and a significant part of the Alps, including the region around Mont Blanc that stretched into France, and some of the stunning landscapes of Northern Italy. Having crossed Lake Como and reached Bellaggio, he visited Milan, where, from the roof of the cathedral, he was able to see one of the principal destinations on his tour, the second highest peak in the Alps, and, due to its central location, the first summit visible from where he was standing – Monte Rosa. On 12 September 1866, following the standard route known since 1855, Roland Eötvös reached the second highest point in the Alps, the Dufour peak (4,633 m). Later, in 1871, Mór Déchy would be the first to reach the summit following a second, southern route.





Entries by József Eötvös and Roland Eötvös in the visitors' book of the Great St. Bernard Hospice



The first ascent to the Cadin Peak – photograph by Roland Eötvös

After climbing Monte Rosa in 1866, he was forced to leave behind his friend, Sándor Kmoskó, who was so frozen after his long walk through the snow, especially after the strong winds had ripped off his hat, that he was temporarily unable to continue. On 17 September, at 9 o'clock in the morning, Roland continued alone on horseback on the planned route towards the Hospice Saint-Bernard, with only his exuberant French guide, Daniel, when he was suddenly struck by a wave of private anguish that even the guide's cheerful singing could do nothing to alleviate. They were also caught in heavy rain, thus from Orsieres, after a brief rest, they continued to St-Pierre by carriage, but were forced by the fog and darkness to remain in Cantine de Proz. During the night, a young American traveller emerged from the storm on muleback, who, after a brief conversation conducted in a mixture of English and French, turned out to be James Neilson, with whom he continued his expedition. In the snowstorm, using big blue umbrellas, they took it in turns to sit on the mule, while the other clung onto its tail. It was in such conditions that they managed to reach the Great St Bernard Hospice. Imagine their relief, first to be welcomed by the famous dogs from the abbey, then to sit by the warm fire in the refectory, eat a hot meal and retire to bed. Based on his diary and on the letters that he wrote to his father, József Eötvös, it is easy to imagine Roland the following morning, leafing through the pages of the old visitors' books and coming across his father's name and the date 9 August 1836, then, as he sat by the comforting fire, moved by the sound of the organ playing in the neighbouring church, it is easy to think of him imaging his father as a young man writing his name in the book, looking at it in fresh ink, now yellowed with age, and finally picturing himself with grey hair: facing the fact that he had been unable to achieve anything of all he had wanted to do. It was his newly acquired American friend who drew him back to reality from this melancholy dream, this Faustian vision of the future. The two Eötvös signatures can still be seen to this day in the monastery's old guest book.

Roland's next expedition was to the Tyrol, between 5 August and 2 September 1869, a trip that he undertook with Béla Inkey, who would later become a renowned geologist. The Swiss expedition, which he had planned in the course of several letters sent from Königsberg, eventually led him here. His recollections of his mountaineering expeditions were recorded in writing, and in appealing sketches, in a concisely and rather epigrammatically written black diary. These laconic records are supplemented with the few, fascinating letters that he wrote to members of his family. During the tour he climbed a number of peaks, including Grossglockner (3,798 m) on 18, and Grossvenediger (3,657 m) on 25 August. Later, including the summer of 1895, in the company of his two daughters, he sought out these places once again, now recording these exalted moments with the help of a camera rather than sketches.

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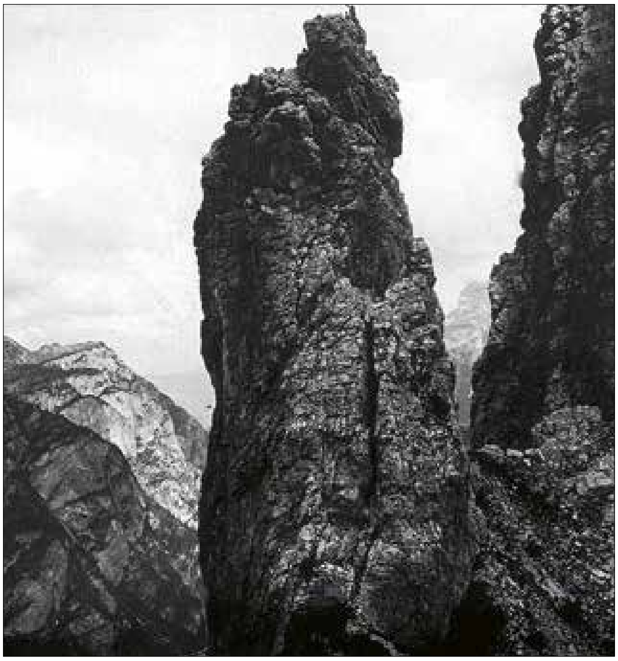
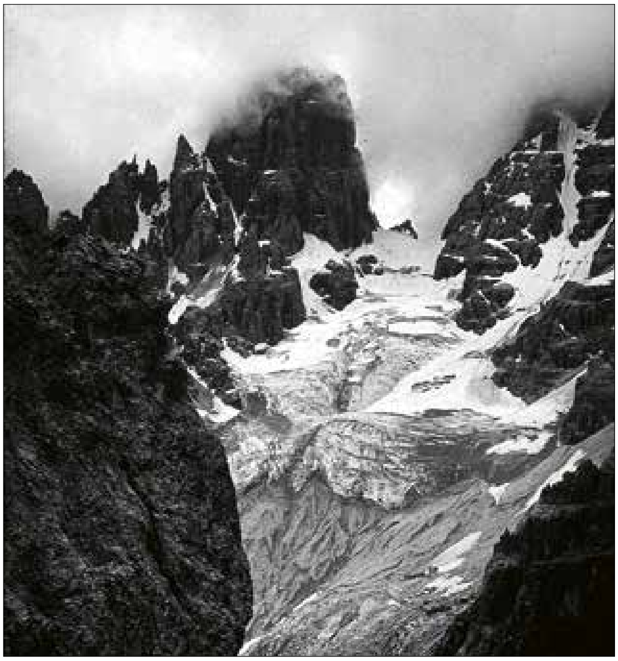


The first ascent of the Torre Giovanni – photograph by Roland Eötvös



Monte Cristallo and Piz Popena

Roland Eötvös remained a devotee of the mountains. For forty years, right up until 1914, he spent nearly every summer perched among the towering peaks in the peaceful valley resort of Schluderbach, northeast of Cortina d'Ampezzo,

He stayed active for the rest of the year, too. He was an accomplished horse rider and rode regularly throughout his life, later on in the company of his daughters, at the National Riding Hall. He loved longer cross-country hacks, and just three years before his death he took part in the pack hunt in Gyál, riding all the way from the Riding Hall and back again. He met his wife, Gizella Horváth, at the ice skating rink in the Városliget (City Park) in Budapest. József Eötvös also contributed to the popularisation of sport in Hungary, when he agreed that his daughters could join the newly founded skating club. In the huge garden of their villa in Pestszentlőrinc, Roland would often play cricket with his daughters, Ilona and Rolanda, and later on enjoyed long bicycle rides with his friends and young university colleagues. On one occasion, he cycled all the way to the Dolomites with his daughters, before the three continued together their amazing climbing tours.

* * *

Eötvös was a member of the *Club Alpino Italiano* and the *Deutscher Österreicher Alpenverein*, but did not play an active role in them. These organisations rather perplexed someone who preferred solitude or sought the company of true friends and active leisure. From his accounts, we know that he never made plans for an expedition. He was always inspired to set off on an expedition by some sudden internal resolve. Before his mountaineering expeditions, he and his guides would always meet at the small chapel in Schluderbach before setting off to the Rosengarten, Pala, or Brenta-Langkofel ranges.

Later, in his old age, he made the following confession to one of his enthusiastic young mountaineering disciples: "I may be an old man, but even now I adore the mountains, just as I did when I was young, when, in the face of all opposition, I sought and discovered moments of exaltation, delight and relaxation high up among the peaks."

Even when serious mountaineering became too demanding for him, he did not give up hiking, and while his daughters made their way up the difficult southern face of the Marmolada and Monte Antelao, he took the easier route on the far side, content to observe his daughters' skill. In reality, at the time he was far from being genuinely "elderly", he merely held back from the steep slopes that would put a strain on his knees and tendons, leaving to others the joy of discovery that demanded such special skill and stamina. Thus, by around 1902 or 1903, his days of being the first to climb the great peaks had come to an end.

But the mountaineer, banished from his beloved Earthly paradise by the outbreak of the world war in 1914, did not remain idle: In 1915–16, he travelled to the grey granite mass of the High Tatras, to a farm in Tarpatakfüred, and at the age of 68, alongside his daughters, he climbed the Jégvölgyi Peak, the Gerlach and the Tatra Peaks, and the so-called Swallow's Tower, reaching the Lomnica Peak along the Jordán route, which he enjoyed so much that from then on he referred to it as the Monte Cristallo of the Tatras.

* * *

Partly at the request of his friends and colleagues, Baron Roland Eötvös, the first to conquer many previously unclimbed peaks and a keen amateur photographer, agreed to give illustrated presentations and put together exhibitions in order to share his adventures with his fellow Hungarians.

Almost all the extant photographs are stereoscopic images: slides and a few negatives. The vast majority are of places he visited on his expeditions and record his mountaineering adventures.

From 1888, as president of the Budapest branch of the Hungarian Carpathian Association, then from 1891 as the first director of the Hungarian Tourist Association, he lent his support to hiking and to amateur photographers in addition to his own recordings. As president of the Hungarian Academy of Sciences, Eötvös also played a role in the establishment of the Uránia Hungarian Scientific Theatre, which made a huge contribution to the development of Hungarian photography, and later film. The recollections of Dezső Pekár both complement and support what has already been said.

"Eötvös was an excellent photographer. He was recording fantastic stereoscopic images even in the last decade of the 19^{th} century, particularly in the Dolomites, in the Southern Tyrol. Year after year he would spend his summer holiday in Schluderbach, where he would go for long walks with his two daughters in the nearby mountains. It was during these expeditions that he captured the picturesque details of the Dolomites, and on more than one occasion hair-raising mountaineering scenes, typically with a stand-mounted camera, with a relatively small aperture and rather long exposure. This is why his images are so amazingly sharp that, during one presentation, the slides could be projected to a size of 5 by 5 metres. As my professor, he also got me interested in photography. I developed his images and prepared the copies almost exclusively in the form of slides."

"Later, using an excellent Zeiss lens, but with an otherwise hasty laboratory set-up, we managed to produce over a hundred 40×50 cm enlargements on paper. The enlargements won awards at exhibitions of photography, and many of them still adorn the walls of the old Ploner Hotel in Schluderbach."

* * *

Although Eötvös was deterred from more serious mountaineering by his sorrow at the tragic death of his friend and mountain guide Michael Innerkofler (1844–1888) in an accident on Monte Cristallo, the period until 1892 was not spent in idleness: he climbed mountains in Bosnia and Herzegovina, in the Penj range, and undertook practice climbs on the rocky Kétágú Hill in the Pilis with his daughters, all the while playing an active role in the popularisation and renewal of hiking in Hungary. On 28 December 1888, in the Kisfaludy Hall of the

Hungarian Academy of Sciences, at a session of representatives of the association, which until then had had its seat in Igló (now Spišská Nová Ves in Slovakia), the Budapest branch of the Hungarian Carpathian Association was established. The branch elected Count Albin Csáky, minister of religion and education, as its permanent honorary president, with the university professor and MP Baron Roland Eötvös as president. University professor Lajos Lóczy was made first vice president, the second (managing) vice president was Ödön Téry, and Gusztáv Thirring was appointed secretary.

In 1891, due to a disagreement with the leadership of the Hungarian Carpathian Association, an extraordinary session was held at 5.30 pm on 29 September in the Institute of Physics of the Royal Hungarian University, at which the decision was made to break away definitively and establish a new association. Thus the Hungarian Tourist Association was founded in 1891: Baron Roland Eötvös was made president by acclamation, while Count Géza Teleki was elected vice president. Ödön Téry remained second (managing) vice president, while Gusztáv Thirring continued as secretary.

In terms of organisational structure, the association modelled itself on the prestigious Deutscher und Österreichischer Alpenverein (DÖAV). This meant that the association handed over practical affairs entirely to the branch, while the task of the central association was to provide intellectual leadership and guidance. The central board comprised only a very few members, thus it was not an independent organisation or umbrella association with a separate membership.

The Budapest branch was established on 21 November.

One of the most noteworthy activities carried out by the Hungarian Tourist Association was the inauguration of the Baron Roland Eötvös Shelter, which had been planned since 1888. The wooden structure, which is still standing today, was inaugurated on 5 June 1898, a full ten years after the idea had first been conceived. (In 1983, a team of young and enthusiastic hikers, led by János

The Dobšinská Ice Cave – photographs by Roland Eötvös

Mészáros, saved the building from rotting away entirely.)

In the same year, on 5 November 1898, with the cooperation of physicist Jenő Klupathy and as a result of his hard work, the Budapest University Athletics Club (BEAC) was established, of which, as mentioned above, Roland Eötvös was made president, at Klupathy's request, a post that he held up until 1902.

One of Eötvös's faithful companions during the research he carried out on the frozen Lake Balaton was the geographer Jenő Cholnoky, who later succeeded him as president of the Hungarian Tourist Association. At one of the first presentations organised by the Uránia Hungarian Scientific Theatre, partly with the support of Eötvös in the role of president of the Academy, he presented the pictures taken by Eötvös of the Dobšinská Ice Cave and surrounding area, where he had already undertaken a "geological" expedition back in 1864; he had even sketched the Stracena Rock Gate in his green linen-covered travel journal. The cave was only discovered in 1870. Nor should we forget that it was the young Roland Eötvös who wrote the first scientific description of an ice cave in 1869, the famous Scărișoara Ice Cavern in Bihar (Romanian Bihor) County, which was based on an expedition undertaken in 1868, likewise with Krenner.

Roland Eötvös was proud of his achievements as a mountaineer, but he did not boast about them. Instead, they were described in the specialist literature by contemporary foreign mountaineers, and partly by Marcell Jankovics and Imre Barcza, who followed in his footsteps; by Sinigaglia and Witzenmann, whom we have already mentioned above; as well as by Gustav Euringer, Gustav Gröger and Josef Rabl, in addition to Ottone Degregorio, along with Dezső Pekár and Jenő Cholnoky, who were disciples of his scientific work, even though the latter two did not participate in his expeditions to the Dolomites. He mentioned the Dolomites and the region around Schluderbach exclusively in connection with the geophysical measurements that he performed in order to validate his theories on the Chimabanche plateau, the high ground stretching between Monte Cristallo and the Cadin range, while at the same time the majority of the almost two thousand extant photographs bear witness to his "love of the mountains". It was only in his capacity as president of the Tourist Association that he modestly spoke of the fundamentals of hiking, and his words are a powerful illustration of his humanistic approach, the thoughts of the last great figure in the field of classical physics, the lover of nature Roland Eötvös:

Opening speech by the president at the session of the Budapest branch of the Hungarian Tourist Association, held on 25 January 1890

"Let us then press on boldly toward our goal! That goal is to popularise hiking in Hungary, and since we know that a good hiker is, at the very least, a healthy and strong individual, let us do everything in our power to encourage as many good hikers as possible in our country!"

Opening speech by the president at the session of the Budapest branch of the Hungarian Tourist Association, held on 14 February 1891

"A hiker is someone who sets off on the path because, amidst the tedium of their occupation and the multitude of their troubles, they dream of a better world in which the grass is greener, the sky is bluer, the mountains are higher, the buildings are more beautiful and more distinctive, and the people more friendly; and who, undeterred by the effort involved, searches and searches for the origin of their dream – and, because we are living on this Earth, perhaps they will never find it, yet they do not despair, since even the quest brings happiness.

Some claim that we are living in a materialistic age, and yet never have there been so many hikers in search of beauty for its own sake as there are in our day, and their numbers are continuing to grow alongside the spread of education.

It is a dream that quickens the hearts of all, demands no justification, and exists in its own right, and, where so many people are in agreement, the existence of this association is vital in order to achieve the common goal."

LÁSZLÓ DÁVID TÖRŐ

The commemoration of Roland Eötvös

Roland Eötvös is commemorated in remarkably diverse ways. The physicist has been recalled by politicians, scientists and journalists at different times, but he is also commemorated in the names of scientific and educational institutions, streets, exhibitions, academic competitions and awards. He even has a mountain peak and a crater on the Moon named after him. Since the scientist is commemorated in such extremely diverse ways, the topic may provide an opportunity for further research into the history of memory. What follows will not therefore be about Eötvös as an individual, but about the way in which he is valued by posterity (including his disciples). These evaluations reflect the political, cultural and broader power relations of their day, and reveal at least as much, if not more, about remembrance than about Roland Eötvös himself.

Although later studies (especially those written by scholars) suggest that Eötvös was not expressly a politician, it is remarkable how ingenious they have been in making use of his memory to wage wars of remembrance associated with political battles, and to justify the most disparate regimes.

The scientist was buried during the period of the Hungarian Soviet Republic on 11 April 1919, and, as in the Dualist era, the funeral service began at the National Museum. Even at the funeral, there were already two commemorative traditions in existence, although of course they were not represented equally, as a result of the balance of power. Speeches were given at the funeral by the commissar for public education György Lukács, and by Izidor Fröhlich on behalf of the Mathematical and Physical Society. It is worth noting that not everyone was entitled to express their official remembrance: Albert Berzeviczy, a representative of the Hungarian Academy of Sciences, was not permitted to speak at the event. György Lukács declared that Eötvös, whom he characterised as primarily a scientist, was not the son of the "nation", but of the "society of workers", thereby abandoning the national rhetoric of the Dualist system while retaining the cult of "great men". In his view, the victory of the proletarian revolution also led to the triumph of science, thus it was symbolic that the first of the dead under the system was the "greatest Hungarian scientist". Compared to Lukács, Fröhlich's speech was rather restrained and is to be considered in the spirit of national rhetoric. After enumerating the merits of the Hungarian scientist, Fröhlich consigned his "mortal remains" not to the workers' society, but to the "fatherland" for eternal rest. The significance of the event for contemporaries is illustrated by the fact that a 46-second filmed report was recorded, which gives an idea of the size of the crowd that attended the funeral.

After the fall of the Hungarian Soviet Republic, attempts to actualise the memory of the scientist continued, of course along the lines of different ideologies. In 1923, a portrait of Eötvös by Oszkár Glatz was unveiled at the Pázmány Péter University in Budapest, and several contemporary newspapers (*Az Est*, *8 Órai Újság*, *Budapesti Hírlap*) reported the ceremony. The high level of interest was no accident, since the minister of culture Kuno Klebelsberg delivered a speech in front of the painting. Klebelsberg compared the relationship between the nation and Eötvös to that of a family mourning the loss of a loved one. Using the metaphor of the family, he portrayed the bond that existed between the scholar and his country as natural, enhancing the strength of the relationship through this rhetorical device. From a historical perspective, the minister of religion and education praised the union of the "politician organiser" and the researcher in the person of Roland Eötvös, thereby sending a clear message to his contemporaries: as president of the Hungarian Historical Society, he regarded his own role as similar, since his responsibilities included the organisation of historical research as well as political duties. As minister of religion and education, he believed in the German approach to historiography, thus he judged Eötvös's work according to the traditional Prussian higher education system. In presenting Eötvös's career as a physicist, he held out to his audience the example of German research universities and contemporary Hungarian scientists, using the commemoration to demonstrate the compatibility between the roles of politician and scientist.

Between the two world wars, Albert Berzeviczy, president of the Hungarian Academy of Sciences, the physicist Izidor Fröhlich, the geophysicist Dezső Pekár, and the geographer Jenő Cholnoky, all of whom were friends or disciples of Eötvös, made great efforts to keep his memory alive. In particular, Pekár, who was working on the further development of the Eötvös balance and who had been a corresponding member of the Academy since 1922, regarded Eötvös's legacy as a serious responsibility: when he reported on the ten years of work by the Baron Eötvös Loránd Geophysical Institute at the Academy, he remarked that his election as a corresponding member was owing rather to Eötvös's name than his own merits, adding that he would do all he could to live up to this honour in the future. It was felt as a particular loss by the new regime that Eötvös was buried by its ideological adversaries, thus references to the act of burial were accompanied by the gloomiest of political commentary. On 15 April 1920, Pekár delivered a speech at the commemoration of the Mathematical and Physical Society. He associated

Eötvös's funeral procession departing from the National Museum
The funeral, organised by a ruling power that in principle held all pomp in contempt, in many respects relied on the cult-oriented approach of the earlier system.

the funeral ceremony that had taken place the previous year primarily with the destruction of the nation, condemning the "wicked traitors" and "internationalist adventurers", for whom, according to him, "this land" could never be home. It follows from his reasoning that the Hungarian Soviet Republic had no right to consider the late Eötvös as one of its own.

An emphasis on the national perspective also characterised the three major studies in the Baron Roland Eötvös Memorial Book, edited by Fröhlich and published in 1930. Albert Berzeviczy's "The Two Eötvöses" (originally delivered at the Academy's General Assembly in May 1929) described the relationship between József Eötvös and his son on the basis of their correspondence. Despite the father–son conflict, he compared the two individuals to two equally brilliant stars shining in the heavens of "Great Hungary", as well as in their truncated homeland. He also called for Roland Eötvös's legacy to be edited and professionally published as soon as possible. The study by Izidor Fröhlich was the longest work in the volume, and drew on the most sources: it provided a detailed insight into the everyday life of Roland Eötvös, focusing primarily on the human side of the scientist. At the end of his text, Fröhlich also considered it important to make a reference to the funeral, mentioning that the "constitutionless" government at the time had been reluctant to allow him to deliver a speech in memory of Eötvös. Dezső Pekár's article drew heavily on his 1920 speech, although he added political details (a brief depiction of the grim situation due to the "treacherous reds" and "atheist environment"), calling for greater support for the Geophysical Institute. He expressed particular sadness at the fact that Eötvös's grave was in an extremely "neglected" condition.

Pekár's complaint found an audience a few years later. Sponsored by the Eötvös József Collegium, a memorial to Eötvös by the sculptor Ede Kallós (based on the portrait by Alajos Stróbl) was inaugurated on 30 October 1932. Albert Berzeviczy gave a speech at the graveside next to the newly erected bust, a written version of which was published by the journal *Budapesti Szemle*. Berzeviczy spoke more briefly on this occasion than during the commemoration at the Academy, and, perhaps in keeping with the spirit of the place, was rather gloomier. As well as listing the scholar's merits, he noted bitterly that he had not in the end been awarded the Nobel Prize, because the Swedish Academy had "ignored" Hungary.

In 1944, many people marked the 25th anniversary of the scientist's death. Dezső Pekár proudly explained in the *Budapesti Szemle* that Eötvös had elevated Hungarian culture to European standards, and that his measuring instruments have gained economic significance worldwide: More than 100 of his torsion balances, labelled "Original Eötvös Made in Hungary", were being used by oil companies around the world. Jenő Cholnoky, as president of the Hungarian Tourist Association, introduced Eötvös the mountaineer in the speech he compiled for the General Assembly of the association. As he was unable to attend the General Assembly, his text was read out by executive vice-president Jenő Halasi. Cholnoky recalled his research and exchanges of ideas with Eötvös on the ice of Lake Balaton. He described the renowned physicist as a "fine diplomat" and a "reserved aristocrat". It is hard to judge the significance of his decision to include in his evaluation the fact that, during their research at Lake Balaton, Eötvös slept in a guesthouse in Siófok while Cholnoky opted for a tent, but overall he painted a very positive picture of the scientist. He contrasted the figure of Eötvös with Mihály Károlyi, who, in his opinion, despite his fame and fortune, had brought only harm to his country; unlike him, the aristocratic Eötvös used his personal wealth and influence for the benefit of the nation and was therefore noble in spirit as well. This political comment brought to a conclusion the first quarter of a century of evaluations of Eötvös.

The transitional period of the interwar regime and the communist dictatorship is clearly depicted in the article by physicist Pál Selényi in the journal *Elektrotechnika* published in October 1948. After Eötvös's death, Selényi briefly lectured on experimental physics during the Hungarian Soviet Republic, as a result of which, after the collapse of the regime, he was banned from the Mathematical and Physical Society and from any practical role in official commemorations. After the Second World War, his health deteriorated (he had been assigned to a labour service battalion during the war), although he was able to teach at the university again. His commemoration of Eötvös, written on the centenary of his birth in 1948, contains perhaps only one reference to current public life – namely the centenary of the Hungarian Revolution and the War of Independence. He described his fellow physicist as being an analytical scientist with a characteristically precise and unbiased view of phenomena, and as being morally and humanly blameless. Finally, he praised Eötvös's poetic leanings, and published his own poems in which he praised the scholar.

A few years later, the restrained, more neutral assessments such as that written by Selényi, were replaced with militant commemorations infused with ideology. As part of the break from the "feudal", "clerical" past, the Pázmány Péter University

Limestone bust of Roland Eötvös, inaugurated by Albert Berzeviczy by the grave of the scientist. It can be seen today in plot 10/1 of the Fiume Road Cemetery.

of Budapest was renamed after Roland (Loránd) Eötvös in the 1950/1951 academic year. The decree, signed by Károly Kiss (deputy chair of the Presidential Council) and Piroska Szabó (secretary of the Presidential Council), was published on 17 September 1950. Contemporaries interpreted the renaming in an ideological framework. Prior to the publication of the decree, the daily *Viharsarok* had reported on the opening of the University of Szeged on 16 September 1950, when the change of name was discussed in great detail. The paper quoted a speech by member of Parliament László Orbán: "Changing the name symbolises the expulsion of the spirit of Péter Pázmány, the spirit of feudalism and capitalism, the spirit of clerical reaction, of mysticism, and of its remnants from among the walls of this university, allowing it to be fully occupied by the spirit of Lóránd *[sic!]* Eötvös, the spirit of science, the spirit of a scientific worldview, just as the working people, the interests of our country, and the building of socialism demand."

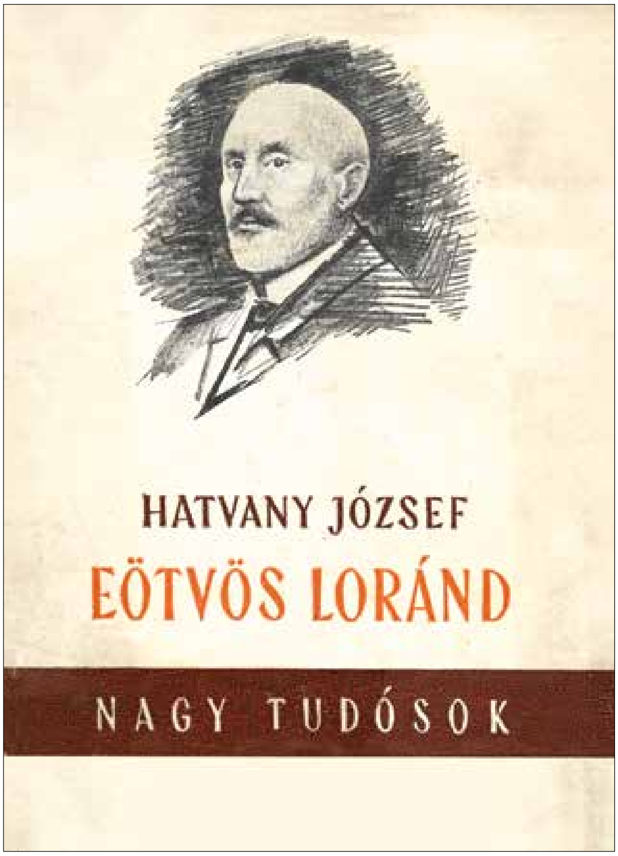
The consolidated regime thus began the ideological reinterpretation of the physicist's life. One of the most thoroughgoing Marxist interpretations of Eötvös was published by the physicist József Hatvany in 1951. The book was intended to strengthen the unity of the so-called Peace Camp (the Eastern bloc) by commemorating great scholars of the past, while at the same time eliminating earlier evaluations of Eötvös (characterised by the dirty word "bourgeois"). Hatvany believed that earlier authors had idealised the renowned scholar and neglected his efforts in the class struggle. The author attempted to make up for this "deficiency" by concentrating on Eötvös's political and public manifestations, trying to draw a contrast as far as possible in his biography between him and the politics and institutions of the Dualist system of his day. While a few decades earlier Albert Berzeviczy had emphasised the indissoluble "marriage" between the Academy and the Eötvös family, Hatvany interpreted the relationship between Eötvös and the Academy as one of social and institutional conflict: according to him, Eötvös had not been unanimously elected as president of the Academy in 1889, because "the most reactionary members would have preferred to see a useless representative of the landowning aristocracy occupying the presidential seat" in the person of Antal Zichy. In his book, Hatvany repeatedly emphasises that Eötvös was not a "reactionary" aristocrat, but that he practically denied his own class by fighting against religious dogma, based on a materialistic worldview. In his summary, Hatvany returned to the alpha and omega of the Eötvös commemorations – his funeral: according to him, the Hungarian Soviet Republic and the working class rightly considered him as one of their own, and it was posterity that had distorted his legacy.

Apparently, it was not only Eötvös's person but also his measuring instruments that became part of the memorial battle, in which the stakes of interpretation were high. As we saw earlier, Dezső Pekár was delighted to inform his readers about the worldwide success of "Original Eötvös" devices in oil prospecting. For Hatvany, however, this was seen as servility to Western imperialism. By passing this judgement, he simultaneously attacked the Horthy system and the contemporary West: "Bearing the name of [Eötvös], the Geophysical Institute became an oil prospecting agency, which, in the absence of government support, was in the service of the infamous Anglo-Iranian Oil Company. […] Hungarian people were made to map the geophysical conditions in the malaria swamps of Burma in order to expose the country to even more terrible exploitation – now they no longer had need of the dezsőpekárs, who in any case did not further develop Eötvös's legacy, but wanted to live off the fruits of his work."

József Hatvany's book received mixed reviews among his contemporaries – alongside the praise, some critical opinions were voiced. Mrs. Ernő Lukács reviewed the work in *Népszava* on 28 August 1951. According to her, there was a huge need for such educational publications, since the working people were scarcely aware of the name of Eötvös, whose materialist legacy could only be fulfilled by the socialist system. In conclusion, she claimed that Hatvany's work on Roland Eötvös filled a gap and was essential for an understanding of "national values"(!).

That same year, the theoretical physicist Géza Szamosi attacked several aspects of Hatvany's interpretation in an article in the journal *Társadalmi Szemle*; although he agreed that the book provided the workers with an appropriate introduction to the progressive scientist, he regarded some of its conclusions as exaggerated and thus "in need of correction". According to him, besides Eötvös also Ányos Jedlik, for example, was a "progressive" scholar during the Dualist era, and had undeservedly been neglected by biographers. The perception of Eötvös as a militant materialist who was unconsciously engaged in the class struggle was unacceptable to Szamosi (who rather saw Eötvös as an idealist, who was a materialist in the field of science alone), something that demonstrates the ambivalent relationship between the ruling power and the physicist of the Dualist age. According to Szamosi, "Our respect for Eötvös lies not in the fact that he stands politically close to us – which is not true – but because he was a progressive in his own day, loved his country, and enriched our science with brilliant results – which is true." It is worth adding briefly to the debate that, although it basically took place among physicists, its forums (political daily newspapers and journals) indicate that it was a conflict of remembrance that had an impact on cultural political and public life.

Eötvös continued to be the subject of commemoration by Hungarian physicists. Published on 8 April 1954, the article by Kossuth Prize–winning physicist János Renner in *Népszava* is proof that Hatvany's rhetoric did not fully permeate the discourse on Eötvös in Hungary. Renner expressly praised the utilisation of Eötvös's measuring instruments for oil prospecting and the operations of the Geophysical Institute between the two world wars (although, according to him, it had only a modest influence compared to the socialist era) – but the only author he quoted at length was the Marxist philosopher György Lukács.



Published in 1951, József Hatvany hoped that his book would become the quintessential Marxist interpretation of Eötvös, but he was not entirely successful in this respect: the publication met with a mixed response.

In 1963, the Eötvös Loránd University dedicated a memorial session to its namesake, at which, among others, Károly Novobátzky, a member of the Hungarian Academy of Sciences, praised the renowned scientist. His speech was published by the journal *Fizikai Szemle* of the Eötvös Loránd Physical Society a year later. Novobátzky characterised Eötvös's scientific career as unequivocally "progressive", describing Eötvös as someone who had discarded his "ceremonial aristocratic attire" and donned a "laboratory coat" instead, performing serious scientific work that was both analytical and speculative, instead of dealing in "patriotic catchphrases". He spoke appreciatively of the Eötvös József Collegium, but again highlighted the ideological

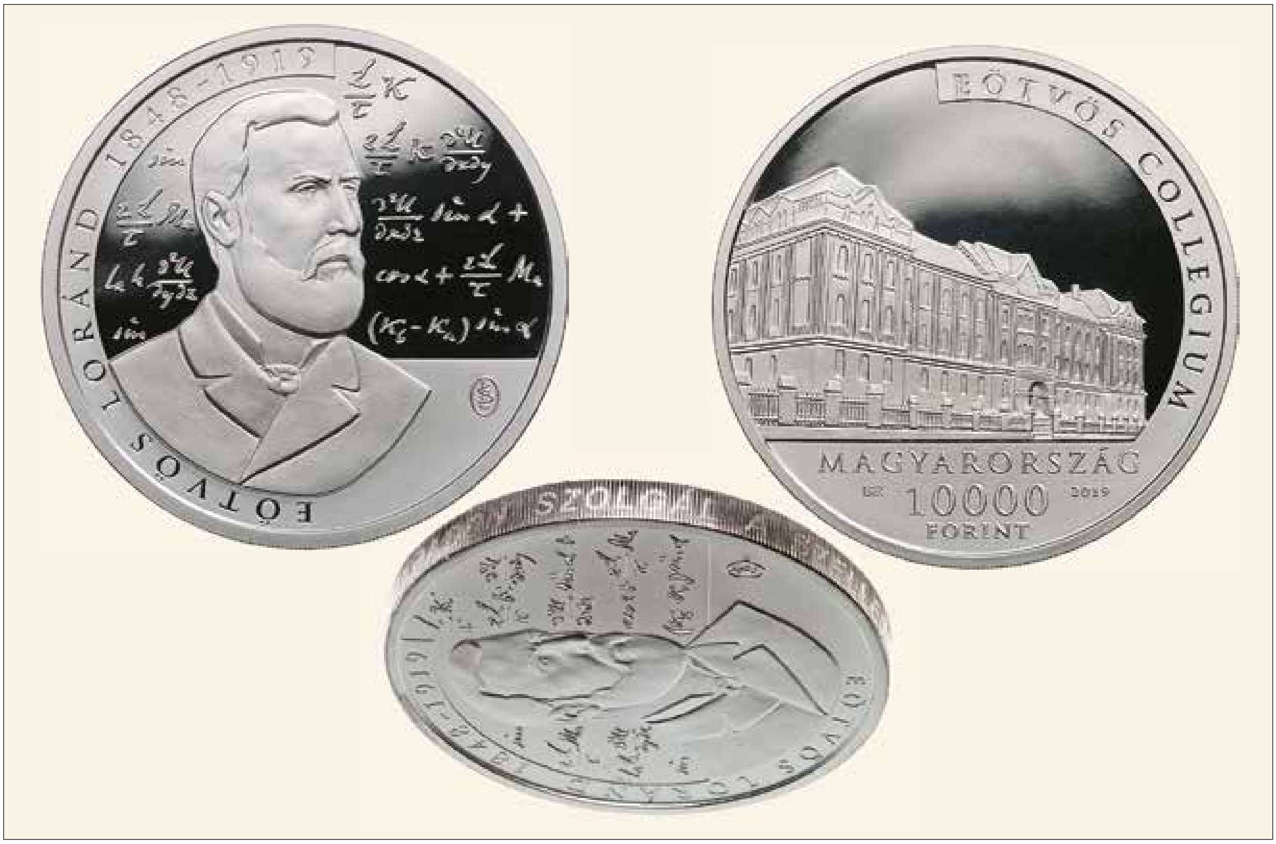
Vice-rector Miklós Világhy opens the Eötvös session at the Eötvös Loránd University in 1963. Pictured from left to right: deputy dean József Molnár, physicist Károly Novobátzky, physicist Lajos Jánossy, geophysicist László Egyed.

distance between the remembering individual and the subject of his remembrance. According to Novobátzky, a new Collegium-type institution would be of use only if it provided political-ideological training, rather than merely scientific teaching. Despite these minor amendments, he nevertheless considered the personality and the scholarly and public work of Roland Eötvös to meet all the required standards.

In addition to texts that contained political overtones, the memory of Roland Eötvös is preserved in countless tributes and awards, as well as in the names of institutions – since the change of political regime in 1990, his work has attracted unanimous respect and he is remembered today primarily as a scientist (rather than a politician). The Eötvös Loránd Memorial Exhibition, which has been organised on a regular basis since October 1970 in various venues, was hosted by the Tihany Observatory of the Eötvös Loránd Geophysical Institute between 1992 and 1998, and in the capital city since the autumn of 1998. The main objects in the exhibition are Eötvös's sports-related belongings, his field instruments, as well as contemporary photographs showing his research, which help place the instruments in their historical context.

Founded in 1949 (as one of the successors of the Mathematical and Physical Society), the Eötvös Loránd Physical Society recognises outstanding achievements in Hungarian physics research, with the awarding of the Eötvös medal since 1969. The first winner of the prize was János Renner. Furthermore, the institute regularly organises physics competitions for high school students, and publishes reports of the events. As already mentioned several times above, the Eötvös Loránd Geophysical Institute likewise continued to operate, although the Hungarian Institute of Geology and Geophysics became its legal successor in 2012.

While not attempting to be comprehensive, the goal of the above overview was to present, by means of the (mainly textual) resources of collective memory, how evaluations of Eötvös have changed over time. These evaluations have not only changed according to the various political-historical periods, but, within a single period, several often contradictory narratives have existed side by side – even if the version supported by the current regime was inevitably dominant. Leaders of institutes that bear Eötvös's name have sought to legitimise their operations by reference to the physicist's legacy. However, such legitimising efforts were not inno-



Commemorative silver coin issued in 2019 to commemorate the centenary of Roland Eötvös's death – design by Borbála Szanyi

cent, resulting as they did in the undermining and stigmatisation of unwanted political rivals. The power relations of these conflicts of remembrance also determined who owned the rights to recollection, and decided in advance which narrative scheme would be successful in conveying its message about Eötvös to its target audience. Despite it being a question of the natural sciences, it was not only politicians but also physicists who found themselves confronting one another or the ruling political power according to their point of view. It is also worth noting that it was not only Eötvös's person or public persona that became the subject of judgments: even the "physical" objects connected to him (such as his measuring devices) prompted different modes of remembrance. This presentation of their diversity demonstrates both the complexity of the theme and the importance of memory studies.

Timeline

COMPILED BY SÁNDOR PERJÁMOSI

17th century nobleman Miklós Eötvös, the first known ancestor of the Eötvös de Vásárosnamény family, is mentioned among the Szatmár County landowners.

1768 Miklós Eötvös receives baronial title.

1763–1838 Ignác Eötvös I is master of the cupbearers.

1786–1851 Ignác Eötvös II serves as master of the treasury.

BARON JÓZSEF EÖTVÖS

3 September 1813 birth and baptism of József Eötvös.

1825 his father appoints József Pruzsinszky as his tutor.

1826–1831 studies philology then law at the University of Pest; forms a lifelong friendship with László Szalay.

summer 1831 as lord lieutenant *(főispán)* of Sáros County, Ignác Eötvös is entrusted with the task of putting down the cholera riots in Upper Hungary.

1832–1836 diet in Pozsony (Bratislava). József Eötvös participates as a representative of absent members of the Upper House. Becomes friends with Ferenc Kölcsey.

14 September 1835 elected a corresponding member of the Hungarian Academy of Sciences.

summer 1836 – autumn 1837 his grand tour in Western Europe: travels to England, France, the Netherlands, Germany and Switzerland, and perhaps Italy.

1837 moves to Sály, Borsod County. Participates in the Borsod County assemblies.

autumn 1837 beginning of a lifelong friendship with Ágoston Trefort.

1838–1841 publication of the *Budapesti Árvízkönyv* (Budapest Flood Book), featuring his first novel *A karthauzi* (The Carthusian).

23 November 1839 becomes a full member of the Hungarian Academy of Sciences; next day he delivers a commemorative speech for Kölcsey at the Academy session held in his honour.

1841 due to the financial crisis in the Eötvös family, he moves in with Ágoston Trefort in the Wodianer House.

13 September 1842 marries Ágnes Rosty.

1845 publication of his second novel *A falu jegyzője* (The Village Notary).

1847 publication of his third novel *Magyarország 1514-ben* (Hungary in 1514).

17 March 1847 Ágoston Trefort marries Ilona Rosty.

7 April 1848 in the first independent Hungarian government of Lajos Batthyány, Eötvös is given the portfolio of religion and public education.

27 July 1848 birth of Roland (Loránd) Eötvös.

1848 in *A magyar egyetem alapszabályai* (The fundamental rules of the Hungarian university), he outlines the establishment of separate training institutions for science and grammar school teachers.

autumn 1848 – end of 1850 voluntary exile of the Eötvös and the Trefort families.

November 1850 they return home from Germany.

May 1851 the family moves to the Eötvös villa on Svábhegy. From this time on, they spend the summers in this resort, and during winter they live in Pest in Sina House, 10 Erzsébet Square.

1851, 1854 part I and II of *A XIX. század uralkodó eszméinek befolyása az* álladalomra (The Influence of the Dominant Ideas of the 19th Century on the State) published in German and Hungarian.

1860–1866 president of the Kisfaludy Society

18 March 1866 elected president of the Hungarian Academy of Sciences.

17 February 1867 the monarch appoints the Royal Hungarian Ministry, led by Count Gyula Andrássy. József Eötvös becomes minister of religion and public education for the second time.

February 1868 the state-run weekly *Néptanítók Lapja* (Schoolteachers' Journal) is launched at his initiative in seven languages. Every teacher receives it for free.

June 1868 submits the public education bill.

1870 issues the organisational rules of the Royal Hungarian Secondary School Teacher Training College.

2 February 1871 József Eötvös dies in Pest.

BARON ROLAND EÖTVÖS

27 July 1848 birth of Roland Eötvös.

from the 1857/1858 academic year becomes a public student with the Piarists in Pest.

1864 "geological tour" in Upper Hungary with his then tutor József Sándor Krenner.

1865 graduates from secondary school.

1866 studies law at the Royal Hungarian University of Pest.

12 September 1866 scales the Dufour Peak, the highest peak in the Monte Rosa group.

17–18 September 1866 at the Hospice du Grand Saint-Bernard, he reads in the guestbook the entry written by his father on 9 August 1836.

1867–1870 studies natural sciences at the University of Heidelberg.

August 1869 travels to Tyrol: climbs the Grossglockner on 18 August and the Grossvenediger on 25 August.

1869 elected as a member of the Hungarian Society of Natural Sciences.

4 January 1870 elected as a member of the board of the Hungarian Society of Natural Sciences.

8 July 1870 earns his doctorate summa cum laude from the University of Heidelberg.

autumn 1870 participates in the activities of the Hungarian Society of Natural Sciences.

7 December 1870 his first presentation at the Hungarian Society of Natural Sciences on "The Doppler effect and its application in acoustics and optics".

January 1871 elected as a member of the editorial board of the *Természettudományi Közlöny* (Communications in Natural Sciences), in the thematic group "astronomy, physics and meteorology".

14 March 1871 becomes associate professor at the University of Pest.

1871 requested to give practical training in the natural sciences at the training institution for secondary school teachers.

1871 via an accelerated habilitation process, he obtains the right to lecture on theoretical physics at the university.

19 July 1871 gives his first lecture at the session of Department III of the Hungarian Academy of Sciences.

from 1872 member of the Upper House.

1872 appointed full professor.

1872 appointed head columnist of the natural science section of the Communications in Natural Sciences; participates in the dissemination of the society's publication series.

May 1873 elected as a corresponding member of the Hungarian Academy of Sciences.

1874 travels to France, visits the École Normale Supérieure in Paris.

from the 1874/1875 academic year member of the teachers examination committee.

1875 obtains the right to lecture in experimental physics.

28 July 1875 marries Gizella Horváth (daughter of Boldizsár Horváth, former minister of justice).

1876 announces a new method for the measurement of the capillary constant.

1877 birth of his first daughter, Jolán, who dies at the age of 2.

21 July 1877 climbs the Zwölferkofel (Cima Dodici, "Croda dei Toni") in the Dolomites.

10 January 1878 the birth of his second daughter, Rolanda Mária.

1878 as successor to Ányos Jedlik, appointed head of Institute I of Experimental Natural Sciences.

20 July 1878 climbs the Sextener Rotwand (Croda Rossa di Sesso).

25 July 1879 climbs the Elferkofel (Cima Undici).

19 January 1880 inaugural lecture as a corresponding member of the Academy.

21 January 1880 elected as one of the two vice presidents of the Hungarian Society of Natural Sciences, an office he held until his death.

4 June 1880 birth of his daughter Ilona.

13 November 1881 awarded the French Légion d'honneur.

17 May 1883 elected as a full member of the Hungarian Academy of Sciences.

1883–1886 the Physics Building of the university is built under his personal supervision.

19 July 1884 the first person to scale the Croda da Lago. The route has been known as the "Via Eötvös" ever since.

1885 elected as a life member of the Upper House.

19 January 1885 inaugural lecture at the Academy.

1886 publishes the Eötvös rule on the temperature dependence of the capillary constant.

1888 establishment of the Budapest branch of the Hungarian Carpathian Association (founded in 1873); Eötvös elected as its first president.

1888 with the assistance of Károly Tangl, Eötvös begins measurements to demonstrate the proportionality of gravitational and inertial mass.

from January 1888 in ten weekly presentations organised by the Hungarian Society of Natural Sciences, he lectures on "the current state of physics and its research methods".

3 May 1889 following the death of Ágoston Trefort, Eötvös is elected president of the Hungarian Academy of Sciences.

1899 on his initiative Andor Semsey announces ten scientific competitions in different fields.

1890 publishes the torsion balance measurements that prove the universal proportionality of gravitational and inertial mass, more accurately by almost three orders of magnitude than ever before.

December 1890 at his proposal, the decision is taken to establish the Mathematical and Physical Society.

May 1891 the manufacturing plant of Nándor Süss produces the *horizontal variometer* (or *Eötvös balance*), which was used to carry out the first field surveys of the gravitational field curvature on Ság Hill in August.

1 June 1891 issues 1 and 2 of the *Mathematikai* és *Physikai Lapok* (Mathemathics and Physics Journal) were published with the contribution of Eötvös.

1891–1892 rector of the University of Budapest for one year.

15 September 1891 inaugural speech as university rector on the *Tasks of the University*.

29 September 1891 foundation of the Hungarian Tourist Association: Roland Eötvös becomes its first president.

5 November 1891 inaugural general meeting of the Mathematical and Physical Society, at which he is elected first president.

15 January 1893 announces the annual Széchenyi Celebration

4–5 April 1893 the first general meeting of the Mathematical and Physical Society. On its agenda were lectures by Eötvös and other teachers of the university, and experiment-demonstrations by secondary school teachers.

1894 the mineral Lorandite is named after him.

12 April 1894 attends the funeral of Lajos Kossuth as president of the Academy.

10 June 1894 – 15 January 1895 minister of religion and public education in the second government of Sándor Wekerle. Undertakes preparatory work for the establishment of the Baron Eötvös József Collegium.

25 October 1894 at the celebratory meeting of the Mathematical and Physical Society, to honour his ministerial appointment, he is presented with the "Greeting" signed by 387 members of the Society. At the same time, he presents the prizes and medals for the students' competition initiated by him.

summer 1895 visits and takes photographs of the Dobšinská ice cave and surroundings. Climbs the Grossglockner with his two daughters.

1895 the Baron Eötvös József Collegium is established on his initiative. He is a trustee from that year until his death.

1896 awarded the Grand Prize of the Academy.

May 1896 receives Franz Joseph at the Jubilee Assembly of the Hungarian Academy of Sciences.

1896 appointed director of the Budapest Secondary School Teacher Training Institute.

1898 the simple horizontal gravity variometer, later known as the Balaton torsion balance, is completed.

1898 establishment of the Budapest University Athletics Club (BEAC). Eötvös is made its first president.

5 June 1898 inauguration of the Dobogókő hiking shelter of the Hungarian Tourist Association, named after him.

1899 he establishes a model system of the teacher training institution by implementing a new regulation.

1900 gives a presentation on his measurements of gravity and Earth magnetism at the International Congress of Surveyors in Paris.

1900 wins a prize with his Balaton torsion balance at the World Exhibition in Paris.

1901 participates at the meeting of the International Association of Academies in Paris.

winter 1901 gravity survey on the frozen Lake Balaton, which proves that the balance is suitable for geological research.

8 August 1901 Rolanda and Ilona Eötvös are the first to climb the southern face of the Tofana di Rozes.

1902 a peak is named after him in the Cadin mountains.

winter 1903 gravity surveys on the ice of Lake Balaton.

1904 appointed as executive privy concillor.

9 October 1905 resigns as president of the Hungarian Academy of Sciences, allowing him to concentrate on his scientific activities.

1906 the Beneke Foundation issues a call for proposals to verify the material-independent ratio of gravitational and inertial mass with greater accuracy than ever before.

1906 the International Congress of Surveyors in Budapest calls on the Hungarian Government to fund Eötvös's surveys.

1908 a portable field version of the double horizintal variometer is constructed.

September 1908 receives state funding disbursed over three years for his torsion balance surveys.

1909 submits his measurements of the universal proportionality of inertial and gravitational mass with an accuracy of 1 : 200,000,000 for the Beneke competition.

1909 receives honorary award Pro Artibus et Litteris.

1909 gives a presentation at the International Congress of Surveyors in Paris.

1910 corresponding member of the Prussian Academy of Sciences.

1911 opening of the new building of the Baron Eötvös József Collegium.

1912 presentation at the International Congress of Surveyors in Hamburg.

1912 the annual general assembly of the Mathematical and Physical Society awards him the Kálmán Szily Medal and Prize. He donates 1,500 crowns to the Hungarian Society of Natural Sciences and 500 crowns to the Mathematical and Physical Society.

1915 and 1916 because of the First World War he spends the two summers in the High Tatras, Tarpatakfüred (Kühlbachtaler Bad).

1916 the surveys at Egbell (Gbely) oil field prove the applicability of the Eötvös balance in oil and gas prospecting.

1916 president of the jury for the first Károly Ireneus József Physics Competition of the Mathematical and Physical Society.

1917 presents his rotating balance to demonstrate the Eötvös effect**.**

December 1918 "Baron Roland Eötvös special issue" of the Mathematics and Physics Journal presented to him on his sickbed.

30 March 1919 death of his wife.

31 March 1919 completes his article on the Eötvös effect and the tool to demonstrate it, the rotating balance, which is published in German in the journal *Annalen der Physik*.

8 April 1919 Roland Eötvös dies in Budapest at 10:30 pm.

11 April 1919 memorial ceremony held at the National Museum, the funeral takes place at Kerepesi Cemetery.

1920 publication in Hungarian of the description of the device demonstrating the Eötvös effect in the journal *Mathematikai* és *Természettudományi Értesítő.*

1920 on the initative of Dezső Pekár**,** the Geophysical Institute is renamed after him.

1921 the Mathematical and Physical Society adopts the name of its founder, Roland Eötvös.

1922 publication of the measurements submitted to the Beneke competition in the journal *Annalen der Physik*.

1923 following a commemorative speech by minister of religion and public education Kuno Klebelsberg, a portrait of Eötvös by Oszkár Glatz is unveiled at the Péter Pázmány University in Budapest.

1930 the László Ungváry Prize is awarded by the Academy to Albert Apponyi, and posthumously to Roland Eötvös.

1930 Izidor Fröhlich edits the Loránd Eötvös Commemorative Book, published by the Hungarian Academy of Sciences.

1932 inauguration of the monument at his grave in the Kerepesi Cemetery.

1944 the 25th anniversary of Eötvös's death. Commemorative speeches by Jenő Cholnoky and Dezső Pekár.

15 February 1945 death of Ilona Eötvös.

1948 commemorative speech by Pál Selényi on the centerary of Eötvös's birth.

1948 centennial exhibition at the Science Museum, London, titled "Hungary's greatest man of science"

1949 Eötvös Loránd Physical Society is established as the legal successor to the Physics Branch of the Mathematical and Physical Society.

1950 Pázmány Péter University in Budapest is renamed after Eötvös from the 1950/1951 academic year.

1953 the collected works of Eötvös, edited by Pál Selényi, are published by the Hungarian Academy of Sciences *(Roland Eötvös Gesammelte Arbeiten).*

13 April 1953 death of Rolanda Eötvös.

1957 Eötvös Loránd Geophysical Institute establishes the Eötvös Loránd Memorial Medal.

1958 the improved Eötvös balance wins a Grand Prix at the Brussels World Expo.

1963 Eötvös memorial ceremony at the Eötvös Loránd University.

1969 the Eötvös Gold Medal is awarded for the first time to physicist János Renner, a student of Eötvös.

1970–1971 the first Eötvös Loránd Memorial Exhibition at the Tihany Museum.

1973 the government establishes the Eötvös Loránd Prize (reestablished in 1991), to reward creative, instructional and organisational activities in the industrial sector.

since 1986 the term "fifth force", related to the Eötvös experiments, is used in international literature.

1991 asteroid 12301 Eötvös is named after him.

1998 the Eötvös Loránd Memorial Exhibition opens in Budapest.

2015 UNESCO enters three documents related to the Eötvös torsion balance into the Memory of the World Register.

November 2017 UNESCO General Conference adopts the decision that the 100th anniversary of the death of Roland Eötvös should be commemorated by the world scientific community and Hungarian society in association with UNESCO.

12 October 2018 European Physical Society (EPS) recognises the former physics building of the Eötvös Loránd University – the venue of Eötvös's famous experiments – as an EPS Historic Site.

8 April 2019 National Bank of Hungary issues commemorative coins to honour the 100th anniversary of Eötvös's death.

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Notes

[1] Below the picture is an excerpt from Roland Eötvös's poem *To My Father,* written on 19 March 1863.

[2] Below the picture is an excerpt from Roland Eötvös's poem *To My Mother,* written on 18 September 1863.

[3] A recording of the demonstration is available here: https://www.youtube.com/watch?v=MJyUDpm9Kvk

[4] Nándor Süss (Marburg, Hessen, 1848 – Budapest, 1921) was a "precision mechanic" who acquired his skill in his grandfather's workshop in his native town of Marburg, Hesse. In 1876, he was invited by the University of Kolozsvár (Cluj) to take up a post in mechanics. In 1884. he was ordered to Budapest by the minister of religion and education, who commissioned him to establish a state mechanical training workshop. In 1900, the training workshop was transformed by Süss into a private company, operating as a joint stock company from 1918. This formed the basis of what later became the Hungarian Optical Works (MOM). Süss died in a tram accident in 1921.

[5] Dezső Pekár (Arad, 1873 – Budapest, 1953) completed his higher education at the Budapest University, where he was invited by Roland Eötvös to act as his teaching assistant in 1895. Alongside Eötvös, he took part in gravity research using the Eötvös balance. After the death of Roland Eötvös (1919), he directed Hungarian geophysical measurements until 1934. Under his leadership, the Eötvös Loránd Geophysical Institute acquired increasing prestige after the First World War, and his measurement methods were taught to foreign students on the courses that were given there. Drawing on his experience in the field, he designed the smaller Eötvös-Pekár balance, which was easy to transport on difficult terrain.

[6] Andor Semsey (Kassa/Kosice, 1833 – Budapest, 1923) was a big landowner, a member of the Hungarian Academy of Sciences, a naturalist, and a generous patron of Hungarian science.

[7] István Rybár (Budapest, 1886 – Budapest, 1971) was a Hungarian physicist and geophysicist, a member of the Hungarian Academy of Sciences, and the developer of the so-called AUTERBAL (Automatic Eötvös-Rybár balance). Eötvös employed him to carry out measurements of gravity and the Earth's magnetic field as soon as he had completed his university studies. In 1912, he became an assistant professor to Eötvös, and a senior lecturer in 1920. During his 11 years working alongside Eötvös, he participated in all of Eötvös's experiments, gaining an insight into his research methods and plans. In the autumn of 1921, he was appointed head of the Department of Applied Physics. In 1940, he returned to the Department of Experimental Physics, where he taught until his retirement in 1949. He worked as a research fellow at the Eötvös Loránd Geophysical Institute until 1962.

[8] Jenő Fekete (Veszprém, 1880 – Budapest, 1943), a geophysicist, was Roland Eötvös's colleague and a corresponding member of the Hungarian Academy of Sciences (1941). He studied at the University of Budapest. He worked for Roland Eötvös for 15 years. In 1915, he was appointed as a geophysicist, and from 1919 he worked at the Eötvös Loránd Geophysical Institute. He carried out torsion balance measurements for Royal Dutch Shell in Mexico in 1923, and in Texas from 1931, before returning home in 1934 to take over the leadership of the Geophysical Institute.

[9] Tellurics is one of the methods of geoelectric geophysical research. It involves the measurement of the parameters of the natural Earth currents induced by changes in the magnetic field, making it possible to determine the geological structure of the surveyed area. Seismology is a method of geophysical exploration that uses artificially generated elastic waves (quake waves). In principle and practice it is similar to radar, in that the geological structure of the surveyed area is determined on the basis of reflected signals.

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[12] John Noble Wilford: "Hints of 5th Force in Universe Challenge Galileo's Findings." *The New York Times,* 8 January 1986.

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[14] As part of the centennial series of events, a new English translation of the EPF article containing the Eötvös manuscript was published with the support of the Hungarian Academy of Sciences.

[15] Kaons, or K-mesons, were discovered in the second half of the 1940s. These were the first particles discovered to have a quality known as strangeness. It was partly the anomalies identified during experiments with K-mesons that led the authors of FSSTA to re-analyse the EPF experiment.

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Publisher in charge András Sándor Kocsis,
President and CEO of Kossuth Publishing

Project manager Attila Nádori
English translation by Rachel and János Hideg
Copy editing and picture editing Attila Landauer and Lilla Landauer
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Prepress GMN Color Digital

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NYOMDA- ÉS PAPÍRIPARI SZÖVETSÉG

Printed and bound by Alföldi Printing House
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