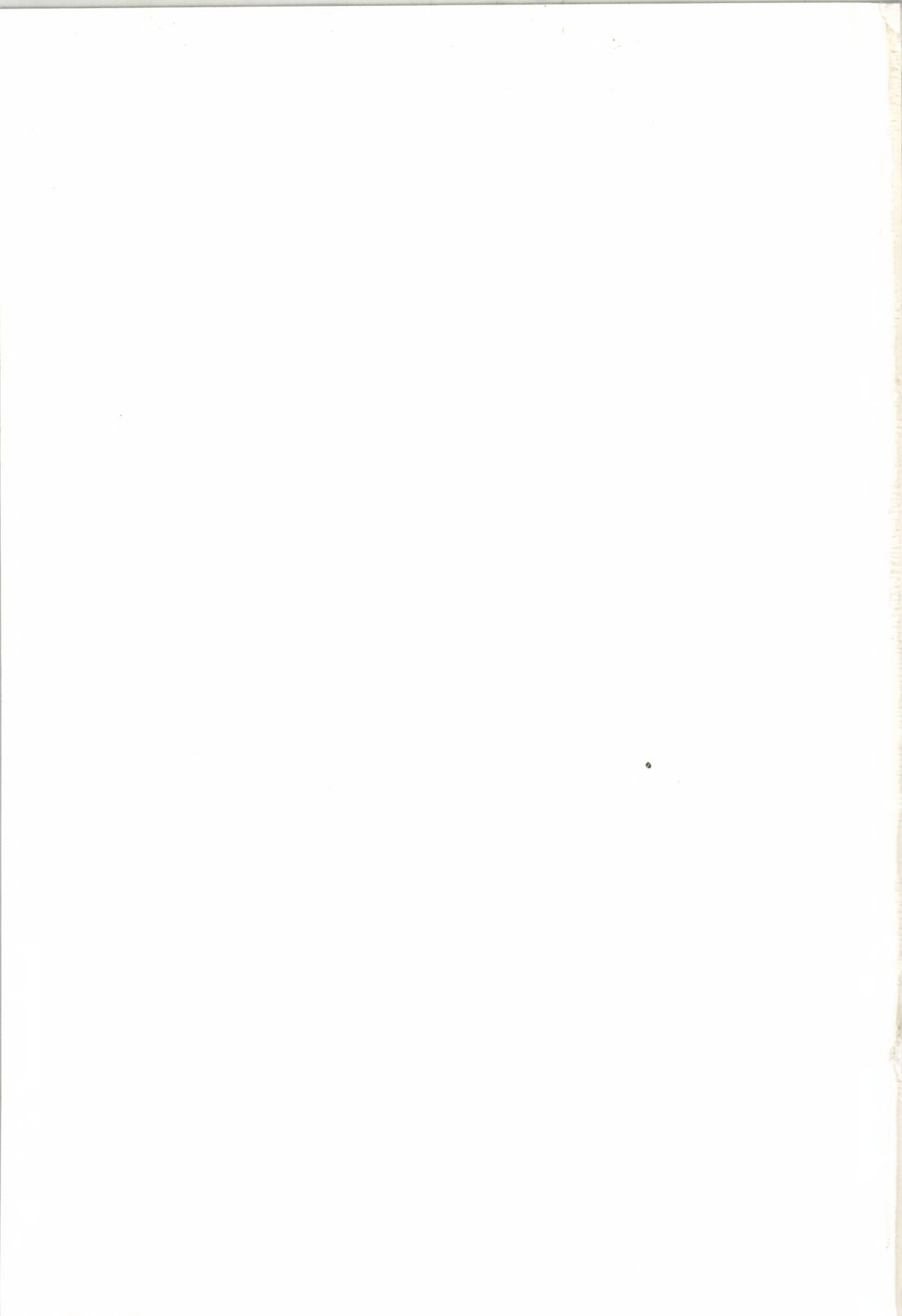


GEORGE MARX

*THE VOICE
OF THE
MARTIANS*





THE VOICE OF THE MARTIANS



THE VOICE OF THE MARTIANS

George Marx



Akadémiai Kiadó, Budapest

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of the Hungarian Academy of Sciences

ON THE FRONT COVER:

Henry Moore's *Monument of the Atomic Power*,
commemorating the first nuclear pile in Chicago.

This is the picture of the copy of the statue,
standing in the Johns Hopkins University in Baltimore.

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*Dedicated to the Memory of Leo Szilard
on the centenary of his arrival to Earth*

The Science of Survival

May you live in interesting times!
(ancient Chinese New Year's wish)

FROM BATTLEFIELDS TO SWEDEN

During World War I deep in imperial Russia, in Turkestan, near the Afghan border at the town of Merv, there was a camp for prisoners of war. One day in October 1915, a Russian officer was desperately looking for a certain Dr. Bárány. When the officer found him, he handed over a cable from Stockholm, informing the prisoner of war that he had been awarded the Nobel Prize. The president of the Swedish Red Cross, Prince Charles, later contacted the president of the Russian Academy of Sciences, Grand Duke Konstantin, to release Robert Bárány to attend the Nobel Ceremony in Stockholm. The Austrian–Hungarian Imperial Army (where Bárány was a field chirurg) offered an exchange of captured officers, but that contradicted the military principles of the Russian Imperial Army. Anyway, POW Bárány was transferred to the University of Kazan. As a youth, his leg had been infected by tbc, resulting in a limp. A Russian chirurg advised Bárány to claim that the condition of his leg was worsening in the prison camp, and he should ask for a release. Bárány did so. Informed of his appeal, the Russian general ordered the release of Robert Bárány as a war invalid. As Bárány began to explain that his stiff leg was due to a childhood illness, the general replied, – *It's me who decides who is a war invalid, not you!* – Thus Dr. Bárány was transferred to Finland and released to Sweden. ROBERT BÁRÁNY (1876–1936) received the Nobel Prize from the King of Sweden “for his work on the physiology and pathology of the vestibular apparatus” on 11 September 1916.

This story characteristically illustrates the fate of scientists in Central Europe, a region always at the crossroads of history, but especially so in the 20th century. This book has been written about the advantages of living in such an interesting region of space-time.

The Bárány family had settled in the Hungarian town of Várpalota in 1750. József(?) Bárány was a teacher there. After his death, his 14 years old son, Ignác Bárány left stormy Hungary for imperial Vienna (1855) where he married a Czech girl. (The Jewish community of Várpalota was

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professor gunnar holmgren stockholm sveda

erfahre durch schwedischen gesandten von der
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herzinnigsten dank an dr barany kriegsgefangener

exterminated later in the 1944 holocaust.) Their son, Robert Bárány was born in Vienna in 1876. His Hungarian father obtained Austrian citizenship in 1877. Robert studied medicine at Austrian and German Universities, and became a research assistant at the University of Vienna. Robert Bárány married an Austrian girl.

The vestibular system was studied already by several Austrian, Czech, French, Swedish medical doctors, trying to find out whether it is located inside the brain or elsewhere. The Austrian physicist Ernst Mach was interested in the origins of inertia, therefore he searched also for the sense of direction. Once in the hospital Dr. Bárány had to wash the ear channel of a patient, but the patient complained, – *Doctor, the water is too cold and makes my head swimming!* – On the next occasion the patient said, – *Doctor, now the water is too hot, my head swims again!* – By closely watching the patients, Dr. Bárány noticed that in the case of cold water the eyes moved off in one direction, but in case of hot water in the opposite direction. Lukewarm water had no effect. In this way Robert Bárány concluded that the temperature differences initiated a

flow of the liquid in the labyrinth of the inner ear and was responsible for the swimming sensation in the patient's head. The sensors of this flow inform the brain about the direction of motion of the head.

Bárány's conclusion was in full agreement with the published research result of the Hungarian medical doctor, Endre Hőgyes, who removed the labyrinth of test animals: these animals lost their sense of direction. In this way Bárány empirically clarified the long debate about the location of the vestibular organ. For his discovery, Robert Bárány received the Pulitzer Prize of the International Otological Congress in Boston (1912). He also received the Guyot Prize from the University of Groningen (1914).

When World War I broke out in 1914, Dr. Bárány volunteered for medical field service, motivated by his interest in soldiers with brain and ear injuries. He was sent to Fort Przemyśl, where he performed surgery and collected data on hundreds of soldiers during the long siege. Finally the Fort was captured by the Russian Army. As a prisoner of war, Dr. Bárány treated both Russian soldiers and Austrian–Hungarian prisoners of war. It was in this POW camp that he received the happy news about the Nobel Prize [facsimile].

Telegram to Professor Gunnar Holmgren, Stockholm, Sweden
I have learned via the Swedish Ambassador that I obtain the Nobel Prize that makes me highly happy. I express my heart-deepest thanks to you and by you the Faculty of Medicine in Stockholm
Merv, 4, November 1915 Dr. Barany, prisoner of war

In his Nobel lecture in Stockholm Bárány emphasized the merits of Endre Hőgyes, and in so doing made it evident that he, born in Austria, understood Hungarian as well: Endre Hőgyes has published all his papers only in Hungarian. Bárány concluded his Nobel lecture saying:

– *The war invalids, who let me perform physiological experiments (without extra danger or pain to them) have served the interest of all of mankind.*

After the glorious Nobel ceremony Robert Bárány returned to Vienna. There he learned that the Council of the Faculty of the Vienna University had rejected his nomination to university professor because his jealous university colleagues had queried his priority. A cartoon in a Viennese newspaper depicted Dr. Bárány with the Nobel diploma in the background, with these words: *"I have succeeded in curing all kinds of ear injuries but the deafness of the Vienna Faculty."* He had to clear himself in court from the accusation of plagiarism. After having done this, Bárány accepted the invitation of Uppsala University and obtained Swedish citizenship (offered to Nobel laureates in trouble) in 1917.

Robert Bárány's oldest son, Ernst Bárány, having hesitated between the study of radio electronics and hearing, between the study of physics and medicine, finally became a professor of medicine at the University of Uppsala. His son, Anders Bárány, however, is now professor of physics at the University of Stockholm, president of the Swedish Physical Society, and serves as the secretary of the Nobel Committee for Physics.

Buried in the Jewish cemetery of Stockholm, Robert Bárány's tomb carried the inscription: "*From the world's otologists.*" He donated his books to the National Library in Jerusalem. At his birth centenary in 1976 the Austrian Postal Service issued a memorial stamp with the face of Robert Bárány followed later by the Swedish and Hungarian Postal Services. Robert Bárány has left a message for us:

– A scientist has three kinds of duties: (1) Making close observations, discriminating the relevant from the irrelevant, and deriving thoughtful conclusions. (2) After a discovery, the scientist's duty is to present his finding and to fight for its general acceptance with all his energy. In the scientific literature I very often see that important facts have become neglected because the discoverer was not persistent enough in making his finding accepted and thus it became forgotten. (3) The scientist must transfer the spirit of research to his students with full energy. This can be done most efficiently by creating a scientific school. Human life is too short to solve alone all the problems which we are confronted with.

After World War II, almost 50 years after Bárány's adventurous Nobel Prize, a Hungarian physicist received the Nobel Prize in physiology, for his research of the inner ear. At the dinner following the Nobel ceremony in 1961, George von Békésy said:

– As you may know, the first recipient of the Nobel Prize in otology (the science of the ear), Robert Bárány, was of Hungarian origin. I do not think that it is by pure accident. Otology in Hungary has reached very high standards and there was a genuine interest in it. I have always had the impression that there must have been one outstanding man who set the pattern. For a long time I was not able to discover his name in any handbook, but one day I found out about him. His name was Endre Hőgyes, and a small street I used to walk on in Budapest was named after him. His work concerned eye movements connected with the vestibular organ, and because he was a proud Hungarian, he published only in the Hungarian language. That is rather hard to read, though not quite as difficult as Sanskrit. But even so, the scientific atmosphere he left behind him could be felt indirectly. This historical con-

tinuity, together with the fact that the ear is a point on which many scientific fields converge, gives me hope that whatever contribution I have been able to make will endure.



GEORGE VON BÉKÉSY (1899–1972) had a Hungarian father and a Slovenian mother. His mother had learned German from the rabbi of her small Slovenian village. George von Békésy was born in Budapest; his mother's tongue was German, his father's tongue was Hungarian. He attended schools in Munich, studied *chemistry* in Bern, obtained a Ph.D. degree in *physics* in Budapest (1923), worked in telecommunication *engineering* in the laboratory of the Hungarian Postal Service, just to obtain the Nobel Prize in *physiology*. During his life Békésy crossed several political and disciplinary borders.

Békésy worked for Siemens in Berlin, but his patriotism brought him back to Hungary, defeated and partitioned after World War I. The laboratory of the Hungarian Telephone Service was well equipped. When complaints arrived from abroad about the poor quality of the long-distance phone lines running through Budapest, Békésy, as the youngest assistant, was charged to solve the problem. He did it in a simple way. The clicks caused by connections and disconnections contained many frequencies. By analyzing them he could give a good diagnostic description of the network. This practical goal led him to investigate the *weakest part* of the system: the receiver. The functional similarity between the microphone membrane and the ear drum led him to the study of the inner ear.

In 1928 Békésy published the results of his research, bringing him recognitions: the Denker Prize from Germany and the Guyot Prize from the Netherlands. He regarded as his greatest honor the invitation of ROBERT BÁRÁNY, the Nobel laureate professor, to come to Uppsala. But because of the fragile health of his lung, Békésy was unable to accept the invitation to Sweden.

Békésy's research had shown that Helmholtz's theory of hearing was wrong. It was not the eigenvibrations of the cilia (ear filaments) but those of the cochlea (ear fluid) that played a decisive role in sensing the frequency of sound. Acknowledging these achievements, Békésy was promoted to professor of physics at the University of Budapest (1943). But now *World War II* was on. An American air raid destroyed a neighboring building, partly Békésy's laboratory as well. Street fighting contributed to further damage of the equipments and papers. His later co-worker, Floyd Ratliss wrote,

– The bombing and artillery fire had revealed the archeology of Budapest. On the upper level of the ruins he could see remains of the buildings

erected in the Empire style of the 19th century. Deeper the Baroque style could be seen in staircases. Where the bombs and shells opened even deeper craters, one could see Gothic cutting of stones and still farther down, a Romanesque style. This sequence showed the whole history of Budapest from the Roman era to modern times. What he saw there gave Békésy some hope for the future: for him, Budapest and its people seemed invincible. The Hungarians might surrender their military forces to an enemy, but never would they surrender their fierce pride and love of freedom.¹

With some sense of guilt George von Békésy accepted an invitation to the Karolinska Institute in Stockholm (1946). Having dissected the ears of human corpses, Békésy could now do experiments on the ears of living apes.

In the meantime, however, Hungarian politics made a sharp left turn. When he applied for permission to conclude his research in Sweden throughout a second year, Budapest University deprived him of his professorship. George von Békésy was then invited to join the faculty at Harvard University. He landed in the United States in 1947 with 50 dollars in his pocket. The only problem was that the immigration officer asked him, – *Are you healthy?* – To the surprise of the border inspector Békésy answered, – *I am not* – because he had understood the question to be “are you wealthy?” At Harvard Békésy carried out research on living ears, then with enlarged mechanical models, in order to study the vibrations of ear fluid. (His critics objected that for his measurements he had to use high sound intensities, exceeding the tolerance of the living ear. But by five years after his death, measurements performed at normal sound intensity utilizing the Mössbauer effect proved that Békésy’s conclusions were right.)

In 1961 Békésy received the Nobel Prize “for his discoveries concerning the physical mechanism of stimulation within the cochlea,” initiated in Budapest. When the Budapest School of Medicine made him honorary doctor (1969), it was a much appreciated though bitter-sweet honor. He did not go to Budapest; the diploma was presented to him at the Hungarian Embassy in Washington, D.C. He never returned to his native country. In his autobiography Békésy made the following comparison:

– *Hungarians like good living; they have discovered that research is a joy; thus they become enthusiastic researchers who spend nights in the lab without even asking for an increase in salary. In the U.S. this goes a dif-*

¹Floyd Ratliss: *The Georg von Békésy Collection*, Allhems Förlag, Malmö

ferent way: there people work for dollars. There are exceptions but they don't make a majority. A quick outcome is the most important thing. – This may explain why he moved to Hawaii for his later years (1966):

– Hawaii is the most interesting place; it's international to a degree which is almost hard to understand. There are groups from Asia, Australia, America and Europe, they still are able to survive and respect each other. At the same time it forces me to realize that the whole way of thinking and working and taste is completely different in the East from the West. This difference cannot be erased by organizers or even by big wars. There are so many cultures with their own histories and own ways of evaluating life. It is in Hawaii where I first realized how complicated the world really is and how difficult it is to understand another person's opinion, even if I do my best to understand it.

In his last will, he donated his unique collection of Oriental works of art to the Nobel Foundation. At the sound of Hawaiian music, his ashes were scattered over the waves in the middle of the Pacific Ocean, a long way from Budapest.

TRACING LIFE ACROSS BORDERS

It was once thought that alchemy would solve the financial problems of royal patrons by revealing the process whereby lead would be transformed into gold. From the failure of these efforts, the realization emerged that chemical elements were immutable, and thus the science of chemistry was born. At the end of the 19th century it was generally assumed that some 100 chemical elements were made of 100 sorts of atoms, each one being indestructible and eternal.

Once upon a time Lord Rutherford, discoverer of the atomic nucleus, met his assistant, the chemist GEORGE DE HEVESY (1885–1966) in the corridor of his laboratory in Manchester, and said to him, – *My boy, if you are worth your salt you will separate the active Radium-D from that nuisance of lead!* – Hevesy, using all the tricks of chemistry, tried hard to do so. His unsuccessful attempts resulted in the understanding that atoms of the very same chemical element (e.g. lead) could differ from each other. One of them may be stable, while the other one may radiate and decay spontaneously. This realization was the breakthrough leading to the concept of isotopes.

– But if I am unable to distinguish between Radium-D and lead, then it has to be impossible for Nature as well – Hevesy argued to himself, perhaps on the train between Budapest and Vienna. The idea of radioactive tracing was thus born (Budapest 1913).

Hevesy became a lecturer in Budapest. During World War I ROLAND EÖTVÖS recommended the nomination of Hevesy to professor at the Budapest University and to head the Institute for Applied Physics (1917). (George von Békésy became head of the same institute at the time of World War II.) Assignment was provided under the newly established republic (1919), signed by THEODORE VON KÁRMÁN, state secretary (later state commissar) for university affairs. Hevesy started to organize his laboratory for the study of radioactivity. But soon foreign troops marched into the streets of Budapest (June 1919), then nationalist troops took power, in order to bring back the ancient regime (November 1919). The Eötvös-epigons, being schooled only in classical mechanics, deemed it timely to get rid of Hevesy, who was spreading conspicuously novel ideas such as radioactivity (1920). George de Hevesy was deprived of his professorship for having been appointed by "suspicious communist sympathizers" like von Kármán. Thus the dream of the three noble giants, Baron Roland Eötvös, Theodore von Kármán and George de Hevesy – about establishing a nuclear laboratory in Budapest in the early 20th century – collapsed.

Hevesy then accepted the invitation of Niels Bohr, to organize a nuclear laboratory in Copenhagen (1920). His goal was to utilize radioactivity as a tracer in biology. The natural isotopes at the end of the Periodic Table were not suitable, since they played no role in biology; they were even toxic. To fully achieve his goal, he developed neutron activation for making radioactive isotopes of life-essential elements. His first product was radiophosphorus. This enabled him to study the metabolism of phosphorus, among others in the energy carrier ATP and in the genetic material DNA. For this work he is considered to be the founding father of radio-medicine. He was awarded the Nobel Prize in chemistry "*for his work on the use of isotopes as tracers in the study of chemical processes*" (1943).

After the Nazi occupation of Denmark Hevesy moved to Sweden, where he became the professor of organic chemistry at the University of Stockholm and initiated the nuclear medicine. After World War II he never returned to Hungary. He rests in Freiburg, Germany.

ELECTRONS AND LIFE

ALBERT SZENT-GYÖRGYI (1893–1986) *always longed for an ivory tower, yet wound up unerringly on the barricades* – claims Ralph Moss in the biography most appropriately entitled *Free Radical*.

Albert was the son of reputable noble Hungarian families. In keeping with family traditions he studied at the Medical School in Budapest, then

started a wandering life through Prague, Berlin, Hamburg, Leiden, Groningen, London, Boston, Rochester, and Cambridge. His research began in anatomy, then moved to physiology, biochemistry, molecular biology, reaching quantum mechanics. Returning to his *alma mater* in Budapest Szent-Györgyi taught his students:

– *The Creator surely did not stop at the molecular level, just to save biologists from learning the quantum mechanics of the electron. He might know a lot of quantum mechanics and materials science to be able to apply them so successfully.*

Szent-Györgyi was mainly interested in the biochemistry of oxidation: how the transfer of an electron from one molecule to another can supply a cell with energy. He found a specific compound which did not burn, but catalyzed and regulated oxidation.

In Cambridge a message reached the young scientist from Hungary (1929). The young man obtained a cathedra at the University of Szeged in 1931, and also received research support from the Rockefeller Foundation. He succeeded to show that the catalyzer of oxidation is identical with the vitamin C of the physiologists. He isolated the pure compound from *paprika* (the famous Hungarian red-hot chili pepper) and clarified its chemical composition, bringing the Nobel Prize in physiology to Hungary “for his discoveries in connection with the biological combustion processes, with special reference to vitamin C and the catalysis of fumaric acid” (1937). The worldwide carrier of vitamin C started from Szeged.

World War II erupted two years later and Hungary soon found herself on the losing side. The leaders of Hungary looked for an escape from the alliance with Hitler. Albert Szent-Györgyi, with the aura of his Nobel Prize and with his British connections seemed to be the appropriate person to establish contact with England in 1944. Under the guise of a scientific lecture tour Szent-Györgyi travelled to Istanbul and there approached the British Embassy. The Intelligence Service contact turned up at the agreed upon restaurant, listened to Szent-Györgyi, then recommended that the professor organize sabotage against the German war efforts within Hungary. The only risk was that the professor did not know whether the gentleman worked for the British Intelligence Service or for the German Gestapo. Well, from that conspiratorial meeting Szent-Györgyi returned safely home, the first alternative having turned out to be the case. The Western Alliance, however, instructed Hungary to surrender to the Soviet Union, according to the Yalta Pact. German troops moved into Hungary; the resistance movement was betrayed. Hitler shouted that Szent-Györgyi was a “*Schweinhund*” (pig-

dog), demanding his extradition. The professor dived underground. The king of Sweden declared Szent-Györgyi to be a Swedish citizen, thus the professor obtained a Swedish passport under the name of Mr. Swensen. He took refuge in the Swedish Embassy in Budapest. But before going underground, he mailed the interesting result of his recent muscle research to a prominent Swedish journal. The Swedish editor wanted to inform the author about the referee's report, but did not know the address. Thus he sent a cable to the Swedish embassy in Budapest, asking the Ambassador to transfer the message to Szent-Györgyi wherever he was. The cable was intercepted by the Germans. Fortunately, someone had hinted to the Ambassador about Szent-Györgyi's endangered incognito and the Ambassador smuggled "Mr. Swensen" out of the embassy building that evening in the trunk of his car. During the same night "a mob raided the embassy building" but the raid was too late: Szent-Györgyi was already hiding in another uninhabited house that had been ruined by American air strikes.

After prolonged street fighting, Soviet troops overtook Budapest from the Germans. In the destroyed city an English-speaking Russian officer searched for Professor Szent-Györgyi at the instruction of Molotov, the state commissar for foreign affairs in the Soviet Union. In this way the professor and his family obtained food, shelter and safety. He was even invited to Moscow, to take part in the Bicentenary Celebration of the Russian Academy (1945). The Yalta Pact made Hungary part of the European zone under Soviet occupation. Szent-Györgyi looked for reconciliation with the Russians and became the first president of the Hungarian-Soviet Friendship Society. He travelled to Moscow again, trying to meet and convince Stalin personally to stop the brutalities committed by Soviet troops in Hungary, but he was firmly rejected.

Szent-Györgyi believed in democracy and science. He wished to restart research in his home country. He participated actively in reshaping the Hungarian Academy of Sciences, where he became vice-president. Some politicians wanted to make Szent-Györgyi the president of the Hungarian Republic. For research support, the professor wished to approach again the Rockefeller Foundation. He applied for an American visa, with the intention of persuading the Foundation personally, but the visa application was rejected on the ground of the applicant's "communist sympathy and Soviet contacts." Thus Mr. Swensen entered the United States with a Swedish passport.

After the American lecture tour the professor returned. But democracy did not last long enough for Hungary. With the support of Soviet troops the communists took over. To the secret police Szent-Györgyi became a

suspicious person because of his Anglo-American connections. Thus in 1947 he applied for an American immigrant visa. At the Marine Research Laboratory in Cape Code Szent-Györgyi collected an interdisciplinary “laboratory without borders” with the purpose of solving the ultimate puzzles of life. He developed a biological model by assuming that living matter consists of proteins in a conductor (semiconductor) state. Death (and possibly cancer) means losing this semiconductivity. These novel physical ideas were very strange for physicians unexperienced in modern physics, but the 70-year-old scientist learned hard quantum mechanics. During his last visit in Hungary, lecturing to physicists about the electron theory of life at the Department for Atomic Physics at the Budapest University (1978), the professor noted:

– If my idea about the electron conductivity of proteins had been accepted too easily, I would become suspicious: my discovery may not be extraordinary at all!

When the Cold War turned hot in Korea and Vietnam, the professor left the ivory tower of science again, became a devoted opponent of the use of military might. The public debate between two ardent Hungarians, Albert Szent-Györgyi and Edward Teller (organized by the American Association for the Advancement of Science in Chicago) became a media event. Szent-Györgyi’s best-selling book, *The Crazy Ape* (i.e. Homo sapiens) was the most bitter criticism of the U.S. intervention in Vietnam:

– To the superficial observer it must look as if the armies of the two superpowers hold one another in balance. The truth is different. The truth is that these two armies are the sweetest allies, for without the Soviet army we would not need the American Army, and vice versa. The fruits of the labors of the citizens of these two countries would not go to their Defense Departments. Thus the two great armies work in concert, promising fear and hatred to prevent peace from breaking out. They fight peace with all their might. They dominate not only their governments but with their hold on the press they also dominate and direct the minds of people of their nations, equating patriotism with the act of voting huge sums of money for them. What we really need is a defense department against Defense Departments (1970).

It is no wonder that Szent-Györgyi did not climb high in the official scientific establishment of the United States. He worked in a private American laboratory. He has been buried at the West Coast of the Atlantic.



It is not too difficult to find the similarities between the characters of Albert Szent-Györgyi and his compatriot, LEO SZILARD (1898–1964). Both of them were born in Budapest. Szent-Györgyi started from medicine and

advanced to modern physics. Leo Szilard started from modern physics (in Berlin), then collided head-on with Lord Rutherford and General Groves, and landed in the peace of the Salk Institute in La Jolla, California, in biology. None of them respected boundaries in science and in politics. They were watched by the intelligence agencies of both sides. They appealed directly to the leaders of the United States and the Soviet Union with rational argumentation, in order to save mankind. Szilard travelled around the world contacting scientists to organize the Pugwash Movement in the interest of nuclear disarmament. He scattered ideas to Jack Monod and François Jacob (French Nobel laureates in physiology), to George Klein (leading Hungarian-born cancer researcher in Sweden), and to Jonas Salk (Nobel laureate in physiology in the U.S.). But as a rule of history prophets are rejected.

GEORGE KLEIN (1925–) survived the holocaust by escaping from the train taking him to Auschwitz, found asylum in the Karolinska Institute in Stockholm, where he has become the leader of modern cancer research. His essays on interrelation of modern science and modern society, too, deserved world fame for him. The picture of Leo Szilard looks at him from the wall of his office. We shall meet both of them also later in this book.

The fates of the heroes of modern science with Hungarian accent show strong similarities. The fame achieved in science, the golden aura of the Nobel Prize and the peace of Sweden offered them shelter in stormy weather. It is difficult to define them according to legal citizenship (Hungarian, Austrian, German, Swedish, or American?) and traditional disciplines (physics, chemistry, biology, medicine?). Their adventures concluded with happy endings, thanks mainly to Swedish tolerance and Swedish respect for values, as expressed even by the Nobel Prize.

DIVERSITY

In the small village near Senica (then Northern Hungary, now Slovakia) a farm boy named Karl Gajdusek was born. Before World War I he emigrated to America and lived in Yonkers (New York State), in a settlement of mixed East-European immigrants. He became acquainted with a Hungarian girl, named Ottilia Dobroczi, whose parents had emigrated from Debrecen (Hungary) to America. The child of Karl and Ottilia, CARLETON D. GAJDUSEK was born in 1923. As he remembers, – *the cimbalom in our living room stood beside the piano. Rumanian and*

Hungarian gypsies fiddled the csárdás² and ballgatós³ at our family festivities. An uninterrupted flow of loud conversation in many tongues, rarely English, and kitchen odors of many Habsburg cuisines filled our home. This gave me an orthodox and optimistic view of America as a land of change and possibility which I never lost. Below our almost hilltop home factories, churches, and houses of immigrant factory workers and tradesmen clustered in the valleys of the Indian-named creeks. In this hollow stood Hungarian, Slovak, and Polish catholic and Russian orthodox churches and a Presbyterian mission. On my Slovakian fathers's side we were a family of farmers and tradesmen, and my father's temperament for laughter and ribald fun, lust for life in work and play, song, dance, and food, and above all, conversation, affected us strongly. On my Classicist–Romanticist Hungarian mother's side were more sober academic and aesthetic aspirations of four university educated first generation American siblings and a heroic interest in fantasy and inquiry, in the classics and culture, nature, nurture, and progress. Because of my mother's unquenchable interest in literature and folklore, my brother and I were reared listening to Homer, Hesiod, Sophocles, Plutarch, and Virgil long before we learned to read.⁴ – When his father revisited Europe, Carleton spent his time with grandparents in Hungary.

Well, Gajdusek started his intellectual adventures in his school years. He liked mathematics and science: – *When I was about ten years old, I wrote an essay about why I planned to concentrate on chemistry, physics, and mathematics, rather than classical biology, in preparation for a career in medicine.⁵ – Tante Irene Dobroccki worked in economic entomology in Southeast Asia, and after having returned to America she introduced the boy to the joys of natural history and alien cultures. Carleton explored the Museum of Natural History in New York, then listened to Victor Weisskopf's physics lectures at the University of Rochester. Finally at Viktor Hamburger's course at Woods Hole Marine Biology Laboratory he decided in favor of virology. Carleton enrolled at the Harvard Medical School. After university graduation he wandered further westward and at Caltech attended physics lectures from Max Del-*

²the most popular Hungarian folks dance

³the music to be listened to

⁴Gajdusek's autobiography written for the occasion of his Nobel Prize, 1976

⁵Gajdusek's Nobel autobiography

brück, chemistry from the Hungarian László Zechmeister, biochemistry from Linus Pauling. Friends – like Aage Bohr and Benoit Mandelbrot – “*had a profound effect on my intellectual development, goals and appreciation of quality in creative life.*”

Gajdusek's intellectual adventures guided him to geographic adventures: in researching strange epidemics he went to Iran, Turkey, Afghanistan, Africa, Siberia, Malaysia, Polynesia, to the aborigines of Australia, the Hindukush, the jungles of Bolivia, the valleys of the Himalaya, the Solomon Islands, and Papua New Guinea.

The young Carleton was especially impressed by the biographies of Marie Curie and Louis Pasteur. Pasteur understood the origins of epidemic diseases by discovering bacteria which exploit the resources of the human organism to their own advantage. In an even more compact way, the virus can implant an alien genetic information by their nucleic acid molecules into the human cell, instructing it to reproduce copies of the attacking enemy. But not all the diseases followed this pattern. Gajdusek became fascinated by epidemics which showed different behavior. In order to solve these biological puzzles, he had to become an expedition leader, field virologist, fast learner of new languages, determined epidemiologist and ethnographer at the same time, eager to learn not just about obviously important facts from local chieftains but also about unimportant-looking details from children.

– *The youth are the most valuable sources of information and also the best company.*

Carleton Gajdusek came upon the first cases of *kuru* in some remote and isolated villages of New Guinea in the 1950s. In local language *kuru* means trembling; it is a degenerative disease of the central nervous system, manifesting itself in increasingly severe trembling, loss of balance, and an inescapable death within one year after the appearance of the first symptoms. The *kuru* is epidemic but with a surprisingly long latency period (about two years); it is a so-called *slow infection*. It was more common among women than among men. Slowly the explanation emerged: in the affected tribe it was the custom to honor the deceased parents by eating them, in order to offer them a continuity of life. In the kitchen the women did the preparation; they were in contact with the diseased brain, which turned out to be the most infectious. With a small piece of brain Gajdusek succeeded to transfer the *kuru* to apes. The incubation time was long, but the outcome was always fatal, indicating that the human immune defense did not work against it. Gajdusek found that common medical disinfectants like alcohol, formalin, or heating to 80 °C did not harm the infectious agent of *kuru*. Even boiling it at 100 °C weakened it a bit but did not elim-

inate it (1966). Tikvah Alper noticed (1967) that ionizing radiation – which destroys nucleic acid – does not harm the infectious agent of scrapie. Because the spreading of kuru seemed to be a miracle and physicians were helpless, local people explained it as witchcraft. Gajdusek also concluded that the infective agent could not be a bacterium or virus: alien DNA or RNA could not be found in the brain cells of the victim. Stanley B. Prusiner has found that chemicals which destroy nucleic acids (like diethylpyrocarbonate) do not affect the infective effect.⁶

In the 1960s and 1970s the recognition emerged that there are other rare (isolated) diseases of the same type: the *scrapie* of sheep, the *mad-cow disease* (spongiform encephalopathy) rampant in Great Britain, the *Creutzfeldt–Jacob disease* among humans (producing a recent epidemic in the Orava region of Slovakia). Perhaps *Parkinson's disease* and even *Alzheimer's disease* of humans, too, belong to this category. Each of them attacks the central nervous system, producing similar symptoms, resulting in a sponge-like decay in the brain. As Gajdusek said, both *ritual cannibalism* (e.g. head hunting) and *high tech cannibalism* (e.g. human transplants) may infect people. Brain surgeons have a higher risk of being infected by Creutzfeldt–Jacob disease, and it can be transferred by (only classically disinfected) medical tools. One out of a million people get this disease, but thirty out of a million among Israeli Jews of Libyan origin get it – possibly because they consume the eyeball of sheep as a delicacy. The infection can be transmitted between animals and humans.

– *The kuru agent is the smallest and so far the most mysterious actor on the boundary between the living and the dead* – as GEORGE KLEIN has put it in his romantic description of the geographic, folkloric and scientific voyages of this Odysseus of the 20th century who has even been given the opportunity to experience being imprisoned in America.⁷ Stanley Prusiner gave the name *prion* (protein-like infectious particle) to the slow infectious agent. Gajdusek had assumed from the beginning that it was a protein. This protein has been successfully isolated from hamsters' brains and it has been sequenced. It seems now that it is present in the membrane envelope of the neuron cells, and – at a slow pace – it can transform the healthy proteins of the neighboring nerve cells to harmful ones, resulting in a sponge-form decay of the brain over a period of years. The physicist S. Griffith has assumed that the

⁶Ferenc Solymosy to the author, 1996

⁷George Klein: *The Way Out*, Stockholm, to be published, 1997

configuration of the defect protein with lowest energy differs from the normal configuration of the healthy protein, and the defect protein may force its alien configuration onto the normal proteins by contact; this is how the malevolent configuration may spread. As Charles Weissman has put it:

– *The advancement of the prion climbed from the Ditch of Doubt to the Mountain of Respectability but so far it hasn't reached the Peak of Universal Acceptance.*

Carleton D. Gajdusek received the 1976 Nobel Prize in medicine “for his discovery concerning new mechanisms for the origins and dissemination of infectious diseases.” The kuru is gradually disappearing nowadays due to the elimination of ritual cannibalism in New Guinea. But the Creutzfeldt–Jacob and Alzheimer syndromes are still among us. To understand them has been a Long March for Gajdusek: from learning Papua languages, observing native rituals, enjoying diversity of cultures, languages, and scientific ideas. Carleton speaks Dutch, English, French, German, Indonesian, Persian, Russian, Slovakian, Spanish, several languages from Papua New Guinea, Melanesia, Micronesia – and even understands Hungarian. George Klein used to quote him Hungarian poems from Babits and other 20th century poets.⁸ Gajdusek donated his rich and unique ethnographic collection of arts to the Peabody Museum in Salem. He dislikes the conformity of globalized TV culture, preferring diversity. – *Carleton, if anybody, is able to see our world from many diverse cultural vantage points simultaneously. He needs no visa when crossing the borders between Washington D.C. and the Stone Age.* – According to colleagues, – *we might never have an answer to these questions without Carleton's close contact with the natives and their culture.* – And in conclusion, let's listen to Carleton:

– *Life is much too valuable to be fettered with chains, too fleeting to be lived incompletely, too impersonal to be drenched in sentimentality, too promising to be channelled, too costly to be wasted on superficialities. Intensity, depth, antithesis, change – harmony and then dissolution in death. Pain is temporary and unimportant, only a sign that life is not lived in the right manner. To abandon oneself to pain and live in its ramification is a banality. When you feel pain, you should quickly change course in order to transform the pain into something superficial or else give up the ghost!*



⁸George Klein: *The Way Out*, Stockholm, to be published, 1997

Not all the explorers of the borders between exact science and life science were lucky enough to reach a quiet harbor and survive. ERWIN BAUER (1890–1942) was born in Hungary. He studied medicine in Budapest and Göttingen. In Budapest he became a member of the innovative circle of Leo Szilard, Arthur Koestler and others, enthused for the leftist revolutions in 1918 and 1919. Then after the rightist takeover, as a Jew and as a liberal, he emigrated. He obtained positions at the universities of Vienna, Göttingen, and Prague.

Bauer had an open look at life itself. He is one of the founders of theoretical biology, stating, – *Each living being is an open thermodynamical system, which is not in equilibrium with its environment.* – According to Bauer, *the survival of organisms having adjusted to the environment successfully is the conservative force in biology that stabilizes the species. Failures in the environment drive the formation of new species.* – These ideas serve as basics for today’s exact biology.

So far the story of Erwin Bauer runs parallel to that of his friends: exploring and trespassing borders between disciplines, countries, ideologies. Bauer did it in an even more consequent way: he accepted the invitation to Moscow University (1927), and later headed the Biology Institute of Leningrad University. Then under Stalin’s “cleansing” he was imprisoned (1937). His biologist friends tried to liberate him, but too late: he died of starvation in an unknown Soviet camp of political prisoners during World War II. His ideas survive in the book *Basic Principles of Pure Scientific Biology* (1920, printed in German, Russian, Hungarian).

An other Hungarian–Austrian–Canadian, *Ludwig von Bertalanffy* (1901–) applied system theory to biology.

When in 1919 THEODORE VON KÁRMÁN (Budapest-born inventor of the *streamline*) had to leave Hungary after World War I due to a extreme-right takeover, he said,

– *I had enough of politicians. Suddenly I was enveloped by a feeling that only science is lasting.*

After World War II GEORGE VON BÉKÉSY was forced to leave Hungary because of extreme-left rule. His message was shorter:

– *Experiments outlive politicians.*

Chain Reaction

*When humankind first came upon the scene,
It found a well-stocked larder at its disposal:
Man only needed to reach out his hand
To gather all he needed, fit for use.
And so he squandered all, without a thought,
Like maggots in the cheese, and in his stupor
Found time to dabble in romantic theories
And seek out stimulants and poetry.
But we, who are left with the last crumbs of cheese,
We must be prudent, since we've known for years
That our supplies are low and we might starve.
The Sun will cool down in four thousand years,
The Earth will yield no vegetation then;
And so we have but these four thousand years
To find something to take the place of sunlight,
And I believe our scientists can do it.¹*

Inspired by the great European ideas and revolutions, Hungarians rose against the foreign power in 1848. After a year and a half of struggle the Habsburg emperor asked for and received military help from the Russian czar. Thus the idea of Hungarian freedom and democracy was defeated (1849). The population retreated into passive resistance. Resignation and a sense of pessimism prevailed in the country. It was in this pessimistic mood, that – retired to his country estate – a Hungarian nobleman, Imre Madách (1823–1864) wrote a European masterpiece of Hungarian literature: *The Tragedy of Man* (1860). In this drama Adam is reincarnated in the great figures of history over and over again, in his search to find the purpose of human life. In scenes from the Garden of Eden, Egypt, Rome and Byzantium, he searches for new social models and reappears in the figures of Kepler and Danton; later on he becomes a capitalist entrepreneur. Finally, disappointed with financial power as well, he turns towards science to save mankind. In the scene staged in a laboratory of the future he listens to a lecture of the scientist quoted above. LEO SZILARD read the drama at the age of ten (1908), and as he said,

¹translated by George Szirtes

– *Apart from my mother's tales it had the most serious influence: I grasped early in life that "it is not necessary to succeed in order to persevere."*

In the 19th century the Sun was considered to be a hot gaseous sphere, gradually cooling by radiation. This gave a short time scale, reflected in the drama we quoted. According to the calculations of Lord Kelvin the whole Solar System could not be older than 20 million years. He supported this estimation by calculating the cooling time of the Earth, having started from a molten state. These arguments were so convincing that in 1860 Charles R. Darwin withdrew his thesis, expressed in *The Origin of Species*, that life on Earth had a history at least 300 million years long. At a meeting of the Royal Society in 1904, however, Rutherford called the attention of Kelvin to the possibility that radioactivity, this rich source of energy, may offer an escape from the controversy.

In his first geochronological paper (1923) GEORGE DE HEVESY more quantitatively elaborated the idea showing that after the discovery of radioactivity the scientist's fear in the drama was no longer justified. The half life of ^{238}U is 4.5 billion years, the resulting radioactive decay sequence terminates in the stable ^{206}Pb . The half life of ^{232}Th is 14 billion years, and its decay, through a number of unstable daughter elements, terminates in the stable ^{208}Pb . By comparing the amounts of uranium and thorium in the Earth's crust with the amount of the two lead isotopes, Hevesy re-estimated the age of our planet, and obtained something like 6 billion years (1930) – not a bad number, taking into account that he did not know how much lead was present at the beginning on Earth. (The Solar System is 4.5 billion years old; the crust of the Earth has an age of about 4 billion years.) Thus nuclear considerations helped to cure the pessimism of science. Hevesy reported about these new horizons in his Baker lecture held at Cornell University in Ithaca, U.S. (1932).

Let's listen now to another lecture, given by Professor Rufus.

LONDON 1933

– *... and so we can see, that radium, which presented itself to be a fantastic exception, a crazy opposite to everything that the best brains said and believed about the structure of matter, is similar to the other elements in its essence. Radium only does in a more forceful way what the other elements probably also do but unrecognizably slowly. The decay of the radium atom is like a single shout revealing a mob hiding in the darkness. Radium is an element which transmutes itself, but it is*

probable that all the other elements do the same at a less observable rate. Possibly uranium does so as well, as do the other materials in this test tube: thorium and actinium. I believe that we are at the beginning of a long story. The atoms – considered to be rigid, unpenetrable, indivisible, eternal, and lifeless till now – are containers of immense amounts of energy. This is the most marvelous outcome of our research. Not long ago we considered the atoms as bricks, reliable building blocks, to be units of lifeless mass. Now we see: these bricks are containers, treasures, full of the most powerful energy. This tiny bottle in my hand contains only half a liter of uranium oxide, about 400 grams of uranium is in it, it costs only one pound. Ladies and Gentlemen, in this bottle the atoms hide energy which is equivalent to 160 tons of burning coal. If – on my command – this energy would be liberated, the explosions would turn all of us, and every object in this room to dust. If we were able to transfer this power to an electric plant, that would illuminate Edinburgh for a week. But yet nobody is able to say, how we could force this small piece of matter to release its energy faster. Uranium transforms to radium very slowly, radium makes radon and so on. The transmutation is progressing, releasing just a bit of energy in each step, until we reach lead. But we are unable to accelerate this process. Why does it go so slowly? Why do we obtain only a tiny fraction of the energy during each second? Why doesn't the whole material immediately change to an element of lower order? Why can we not speed up the transformation? By possessing the knowledge, we could transform a handful of uranium and thorium into a source of energy, which would be enough to illuminate a city for a year, which could defeat a fleet, which could drive a ship across the ocean. Can you imagine, Ladies and Gentlemen, what all this would mean for humankind? The importance of this discovery would be comparable to the invention of fire that raised humans above animals. We face radioactivity now as our ancestors watched fire before they were able to ignite it for their service. Our ancestor considered fire as an alien beyond his power, like a volcanic eruption, like a red fire storm running through the forest. This is how we now look at radioactivity. But we are at the dawn of a new era. At the pinnacle of civilization, which started with the stone axe and the fire making stick of cave men, just when we face difficulties satisfying our energy need, we glimpse the possibility of a very new civilization. Energy – that was never sufficient for us in the past – is here all around us in plenty, we only have to find a key to the lock – but we'll find it! – This lecture of Professor Rufus occurs in the novel *The World Set Free*, written by H.G. Wells in 1913 (published in Hungarian in 1922). LEO SZILARD was deeply

We might in these processes obtain very much more energy than the proton supplied, but on the average we could not expect to obtain energy in this way. It was a very poor and inefficient way of producing energy, and anyone who looked for a source of power in the transformation of the atoms was talking moonshine. But the subject was scientifically interesting because it gave insight into the atoms.

impressed by this book, in which Professor Rufus discovered a way to speed up radioactivity in 1933. From fiction let us go now to the real 1933. Szilard said, that²

– I found myself in London, and in the 11 September 1933 issue of "The Times" [facsimile] I read a speech by Lord Rutherford given at the British Association under the headline BREAKING DOWN THE ATOMS. He was quoted as saying that anybody who talks about the liberation of atomic energy on an industrial scale is talking moonshine. This sort of talk set me pondering as I was walking the streets of London. I remember that I stopped for a red light at the intersection of Southampton Row, waiting for the light to change. As the light changed to green, it suddenly occurred to me that if we could find an element which is split by neutrons and which would emit two neutrons when it absorbed one neutron, such an element, if assembled in sufficiently large mass, could sustain a nuclear chain reaction. I did not see at the moment just how one would go about finding such an element, what experiments would be needed, but the idea never left me. Under certain circumstances it might become possible to set up a nuclear chain reaction, liberate energy on industrial scale, and construct atomic bombs. The thought that this might be in fact possible became a sort of obsession with me.

This is a story, which – like Hevesy's story with Rutherford – might include legendary elements: according to his friends, Szilard was never stopped by any red traffic light. It is a fact, that *Nature* reported in its 12 September 1933 issue: – *One timely word of warning was issued by Rutherford to those who look for sources of power in atomic transmutations: such expectations are the merest moonshine.* – But Szilard was

²Leo Szilard: *His Version of Facts*, 1978

somehow prepared to save the world. He was forced to escape from Hungary in December of 1919, because he took part in the revolutionary youth movement and at the age of 20 he propagated his ideas of socialist economic reform – an activity not appreciated by the rightist military power established in November of 1919. Szilard emigrated to Berlin. Hitler caught power in 1933. Szilard left Berlin on the very last train crossing the German border which was not checked for Jews trying to leave the country. In London he organized invitations, jobs and escape routes for scientists from Germany; he was perfectly aware that the world needed to be saved – possibly by science. A favorite book during his youth was Madách's *The Tragedy of Man*, from which we took our introductory quote. The other favorite reading of Leo Szilard was *The World Set Free*, in which Professor Rufus liberated nuclear power. Szilard noted, – *All the things H.G. Wells predicted suddenly appeared real to me!* – Szilard visited H.G. Wells and sent a copy of *The World Set Free* to Sir Hugo Hirst, chairman of the British Electric Company (17 March 1934) with the comment:

– *Of course, all this is moonshine, but I have reasons to believe that in so far as the industrial applications of the present discoveries in physics are concerned, the forecast of the writers may prove to be more accurate than the forecasts of the scientists.* – Szilard visited Lord Rutherford, asking for support. Enter EDWARD TELLER:

– *In the fall of 1933 I went to England. There was a meeting of physicists, and Lord Rutherford was the speaker. Rutherford was speaking for ten to fifteen minutes about some crazy people believing in the utilization of nuclear energy. But this was impossible, he claimed. The energy of the nucleus is interesting only for physics itself, it cannot be utilized for anything. I cannot repeat Rutherford's words, as he was explaining it for a quarter of an hour, but this was essentially what he said. I could not understand what happened to him. But after this, the very same week, an old friend of mine met me in London, Leo Szilard. He told me that he had visited Rutherford and told him that nuclear energy could be utilized, and enormous explosions could be generated. In response, Rutherford threw him out of his office. Rutherford got so excited, that even some time later the only thing he could talk about was proving what nonsense this idea was.³*

Szilard visited other *physicists* as well, like G.P. Thomson and M.S. Blackett, trying to obtain their co-operation for the intended experi-

³Budapest lecture 1993

ments, but without success. Blackett replied, – *Look, you will have no luck with such fantastic ideas in England. Yes, perhaps in Russia. If a Russian physicist went to the government and said, “We must make a nuclear chain reaction,” they would give him all the money and facilities that he would need. But you won’t get that in England.* – (He was rather right. In 1928 George Gamow gave a lecture in Leningrad about the nuclear origin of solar energy based on the works of Robert Atkinson and Fritz Houtermans. After the lecture, Gamow was approached by Bukharin, who was then responsible for technological development in the Soviet Union. Bukharin asked Gamow – *whether nuclear processes, similar to those occurring in the Sun, could be harnessed to some direct application here on Earth.* – He offered to turn over to Gamow the Electric Works of Leningrad nighttime. But Gamow soon fell out of grace because he preached such heretical ideas as quantum mechanics, therefore he lost his professorship in Leningrad. He moved via Copenhagen to Washington. (A few years later Bukharin was to be executed, to resurface in Koestler’s *Darkness at Noon*, in the figure of Rubasov.)⁴

Szilard found greater interest among *chemists*, who knew chemical chain reactions like fire. MICHAEL POLANYI, an expert in chemical chain reactions catalyzed by free radicals was especially interested. (Michael Polanyi was the professor of physical chemistry in Manchester, former assistant of GEORGE DE HEVESY in Budapest, Ph.D. adviser of EUGENE P. WIGNER in Berlin.) On 11 November 1934 Polanyi asked Szilard, – *Will you let me report to Aschner that you are in the process of making great inventions and I would see a favorable opportunity for interest?* – (Lipót Aschner was the research supporting director of the Tungsram Company in Budapest. But nuclear power was not liberated in Budapest in the 1930s.) In another letter, dated 28 June 1935, Polanyi wrote,

My dear Szilard, I gather from my talk with Weizmann that he is favorably inclined towards the foundation of a research corporation.
Yours M.P.

Chaim Weizmann, another chemist (later the founding president of Israel) tried to collect the 2000 pounds asked by Szilard for the experiments, but in vain. Finally, on 12 March 1934 Szilard decided to apply for a patent of *“a chain reaction which goes with neutrons. This chain can be realized only with metastable elements. Such an element captures a single neutron, and the liberated binding energy should be enough to*

⁴Ralph Alpher to the author 1992

make the element decay, liberate energy and emit two neutrons. (The metastability of uranium and thorium is shown by their α -decays.) There is a small but nonvanishing chance that explosives constructed according to this principle may become many thousands of times more efficient than customary bombs." The patent was issued under No 440 023 – and classified as secret by the British Admiralty at the request of Leo Szilard. (Several patented improvements followed, describing that the reacting material has to exceed a *critical mass* to make the number of neutrons in the *volume*, carrying the chain reaction on, larger than the number of neutrons escaping through the *surface*.)

Szilard suggested several elements as possible candidates. His favorite was beryllium. (It was well known that the ^8Be isotope was completely unstable: it immediately splits into two ^4He nuclei. Therefore Szilard suggested the $n + ^9\text{Be} \rightarrow 2\ ^4\text{He} + 2\ n$ reaction. Beryllium is rather expensive. This is why he needed the 2000 pounds, which Weizmann tried to collect unsuccessfully.) Later on it turned out that Aston's mass spectroscopic measurements about the mass defect of ^4He were wrong; the reaction can indeed occur, but instead of liberating energy, it consumes energy. Another Hungarian *chemist*, EUGENE P. WIGNER called Szilard's attention to this fact, with only moderate success. Nevertheless, – *I watched Szilard's efforts with great interest,⁵ it did not contradict any known physical principle. Controlled nuclear energy seemed to be only a question of time. I told this to a man from the General Electric Company in late 1935 who consulted me on other business. And I said as much to friends. In the spring of 1935, I gave a short lecture to a popular discussion group in Madison (Wisconsin, U.S.) and predicted we would have nuclear energy production in five years. But I had very little basis for that predicted number. And I did not expect myself to play a vital role in producing it.* – Well, Wigner was wrong: igniting the second fire took two years more than he foresaw.

When Hitler's ambitions became more frightening in Europe, Szilard emigrated to America, as Wigner and others did. There Szilard obtained funds and checked various elements, looking in vain for $n \rightarrow 2n$ reactions. Finally he gave up. On 21 December 1938, he sent a letter to the London Patent Office:

It does not now seem necessary to maintain the patent 8142/36.
I therefore beg for the patent to be withdrawn altogether.

⁵Wigner said to the author

NEW YORK 1939

The neutron was discovered by James Chadwick in the laboratory of Lord Rutherford (1932), but Enrico Fermi was who recognized the importance of the discovery: neutrons are neutral, therefore their entrance into the nucleus is not prevented by any electric barrier. Neutrons are advantageous tools for producing nuclear reactions (1934). EDWARD TELLER visited Fermi, and, as he recalled:⁶

– Fermi irradiated the elements one by one with neutrons. The excess neutrons made the nuclei radioactive. As he reached uranium, he observed not only a single sort of radioactivity, but a lot of them. Fermi concluded that this uranium – being over-rich in neutrons – transformed to a sequence of transuranic elements. (For that Fermi received the 1938 Nobel Prize in physics.) Ida Noddack – who herself discovered two new elements: rhenium and masurium, (rhenium does indeed exist but the “discovery” of masurium was a mistake) – published a paper proposing that the complex radioactivity pattern may indicate the splitting of the uranium nucleus into two fragments. This caused Fermi to calculate that possibility, but he concluded that splitting could not occur because of energy considerations. And his calculations were correct. The only problem was that his calculations were based on an incorrect measurement of atomic masses by Aston. – Still, Fermi almost observed splitting. What he was studying was whether the energy of some emitted α -particles would be larger if the uranium nucleus captured more neutrons. He was observing the reaction with a Geiger counter. In this way he ought to have observed the highly ionizing fragments. But – unfortunately – Fermi was too good at experimenting, and did not want α -particles of low energy to disturb his measurements. Thus he covered the uranium target with a thin absorbing foil, so that only α -particles of high energy could pass through. This was the way he lost the highly charged, strongly ionizing, thus easily absorbed fragments. The splitting of the uranium nucleus was flirting with Fermi. – There was another famous physicist who almost discovered the splitting of uranium: Scherrer in Switzerland. He conducted an experiment similar to that of Fermi, and his Geiger counter indicated huge electric pulses. Scherrer called the maintenance workshop and complained: “The counter functioned all right yesterday, and today it has become faulty: it indicates enormous pulses.” – It is worth meditating about this for a moment. In 1932 Hitler was not yet in power. If in 1932

⁶in a lecture in Budapest, 1993

we had known about uranium splitting, it is impossible to tell who would have continued to work on it and what it would have been used for. The splitting of the uranium nucleus – as we all know – was actually discovered only at the end of 1938.

Germans excel in accurate chemistry. In the Kaiser Wilhelm Institute in Berlin, Otto Hahn and Fritz Strassmann intended to identify chemically the new transuranic elements obtained with Fermi's method. One of the radioactive products looked suspiciously like radium: at the addition of sulfuric acid it went from solution to precipitate as barium and its chemical relative, radium used to do. Now they carefully separated barium and radium, but the new radioactivity remained with barium. Conclusion: neutron + uranium gave barium, and that could only mean that the uranium nucleus did not increase but split into two parts. Their discovery – made in December, 1938 – was published in the German journal *Naturwissenschaften* on 6 January 1939.

Otto Frisch observed the large spikes from uranium splitting. It has become clear to him that the energy of the fragments was very much larger than that of the α -particle coming from a radioactive decay. The liberated energy corresponded to about 10 % of the mass of a proton! Lise Meitner soon explained that the splitting of the uranium nucleus was indeed possible: the electric repulsion between its two positive fragments results in a great deal of energy. William A. Arnold, a Rockefeller fellow, was studying radioisotope tracing under GEORGE DE HEVESY in Copenhagen. Frisch asked Arnold, – *You work in a microbiology lab. What do you call the process in which one bacterium divides into two?* – Arnold answered, – *Binary fission.* – So Frisch decided to call the uranium splitting “fission.”⁷ That same winter Niels Bohr was invited for a lecture tour in the United States. He heard from Frisch about Hahn's and Strassmann's observation before his departure from Copenhagen, but he received the final explanation of the phenomenon given by Lise Meitner on the boat Drottingholm on his way to New York. On 16 January 1939 the Drottingholm landed in New York. John A. Wheeler was waiting for Bohr at the pier. During the customs formalities, Bohr told him the incredible news about splitting the atom. (The word “atom” means unsplitable in Greek.) Wheeler was awestruck:

– *I felt like Adam extending his finger in the painting by Michelangelo in the Sistine Chapel: God had passed the Message!* – Then Bohr went to Princeton. EUGENE P. WIGNER recalled:⁸

⁷Richard Rhodes: *The Making of the Atomic Bomb*, 1986

⁸in an interview with Andrew Szanton in 1991

– I was laid up in the hospital for about six weeks with jaundice. Leo Szilard was staying in my apartment. He came by the infirmary nearly every day to see me and raised my spirits with gentle Hungarian conversation. I appreciated that tremendously. One morning⁹ Szilard came to my bed and said: “Wigner, now I think there will be a chain reaction.” He meant that nuclear fission would make it possible. I disagreed at first, but soon I saw that of course he was right. I had miscalculated how neutron-rich the fission fragments were. Science had already understood chemical chain reactions. In the course of these talks in the Princeton infirmary, Szilard and I developed all of the essential points of fission theory.

Szilard and Wigner were what Alvin Weinberg called *predisposed minds*. The equilibrium percentage of neutrons in uranium is much higher than in its fragments, chemical elements located in the middle of the Periodic Table, thus there is a good chance for the $n \rightarrow 2n$ reaction to occur. And that was what Szilard was desperately seeking to accomplish. He immediately recognized that uranium fission would result in the liberation of nuclear energy. On 26 January 1939 a cable went to the British Admiralty:

REFERRING TO CP10 PATENTS 8142/36 KINDLY DISREGARD
MY RECENT LETTER STOP LEO SZILARD

At this time George Gamow was already a professor at George Washington University in Washington, D.C. In 1939 a theoretical symposium was organized and Bohr was also invited. On 25 January 1939, the night before the symposium, Gamow rang his co-worker, EDWARD TELLER, and said, – *This Bohr has arrived but he has gone crazy! He says the uranium nucleus splits!* – Knowing of Fermi’s experiments, Teller was not so convinced that Bohr was crazy. The next morning (instead of the planned session on low temperature physics) Bohr gave a lecture on nuclear fission, followed by Gamow’s and Wheeler’s interpretation in terms of the liquid drop model of the nucleus. According to Gamow, – *Bohr and Fermi, both armed with chalk, started an animated discussion near the blackboard. Tuve, recognizing that this discussion might be of paramount importance, escorted out two journalists covering the meeting.* – During the following night, in the Carnegie Institution’s Department of Terrestrial Magnetism, the fission experiment was successfully repeated by Merle Tuve, using neutrons produced with the help of

⁹after the Princeton talk of Bohr

the 2 million volt Van de Graaff generator. Bohr, Teller, and others were invited to be present. As Teller said, – *It was unbelievable: the experiment is one of the easiest to perform, yet it still took six years to understand what was actually happening!*¹⁰ – At 19th and G Streets N.W. in Room 202 there is a bronze plaque bearing this inscription:

IN THIS ROOM, JANUARY 26, 1939, NIELS BOHR MADE THE FIRST PUBLIC ANNOUNCEMENT OF THE SUCCESSFUL DISINTEGRATION OF URANIUM INTO BARIUM WITH THE ATTENDANT RELEASE OF APPROXIMATELY TWO HUNDRED MILLION ELECTRON VOLTS OF ENERGY PER DISINTEGRATION.

George Gamow and Edward Teller organized the Washington Conferences on Theoretical Physics, this was the fifth one. On 27 January 1939 in the evening Teller was relaxing at home after all the organizational work related to the symposium when his phone rang: – *Teller, this is Szilard. I am at Union Station, could you come and get me?* – Szilard had just arrived by train from Wigner to Washington, in order to discuss the implication of nuclear fission with his other Hungarian friend, Teller. And so they did till late in the night. Teller offered hospitality, but when Mrs. Teller showed Szilard the guest room, he inquired, – *Is there a hotel nearby?* – Yes, there was. Teller's house was just behind the Wardman Park Hotel. Szilard relaxed, – *Good! I just remembered sleeping in this bed before. It is much too hard.*

– *Soon thereafter Niels Bohr and John Wheeler published their own superb paper on the fission theory* – Wigner remembered. Considered to be a very modest person, we may believe what Wigner has said: – *Reading the work I was pleased to see that in comparing the stabilities of uranium nuclei, Szilard and I had seen farther ahead than those two on several points. Szilard correctly predicted that neutrons would be emitted during the fission process, a result that Bohr and Wheeler doubted. But neither Szilard nor I realized that the fission induced by slow neutrons was due solely to the ²³⁵U isotope; that vital insight belonged to Niels Bohr alone, Szilard and I were skeptical of it until it was verified experimentally. By April 1939, we saw two distinct ways to obtain a fission chain reaction. A chain reaction with slow neutrons looked possible, but for power production only. A fast neutron process looked feasible, but only for violent explosions. Niels Bohr and John Wheeler felt that the chain reaction could not be achieved, except perhaps at low temperatures.*

¹⁰Alpher and Teller to the author 1992

In a debate Wigner argued in favor of nuclear power. Bohr disagreed. When Isaac Rabi¹¹ informed Fermi at Columbia about Szilard's ideas, Enrico Fermi reacted in a similar way, – *Nuts*. – When Szilard learned this, both Rabi and Szilard went back to Fermi's office, asking Fermi for a more detailed answer. Fermi said, – *Well, there is a remote possibility that neutrons may be emitted in the fission of uranium and then of course perhaps a chain reaction can be made*. – Rabi asked what Fermi meant by "remote possibility." – *Perhaps ten percent*. – At this point Rabi exploded, – *Ten percent is not a remote possibility if it means that we may die from it. If I have pneumonia and the doctor tells me that there is a remote possibility that I might die, and it's ten percent, I would be upset about it*.

Szilard, Teller and Wigner were Central European refugees who had first hand experiences with Nazism and anti-Semitism. The atomic bomb must not fall into Hitler's hands! Fission had been discovered in Berlin. The three Hungarians agreed that full secrecy must be imposed immediately. On 2 February Szilard wrote to *Frédéric Joliot-Curie* (who was an excellent nuclear physicist and, as a communist, no admirer of the Nazis):

When Hahn's paper reached this country about a fortnight ago, a few of us became interested at once regarding the question whether neutrons are liberated in the disintegration of uranium. Obviously, if more than one neutron were liberated, a sort of chain reaction would be possible. In certain circumstances this might then lead to the construction of bombs which would be extremely dangerous, especially in the hands of certain governments. Should you come to the conclusion that publication of matters should be prevented, your opinion will certainly be given very serious consideration in this country.

Yours sincerely, Leo Szilard.

Weisskopf wrote to Blackett and Wigner wrote to Dirac (his brother-in-law) insisting upon full secrecy about the English fission research. Eventually the Englishmen agreed to maintain that secrecy.

Szilard borrowed 2000 dollars from a friend and rented radium and beryllium to make a neutron source. The neutrons were slowed down by paraffin, as in Szilard's previous experiments. During the evening of 3 March 1939, on the 7th floor of the Pupin Lab at Columbia University, LEO

¹¹a Columbia University physicist, born in Galicia, a couple of miles from the Hungarian border

SZILARD and Walter Zinn, a Canadian, watched the neutron counter to see whether neutrons would be produced in uranium fission. – *We turned the switch and we saw the flashes. That night there was very little doubt in my mind that the world was headed for grief.*¹² – During the same evening, Teller was relaxing while playing Mozart on his piano, when his phone rang: – *Megtaláltam a neutronokat!* – (For security reasons Szilard spoke Hungarian, meaning: “I have found the neutrons.”) As Szilard recalled in his response at receiving the Atoms for Peace Award in 1960, he had told himself that night: – *H.G. Wells! Here we come!*

Fermi decided to make a similar experiment in the basement of Pupin Hall at Columbia, but he was less successful because he used fast neutrons. Then he borrowed Szilard’s slow neutron source and observed the neutrons from fission in a completely different experimental arrangement. Anderson, Fermi, Hanstein, and also Szilard and Zinn sent their reports to the *Physical Review* on 16 March asking that the papers be registered, but not printed till further notice.

On 8 March 1939, the Joliot-Curie group observed an unknown quantity of neutrons during fission. They mailed their report to *Nature*; on 18 March the paper was published. On 16 March Halban, Joliot-Curie, and Kowarski had observed three to four neutrons per fission; they sent a new report to *Nature*. On 31 March Weisskopf sent a cable from Princeton to Paris in an effort to convince Halban and Joliot-Curie about the importance of secrecy. Finally, on 6 April, a cable arrived from Joliot-Curie:

QUESTION ETUDIEE SUIIS D’AVIS MAINTENANT PUBLIER
AMITIES JOLIOT¹³

The dam was broken and secrecy was withdrawn. On 15 April the *Physical Review* published the paper of Anderson, Hanstein, and Fermi and that of Szilard and Zinn, both dated 16 March 1939: about two neutrons are produced by fission. On 22 April *Nature* published the paper by Halban, Joliot, and Kowarski, dated on 21 March 1939: three to four neutrons are produced by fission. Seeing these printed reports, G.P. Thomson then suggested to the British Government, Georg Joos proposed to the German Minister of Culture, Paul Harteck and Wilhelm Groth recommended to the German Military Command, that research should be started on nuclear weapons. Later on Georgi Flerov wrote a similar letter of recommendation to Stalin. The race was on.

¹²Leo Szilard: *His Version of Facts*, 1978

¹³Question studied, my opinion is to publish now, regards, Joliot

LONG ISLAND 1939

Natural uranium contains two isotopes: 99.3 % of ^{238}U with a long half life of 4.5 billion years (this is about the age of the Earth), and 0.3 % of ^{235}U with a half life of 0.7 billion years. (Most of the ^{235}U has decayed since the formation of our planet.) As Bohr and Wheeler pointed out in their paper (published in the *Physical Review* on 1 September 1939, on the same day when World War II broke out), only ^{235}U was able to split with a high probability, while releasing energy and 2–3 *fast neutrons*. These neutrons have to be slowed down by collisions to produce new fissions, to feed the chain reaction. But the ^{238}U majority likes to capture the neutrons already at medium energies, to make ^{239}U , which does not split but decays into transuranic atoms.¹⁴ This is why a *moderator* is required: the fast neutrons must not collide with the ^{238}U ; they have to be slowed down completely outside the uranium blocks by colliding elastically with inert light nuclei. When a random walk brings the *slow neutron* back to a uranium block, it produces a new fission of ^{235}U , giving new neutrons.

As summer – and World War II – approached, Anderson, Fermi and Szilard began discussing the experimental realization of a neutron chain reaction. In June they published a design for a uranium reactor with water serving as moderator in the *Physical Review*. The moderator material must not absorb neutrons in considerable quantity. George Placzek (a Czech emigree) explained to them that a uranium–water design would not work due to the neutron absorbing property of the hydrogen in water: $n + {}^1\text{H} \rightarrow {}^2\text{H}$. Placzek suggested helium gas as a moderator. Instead of using a gas of low density, LEO SZILARD came up with the idea of using graphite as a moderator. The calculations were promising, so Szilard rushed to Enrico Fermi, proposing to build a uranium–graphite reactor. Fermi said that he had also been thinking about carbon as a moderator, but his calculations were less promising. The reason for the difference was that Fermi considered a homogenous mixture of uranium and coal (possibly to make the calculation simpler); Szilard, however, proposed an *inhomogeneous reactor*: uranium rods (thinner than the mean free path of neutrons, to allow the fast neutrons from uranium fission to leave the uranium rod), and a plentiful supply of graphite blocks (to offer the neutrons a chance to collide with ^{12}C atoms several

¹⁴Resonance absorption of neutrons had been studied by Eugene Wigner in detail already in 1939.

Nach eingehender Besprechung des im nachfolgenden geschuldeten Sachverhaltes halten wir es für unsere Pflicht Ihnen unser für den belgischen Staat möglicherweise wichtigeren Tatbestand mitzuteilen.

Die experimentellen Erfahrungen der allerletzten Zeit lassen es als nicht nur möglich sondern also geradezu wahrscheinlich erscheinen, dass das ~~Element~~ Uran künftig für Kriegszwecke von ~~der~~ eminenten Bedeutung werden wird. Es sind nämlich Dinge bekannt geworden um den ungeheuren ~~Umsatz~~ Preiswertigkeit, Zerfall dieses Elements ~~zur~~ Erzeugung von ~~unvergleichlich~~ ^{unvergleichlich} größerer Wirkung künstlich ~~zu~~ ^{zum Teil} ~~herbeiführen~~ ^{publiziert}, die entsprechenden Tatsachen sind ~~aus~~ ^{aus} den letzten Ketten des ~~Uran~~ ^{Uran} zum Teil sind sie uns dadurch bekannt, dass Dr. sine ~~us~~ ^{us} (L.S.) zusammen mit Professor Fermi an der Columbia University ~~weiter~~ ^{weiter} eingehend Versuche ausgeführt hat, die unveröffentlicht sind.

Es ist mit Sicherheit zu erwarten, dass der Tatbestand in kürzester Zeit die Aufmerksamkeit der Militärmächte auf sich ziehen wird und dass eine Jagd nach Uranerzen in kürzester Zeit einsetzen wird.

Es gibt nur wenige Bisher sind nur wenige von neuwertigen Mengen erhaltene Uranerzlagierungen bekannt: 1. in Tschechoslowakei 2. Canada 3. in Belgisch Congo 4. kleinere zerstreute Ablagerungen an anderen Stellen.

Es scheint also als ein Akt der elementarsten Treupflicht sicherzustellen, dass die für ~~unser~~ ^{unser} belgischen ~~die~~ ^{die} ~~unser~~ ^{unser} ~~alle~~ ^{alle} ~~Elemente~~ ^{Elemente} die reichhaltigsten und schon ~~unser~~ ^{unser} ~~erschaltete~~ ^{erschaltete} ~~mit~~ ^{mit} ~~den~~ ^{den} ~~Belgier~~ ^{Belgier} ~~potenziellen~~ ^{potenziellen} ~~Segnern~~ ^{Segnern} Belgiens fallen können. ~~Es~~ ^{Es} ~~ist~~ ^{ist} ~~hingegen~~ ^{hingegen} ~~Bezeichnend~~ ^{Bezeichnend} ist es jedenfalls, dass die Deutschen, ~~die~~ ^{die} ~~noch~~ ^{noch} ~~vor~~ ^{vor} ~~dem~~ ^{dem} ~~Uran~~ ^{Uran} ~~zum~~ ^{zum} ~~Verkauf~~ ^{Verkauf} ~~angeboten~~ ^{angeboten} haben, neuerdings ~~nach~~ ^{nach} ~~dem~~ ^{dem} ~~nicht~~ ^{nicht} ~~mehr~~ ^{mehr} ~~bereit~~ ^{bereit} ~~sind~~ ^{sind} ~~nach~~ ^{nach} ~~Ausland~~ ^{Ausland} ~~zu~~ ^{zu} ~~verkaufen~~ ^{verkaufen}.

Es durch Verkauf oder auf sonstige Weise

Die unterzeichneten halten es für angemessen ~~zu~~ ^{zu} den im Entwurf beiliegenden Brief an den belgischen Gesandten in Washington zu ~~schicken~~ ^{schicken}. Wir werden diesen ~~Brief~~ ^{Brief} am 20 ten die es Monats ~~sein~~ ^{sein} falls wir nicht von Ihnen in der Zwischenzeit hören dass dies ~~unser~~ ^{unser} ~~wünscht~~ ^{wünscht} ist.

benutzt werden kann als alles was bisher bekannt ist

times before reentering a uranium rod, until they lose their energy). In July, the idea of a nuclear reactor seemed promising. Fermi tried to approach the U.S. Navy to explain the reactor and get support, but in vain. The Navy distrusted a stranger from an enemy country. So Fermi left for a holiday.

In New York EUGENE P. WIGNER visited Szilard, who explained his calculations about the inhomogeneous uranium-graphite reactor. Wigner understood and became concerned. They agreed that Belgium should be warned not to let the Germans get hold of uranium imported from the mines in the Congo. Both Wigner and Szilard were on good terms with Albert Einstein. Wigner remembered that Einstein knew the Queen of Belgium. On a summer Sunday, 16 July 1939, Wigner drove Szilard to Einstein, who was spending the holiday in Peconic, Long Island, in Mr. Moore's cabin by the sea. Szilard and Wigner searched for half an hour, asking every adult about the location of Moore's cabin, but no one knew. Finally Szilard asked a seven-year old boy, – *Say, do you by any chance know where Professor Einstein lives?* – The boy knew, guided them there, though he had never heard of Mr. Moore's cabin.

Einstein did not feel at home with nuclear physics, perhaps because he disliked quantum mechanics. This was the first occasion Einstein had heard about the possibility of a chain reaction, but he understood it quickly – in about 14 minutes.¹⁵

Einstein then dictated a letter to Belgium in German, and Wigner scribbled down his words [facsimile on page 38]. They left. Wigner translated the German text into English, gave it to Szilard, then travelled to California for the rest of the summer.

Szilard began to think that it was not such a good idea to spread the news abroad of the possibility of a nuclear chain reaction. He found a contact to Alexander Sachs who previously had worked on the New Deal of President Roosevelt. Sachs said that if Einstein were to write a letter, he would be ready to personally deliver it to the President. On 19 July 1939 Szilard wrote to Einstein:

I have drafted a letter containing what I believe should be said. I would like to ask Teller to take me, not only because I believe his advice is valuable but also because I think you might enjoy getting to know him.

¹⁵Wigner to the author in Budapest 1983

Hotel King's Crown
420 West 116th Street
New York City

August 9th, 1939

Dear Wigner:

As Teller has already told you it has been decided, following up your initiative, to withhold the letter to the Belgian Ambassador and to substitute for the letter to the State Department a rather different letter to the President. This letter, which is written by E. and has been sent to me to be forwarded, will not be sent by post but handed over to a vice-president of the Lehman Corporation who promised that he will see to it that it gets attention. The only suggestion made in that letter is that the president appoint a person who could serve - perhaps in an inofficial capacity - as a permanent link between the Administration and the physiscists and fulfill a double function, i.e. make recommendations to Government departments and see to it that private funds are provided for accelerating the experimental development.

It seems to me important that you should not talk about this to any third person. I shall let you know if anything develops out of this attempt. Perhaps you could drop me a line, letting me know what your present address is.

Yours



He informed Wigner as well about the new strategy by mail [facsimile]. – EDWARD TELLER owned a 1935 Plymouth car. Enter Teller:¹⁶

– *After the discovery of nuclear fission, people said that a lot of things would be affected by this discovery and it was worthwhile to work on it. The Americans' opinion was negative. But by accident, there was a Hungarian there, Leo Szilard. He was a versatile person. He was even capable of explaining to the Americans the concept of a nuclear chain reaction. Yet there was one thing that even Szilard could not do: drive a car. In the summer of 1939 I was working at Columbia University in New York just like Szilard. One day Szilard came up to me and said, "Mr. Teller, I am asking you to drive out with me to Einstein." (He was never thousing me, never called me by my first name. We had been very good friends, but I was never Ede or Edward, to Szilard I was Mr. Teller.) So, out we drove on 2 August. The only problem remaining was, that Szilard again did not know where Einstein was staying for the holidays. We started asking around but nobody knew. We asked an eight-year old girl – she had a nice pony tail – where Einstein was living. She did not know either. Finally Szilard said, – "You know he is that old man with long, flowing white hair." – "He's staying in the second house!" – We entered; Einstein was cordial, offered tea to Szilard, and being democratic, he invited in the chauffeur as well. Szilard pulled a letter from his pocket addressed to President Roosevelt: SIR, SOME RECENT WORK BY ENRICO FERMI AND LEO SZILARD, WHICH HAS BEEN COMMUNICATED TO ME IN THE FORM OF A MANUSCRIPT, LEADS ME TO EXPECT THAT THE ELEMENT URANIUM MAY BE TURNED INTO A NEW AND IMPORTANT SOURCE OF ENERGY IN THE IMMEDIATE FUTURE.... (The style of the letter reflected more of Szilard than Wigner; it never said "Please.") Einstein read it slowly and said, – "Well, this will be the first case when we use nuclear energy directly, not indirectly (by the Sun producing it, and we are gaining light from the Sun)." – And with these words he signed the letter: "Albert Einstein." Szilard never mailed this letter to President Roosevelt; that would have been a great mistake. That way the letter would have ended up in the hands of a mere secretary, and that the President would have never seen it. Instead – as I said, it was at the beginning of August – Szilard handed the letter to one of his friends, a banker, who knew the President personally. Roosevelt received the letter from Dr. Sachs on 3 October. He could not have received it at a better time. Nazi Germany and*

¹⁶Budapest lecture 1993

Albert Einstein
 Old Grove Rd.
 Massau Point
 Peconic, Long Island

August 2nd, 1939

F.D. Roosevelt,
 President of the United States,
 White House
 Washington, D.C.

Sir:

Some recent work by E. Fermi and L. Szilard, which has been communicated to me in manuscript, leads me to expect that the element uranium may be turned into a new and important source of energy in the immediate future. Certain aspects of the situation which has arisen seem to call for watchfulness and, if necessary, quick action on the part of the Administration. I believe therefore that it is my duty to bring to your attention the following facts and recommendations:

In the course of the last four months it has been made probable - through the work of Joliot in France as well as Fermi and Szilard in America - that it may become possible to set up a nuclear chain reaction in a large mass of uranium, by which vast amounts of power and large quantities of new radium-like elements would be generated. Now it appears almost certain that this could be achieved in the immediate future.

This new phenomenon would also lead to the construction of bombs, and it is conceivable - though much less certain - that extremely powerful bombs of a new type may thus be constructed. A single bomb of this type, carried by boat and exploded in a port, might very well destroy the whole port together with some of the surrounding territory. However, such bombs might very well prove to be too heavy for transportation by air.

-2-

The United States has only very poor ores of uranium in moderate quantities. There is some good ore in Canada and the former Czechoslovakia, while the most important source of uranium is Belgian Congo.

In view of this situation you may think it desirable to have some permanent contact maintained between the Administration and the group of physicists working on chain reactions in America. One possible way of achieving this might be for you to entrust with this task a person who has your confidence and who could perhaps serve in an unofficial capacity. His task might comprise the following:

a) to approach Government Departments, keep them informed of the further development, and put forward recommendations for Government action, giving particular attention to the problem of securing a supply of uranium ore for the United States;

b) to speed up the experimental work, which is at present being carried on within the limits of the budgets of University laboratories, by providing funds, if such funds be required, through his contacts with private persons who are willing to make contributions for this cause, and perhaps also by obtaining the co-operation of industrial laboratories which have the necessary equipment.

I understand that Germany has actually stopped the sale of uranium from the Czechoslovakian mines which she has taken over. That she should have taken such early action might perhaps be understood on the ground that the son of the German Under-Secretary of State, von Weizsäcker, is attached to the Kaiser-Wilhelm-Institut in Berlin where some of the American work on uranium is now being repeated.

Yours very truly,

A. Einstein
 (Albert Einstein)

the Soviet Union had just occupied and divided Poland. By that time an intelligent man like Roosevelt could clearly see: great danger had arrived, it was imminent, the danger was on the doorstep. Right away he wrote to the head of the National Bureau of Standards: "Convene a meeting to discuss the content of the letter in detail."

Historians have discussed who composed Einstein's letter [facsimile] to Roosevelt. We know now from the information of Janet Coatesworth given to Mrs. Szilard¹⁷ that LEO SZILARD phoned Janet, the young stenographer who worked part-time at Columbia University, asking her to come to the King's Crown Hotel. There, in his hotel room Szilard – pacing the floor excitedly – dictated a letter in his "crisp Hungarian accent" to "F. D. Roosevelt, president of the United States." Miss Coatesworth was surprised. When Szilard spoke about "extremely powerful bombs," the typist became convinced that she was "working for a nut." Szilard's text became more and more dramatic, and it concluded by "Yours very truly, Albert Einstein." Miss Coatesworth was completely convinced that Szilard was deranged. Only years later did she learn what a historic session she had participated in.

The meeting of the Uranium Committee was scheduled for 21 October 1939. Lyman J. Briggs, the director of the National Bureau of Standards invited Sachs, Colonel Adamson representing the Army, Commander Hoover from the Navy, Roberts from the Carnegie Institute, and Mohler from the National Bureau of Standards, the government's office for scientific matters. Fermi, Szilard, Teller, and Wigner were invited as physicists involved. Let us listen again to EDWARD TELLER:¹⁸

– Fermi sent a message that he would not come. He had already spoken with the Navy, and they had not listened to him; he was fed up. But they knew that I had known Fermi from back in 1932, when he so cordially invited me to Rome. So they sent me to persuade Fermi to come to the meeting. "I am not coming!" Come! "I am not coming! Why should I? What I have to tell them is very simple. You can tell it to them just as well." So I went to the meeting, as I had been promoted: no longer Szilard's chauffeur, I was now Fermi's messenger boy. We sat there. There was a high-ranking officer from Aberdeen who did not believe a word of what we were saying. He said he did not believe things like that, he did not believe in death rays either (of course at that time there was no laser yet). "In Aberdeen," he said, "we have a goat tied to a post with a rope ten feet

¹⁷1964, quoted by William Lanouette in *Genius in the Shadows*, 1992

¹⁸Budapest lecture 1993

long. We offer 10 000 dollars to anyone who can kill this goat with a death ray. But the goat still is alive and well. And, on the other hand," he went on, "wars are not won by those having better weapons. Wars are won by those who possess the truth." – This was very pleasant to hear from a high-ranking officer, but we had our doubts. Were Hitler and Stalin right in Poland? Different topics were discussed and finally it was my turn. I said what I had come to say: – "I am bringing Fermi's message: graphite is needed for the work. Graphite is cheap, but we need highly purified graphite, and that is not cheap at all. We work at the university, we need no pay. But to get pure graphite, money is needed: \$6000, the first year's budget for the nuclear energy program." – Following the meeting, Szilard almost killed me for my asking for such a small sum, but we were given the \$6000 as the first year budget of the nuclear energy project. – Wigner added¹⁹ that at the meeting he had said, – *If Colonel Keith Adamson's moral approach were correct, then maybe the army's budget should be cut, so that the saved money could be used to propagate understanding among nations.* – The Colonel replied, – *All right, you'll get your money!*²⁰ – The next meeting of the Uranium Committee was called for 27 April 1940, with the same people in attendance. Szilard again tried to explain that one had to find out empirically whether a pile of graphite blocks and uranium metal spheres could sustain a neutron chain reaction, if the assembly was large enough. In 1940 the war ignited Europe but in Washington nothing happened.

– *Democracy was sleeping. Getting the U.S. Government to see the value of fission was like swimming in syrup. We learned that governments do not like fantastic projects,* – bemoaned the polite Wigner. Szilard tried to mobilize Einstein and he himself wrote a memorandum to the Administration, but America was still resting in peace. The explanation of the delay might have been that all military research was protected by high security, including the quest for a nuclear bomb, so in June 1940 the Uranium Committee was reorganized so that Beams, Gunn, Pegram, Tuve, and Urey became the members. As Briggs explained: the proceedings were *top secret*, and neither Fermi, nor Szilard, nor Teller were American citizens yet. (Wigner had obtained his American citizenship only very recently.) For this reason they were left out. It was a Catch-22 situation.

¹⁹to the author in Budapest, 1983

²⁰Wigner claimed that it was he who had asked for \$5000, and this was the support obtained. According to Szilard's recollection [*His Version of the Facts*] Wigner asked for only \$2000 and this was the sum first promised by the government.

ENGLAND 1940

In the meantime England was bombed by the German air force; British scientists were working hard on war technology. The most reliable British physicists were involved in the development of radar, for defense against air raids. When news of uranium fission arrived, the neutron chain reaction (patented by Szilard at the British Navy) seemed to become a real possibility. On a mild spring evening in 1940 Otto Frisch and Rudolf Peierls (refugees from Germany) discussed the possibility of a fast chain reaction in ^{235}U . At this moment of the evening discussion in Birmingham a mysterious face appeared at the open window. Frisch and Peierls were alarmed, thinking on spy stories, but it turned out, he was only an innocent mathematician weeding the college garden. Peierls' report proved the possibility of making a bomb using a few kgs of ^{235}U .²¹

EGON OROWAN studied the properties of metallic uranium. But the main technological problem was the separation of the ^{235}U isotope. In June 1940 Franz Simon (also a German emigree), with his Hungarian student NICHOLAS KURTI, began to study the feasibility of the separation of ^{235}U . Magnetic mass spectroscopy turned out to be very inefficient, therefore the efforts were concentrated on diffusion separation. Lighter isotopes move faster at room temperature, therefore the diffusion through a filter will enrich the light isotope in the gas. Ceramic filter is too thick: the diffusion is too slow but Simon intended to produce 10 kg ^{235}U per month. Kurti reports:

– There was a joke circulating in Oxford, that the first diffusion separation of isotopes was made on carbonated water, using Mrs. Simon's tea strainer. The fact is that one day Simon took a tea strainer from his wife, brought it to the lab and asked us to hammer it flat, till the holes became 20–30 μm small. The isotope enrichment factor of this diffusion membrane was tested with a $\text{H}_2\text{O}-\text{CO}_2$ gas mixture. This was our first experiment. We concluded that a very thin metallic film with tiny holes works fine and is mechanically stable enough. The Simon Report on the feasibility of diffusion separation was sent to G.P. Thomson two days before the Christmas of 1940. Professor Thomson was heading the British committee of the nuclear weapon program. In June 1941 the committee presented an elaborate report on the technological details of the atomic bomb fabrication which was far ahead of the state of affairs in the U.S. Later the British conclusions have turned out to be surprisingly realistic, esp. concerning the diffusion membrane and costs of the sepa-

²¹Nicholas Kurti, lecture in Budapest 1996

ration plant. The inventor was made to Sir Francis Simon. (The technology of the diffusion separation is strictly classified secret and diffusion filters are under embargo till today.)

In 1941 the British government tried to direct the attention of the American government to the importance of making the bomb. A larger British delegation was sent to the U.S., under the leadership of James Chadwick. Mark Oliphant participated at a secret meeting of the Uranium Committee which, for security reasons, Fermi and Szilard were not permitted to attend. He tried to push the Americans towards making the bomb, travelling across the United States to speak to anyone who was ready to listen, with moderate success. – *Considerations other than those of military security prevent me from quoting the exact expressions which Oliphant used* – said Szilard.²² – According to Nicholas Kurti,²³

– *The British reports and pressure made a greater practical impact upon the American nuclear programme than Einstein's letter to Roosevelt. In 1943–1944 I was sent to meet Urey, to work in the Pupin Laboratory, at Columbia University in New York for four months, in order to install a piece of equipment developed by us for the measurement of the isotope enrichment.*

CHICAGO 1942

On Saturday, 2 December 1941, the Japanese made a surprise attack on Pearl Harbor, and annihilated a part of the American fleet. The United States found itself at war. On the very same day Washington decided in favor of “*an all-out effort to build a nuclear bomb.*”

The main question was whether a natural uranium and graphite moderator system could realize a self-sustaining chain reaction or not. The very first challenge was to obtain high purity graphite. To buy graphite Fermi and Szilard needed money. When they obtained the \$6000, Szilard personally talked with the producers of graphite about the necessity of extreme purity. The orientation experiments could start at Columbia University only in July 1941. Szilard also arranged for Teller to be invited to Columbia University for one year. He was needed, among others, to act as a peacemaker between Fermi (nicknamed “the Pope”) and Szilard (nicknamed “the General”).

²²Leo Szilard: *His Version of the Facts*, 1978

²³to the author 1996

– *I certainly tried to make peace but I believe that I failed,* – Teller confessed.

On the day following the Japanese surprise attack Compton ruled that the reactor project should move to Chicago. It was organized at the Chicago University under the code-name “Metallurgical Laboratory.” (Here the word “uranium” was never mentioned, its code-name was “tube-alloy.” ^{235}U was “magnesium,” ^{239}Pu was “copper.”) In the spring of 1942, Compton invited Fermi and Wigner to move to Chicago. Fermi’s code-name was Farmer; Wigner’s code-name was Wagner. Wigner recalled:²⁴

– *One day we were driving together along a high-security road. At the checkpoint, the military guard asked my name. I said, “Wigner – oh, please excuse me: Wagner!” The guard could not help but notice my Hungarian accent. He regarded me with suspicion and asked sternly, “Is your name really Wagner?” What could I say? Enrico saved me. Quite firmly and confidently, he said, “If his name’s not Wagner, then my name’s not Farmer.” And the guard let us pass.*

As Alvin Weinberg said, – *There were two dominant scientific brains in Chicago. Fermi conducted the experimental work. Wigner headed the theoretical research.*

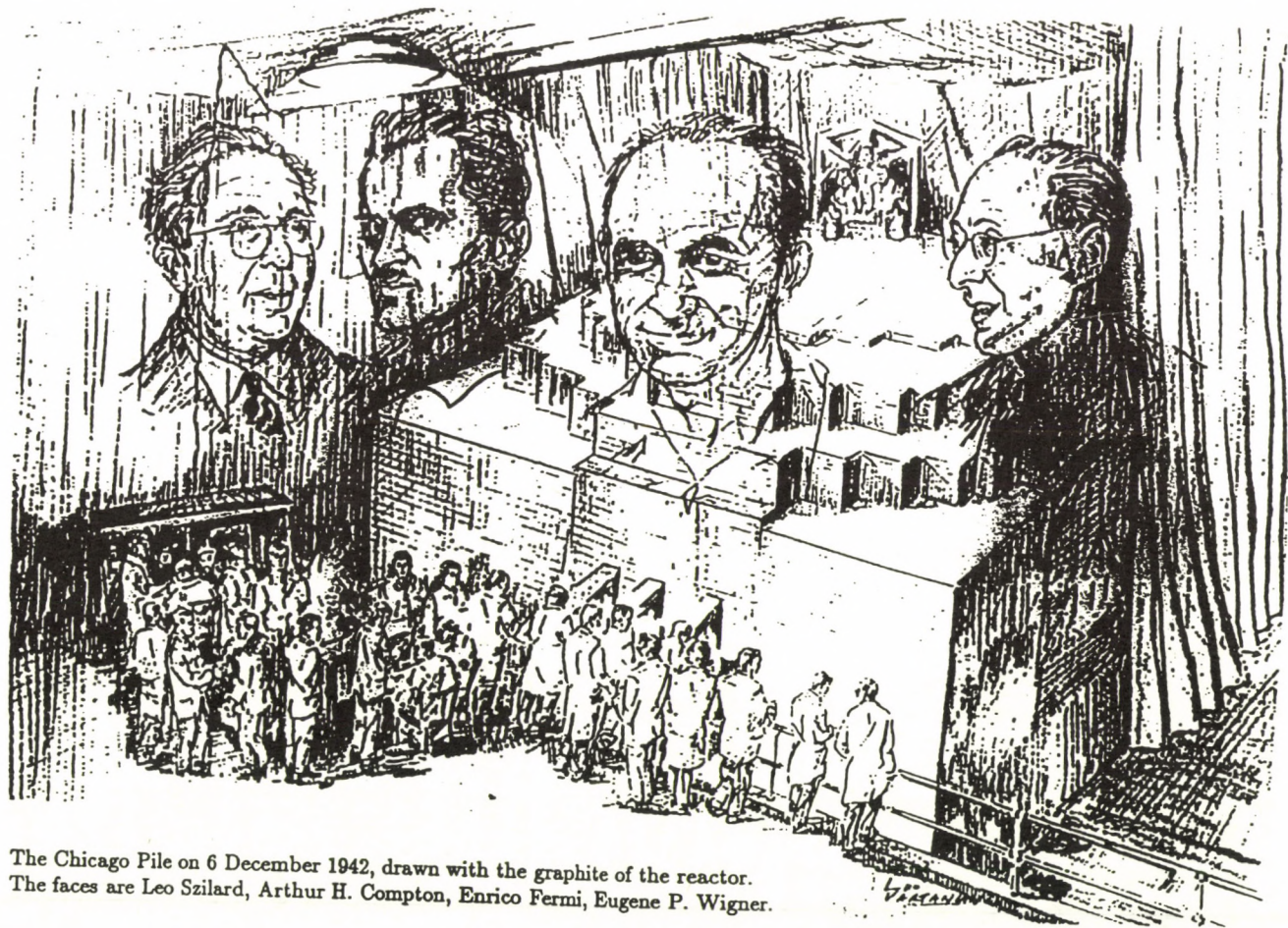
EDWARD TELLER joined them later, his duty being to calculate the possible environmental hazards of the radioactive ^{14}C produced in the pile: $n + ^{14}\text{N} \rightarrow ^{14}\text{C} + p$, and possibly escaping in the form of CO_2 . Szilard, Teller, and Wigner were called the *Hungarian Mafia* in Chicago.²⁵

– *With Fermi in charge of the work, Zinn built the world’s first nuclear reactor, using pure graphite and uranium provided through Szilard’s foresight.*²⁶ – A 2 m · 2 m · 4 m pile made of graphite bricks and uranium plates was assembled gradually under the West Stands of Stagg Field, the sport stadium at Chicago University. In the pile neutron absorbing cadmium rods were inserted to stop the chain reaction, if necessary. Fermi and Zinn sawed and carried the graphite blocks with their assistants. LEO SZILARD, however, considered this kind of work inferior, to be left to assistants and technicians. He came to the Met Lab occasionally, bringing his newest ideas, requesting the others to stop everything they were all doing, and tried to turn them into a brand new direction he had invented in the bathtub that same morning.

²⁴Andrew Szanton: *The Recollections of Eugene P. Wigner*, 1992

²⁵Weinberg to the author, Budapest 1989

²⁶Manson Benedict at the presentation of the Atoms for Peace Award in 1960



The Chicago Pile on 6 December 1942, drawn with the graphite of the reactor.
The faces are Leo Szilard, Arthur H. Compton, Enrico Fermi, Eugene P. Wigner.

An artificial radium–beryllium neutron source was placed at the bottom of the pile, then – according to Fermi’s instructions – the distribution of neutrons was observed as a function of distance measured from the source. As the neutron multiplication approached the critical 100 %, the neutrons reached a larger distance in the graphite before being absorbed. It was Wigner’s duty to calculate the neutron multiplication from the measured distribution of the neutron density dropping exponentially at increasing distances. This was the *Exponential Experiment*.

Fermi performed 25 experiments with different arrangements of uranium and graphite. The first self-sustaining neutron chain reaction was realized on 2 December 1942. Let us quote the description of an eyewitness, EUGENE P. WIGNER:²⁷

– I stood watching Enrico Fermi in a large room beneath Stagg Field. About 8:30 on this Wednesday cca 50 people began assembling in a room of 10 by 20 meters. In the middle of the room a huge pile of black graphite bricks and wood pieces had been heaped up. The bottom half of the pile was square-shaped; the top was narrower. He had given the pile extra control rods in case of an emergency, and even positioned a “suicide squad” above the pile with a cadmium-salt solution in case all the control rods failed to stop the reaction.²⁸ The serious work had begun at about 9:45. The chain reaction was almost achieved around 11:30, but a safety rod, set too low, had stopped it. Fermi sent everyone to lunch and we all returned to the squash court at 2:00. Now Fermi stood with a slide rule at one end of the balcony, with two of his top assistants, Herbert Anderson and Walter Zinn. Next to them was Arthur Compton, the director of the Manhattan Project. The other 40 of us were crowded on the far side of the balcony. Among the others present was my old friend, Leo Szilard. At 3:30 p.m. Fermi calculated the rising rate of the neutron counts and instructed an assistant to pull out the cadmium-plated rod about 25 centimeters at a time. The recorder started to tick: *pit-a-pat, pit-a-pat, pit-a-pat*. The self-sustaining chain reaction was more and more closely approximated. It had died for some time, but after the whole control rod had been pulled out, the recorder ticked more strongly than ever. We knew that a nuclear chain reaction had been achieved. We had released the energy of the atomic nucleus and had successfully controlled that energy. There were

²⁷given to Andrew Szanton 50 years later

²⁸An additional assistant was ready with an ax to cut a rope holding neutron absorbing cadmium rod; this Safety Control Reserve Axed Man was the origin of the SCRAM instruction, which immediately stops present nuclear reactors electronically in case of malfunction.

smiles all around the room, even some applause. But for about 30 minutes we mostly just watched. The scene was not theatrical or striking in any way: Fermi had made the reactor quite weak so that it would not kill us. But it was there, – and it worked. Just before 4:00 p.m. Fermi ordered the reaction stopped. The control rod was replaced and the reaction halted. We had all expected the experiment to succeed. After all, if a carriage is built and we hitched to a team of horses, we expect the carriage to move. Fermi had built the carriage and hitched the horses. He was not the only man who could have created this chain reaction, but perhaps the only one who could have done it so quickly.

– In anticipation of this moment, about ten months earlier in Princeton I had bought a bottle of Italian wine, Chianti, and brought it to Chicago [picture]. I guessed that the war might have prevented Italy from exporting Chianti to America. In a way, it was harder to foresee the shortage of Chianti than to foresee the successful chain reaction. But I had been through World War I, and I knew that such luxuries tend to disappear. I had kept the Chianti behind my back throughout the experiment. Now I produced it from a brown paper bag on the balcony floor, brought it forward, and presented it to Fermi. He thanked me. Fermi uncorked the bottle and asked someone to find paper cups. They were produced and we drank the sweet red Chianti. What beautiful, subtle pleasures wine can give! Quietly, we toasted the event, and wished that somehow this nuclear reaction could make man's life happier, and humankind less prejudiced. Fermi signed his name just below the top of the Chianti label. The bottle went around the room, and below Fermi's signature the rest of us added our names. The bottle ended up in the hands of Albert Wattenberg, a bright young physicist. No written records were made of the witnesses to this historic moment. The names on the Chianti label were used to recreate the group. [Facsimile]

This is how we know today that, besides 38 Americans, an Italian was present (Fermi), a Canadian (Zinn), and two Hungarians (Szilard and Wigner)²⁹. As Wigner briefly summarized: – *Our physical equations worked.*³⁰
– Compton rushed to phone a coded message to Washington:

THE ITALIAN NAVIGATOR HAS JUST LANDED IN THE NEW
WORLD. THE NATIVES ARE FRIENDLY.

²⁹At the 10th anniversary of the Chicago Pile Al Wattenberg was unable to attend the celebration but he sent the bottle with the names, with a mailing insurance of \$1000. This made the news, and a wine importer was so happy about the unexpected advertisement of Chianti that he sent a bottle to each participant involved.

³⁰Paul Erdős to the author 1996

As Manson Benedict added, – *The vessel used by the Italian navigator was built by a Canadian shipwright from rare and costly materials found by a Hungarian explorer.*³¹ – A monument, made by Henry Moore, commemorates the place of the first nuclear chain reaction created by humans on Earth.³²

There can be no doubt that both, Szilard's ideas and foresights, furthermore Fermi's expertise and work, were needed to liberate the energy of nuclei. Based on the application submitted on 19 December 1944, on 17 May 1955 Fermi and Szilard were formally granted U.S. patent No. 2,708,656 for the neutronic reactor [facsimile].

OAK RIDGE 1943

In September 1941 EUGENE P. WIGNER explained to Compton the difference between fast neutrons (atomic bomb) and slow neutrons (nuclear reactor). In his book *The Atomic Quest* Compton recalls how Wigner urged him “*almost in tears*” to act. Ernest O. Lawrence (the builder of the first cyclotron) had to separate the uranium isotopes by mass spectroscopic (electromagnetic) means, and Jesse Beams with an ultracentrifuge. These methods worked, but were rather slow. The ultracentrifuge project was soon halted. The mass spectroscopic separation in Berkeley went on, but with gradually decreasing intensity.

The British experiences on diffusion separation were transferred to Harold Urey (the discoverer of heavy hydrogen), among others by NICHOLAS KURTI. Thus Urey was given the task of separating ²³⁵U by diffusion. The diffusion separation method seemed to be the most promising one. The huge diffusion plant for the separation of the ²³⁵U isotope was built in Oak Ridge, U.S., directed by Urey.

The Oak Ridge Diffusion Plant forced gaseous UF₆ (uranium-hexafluoride, nicknamed “hex,” meaning “witch” in German) through a porous barrier. The molecules of ²³⁵U were a bit lighter, moved faster than those of ²³⁸U. By repeating the diffusion process thousands of times, gradually sufficiently enriched ²³⁵U was obtained. But this method was very slow. Until the end of World War II only a limited amount (only a few kilograms) of ²³⁵U had been separated, enough for only one single bomb. In 1945 that bomb was dropped on Hiroshima.

³¹at the presentation of the Atoms for Peace Award 1960

³²front cover of this book

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2,708,656

NEUTRONIC REACTOR

Enrico Fermi, Santa Fe, N. Mex., and Leo Szilard, Chicago, Ill., assignors to the United States of America as represented by the United States Atomic Energy Commission

Application December 19, 1944, Serial No. 568,904

8 Claims. (Cl. 204—193)

The present invention relates to the general subject of nuclear fission and particularly to the establishment of self-sustaining neutron chain fission reactions in systems embodying uranium having a natural isotopic content.

Experiments by Hahn and Strassman, the results of which were published in January 1939. *Naturwissenschaften*, vol. 27, page 11, led to the conclusion that nuclear bombardment of natural uranium by slow neutrons causes explosion or fission of the nucleus, which splits into particles of smaller charge and mass with energy being released in the process. Later it was found that neutrons were emitted during the process and that the fission was principally confined to the uranium isotope U^{235} present as $\frac{1}{139}$ part of the natural uranium.

When it became known that the isotope U^{235} in natural uranium could be split or fissioned by bombardment with thermal neutrons, i. e., neutrons at or near thermal equilibrium with the surrounding medium, many predictions were made as to the possibility of obtaining a self-sustaining chain reacting system operating at high neutron densities. In such a system, the fission neutrons produced give rise to new fission neutrons in sufficiently large numbers to overcome the neutron losses in the system. Since the result of the fission of the uranium nucleus is the production of two lighter elements with great kinetic energy, plus approximately 2 fast neutrons on the average for each fission along with beta and gamma radiation, a large amount of power could be made available if a self-sustaining system could be built.

In order to attain such a self-sustaining chain reaction in a system of practical size, the ratio of the number of neutrons produced in one generation by the fissions, to the original number of neutrons initiating the fissions, must be known to be greater than unity after all neutron losses are deducted, and this ratio is, of course, dependent upon the values of the pertinent constants.

In the co-pending application of Enrico Fermi, Serial No. 534,129, filed May 4, 1944, and entitled "Nuclear Chain Reacting Systems," there is described and claimed a means and method of determining the neutron reproduction ratio for any type of uranium-containing structure, directly as a result of a simple measurement which can be performed with precision. Accurate values for all of the pertinent nuclear constants need not be known.

We have discovered certain essential principles required for the successful construction and operation of self-sustaining neutron chain reacting systems (known as neutronic reactors) with the production of power in the form of heat. These principles have been confirmed with the aid of measurements made in accordance with the means and method set forth in the above-identified application, and neutronic reactors have been constructed and operated at various power outputs, in accordance with these principles, as will be more fully brought out hereinafter.

In a self-sustaining chain reaction of natural uranium with slow neutrons, as presently understood, reactions occur involving the isotopes U^{234} and U^{235} . Thus, U^{234}

2

is converted by neutron capture to the isotope U^{235} . The latter is converted by beta decay to U^{235} and this U^{235} in turn is converted by beta decay to U^{235} . Other isotopes of 93, and 94 may be formed in small quantities. By slow or thermal neutron capture, U^{235} , on the other hand, can undergo nuclear fission to release energy appearing as heat and gamma and beta radiation, together with the formation of fission fragments appearing as radioactive isotopes of elements of lower mass numbers, and with the release of secondary neutrons.

The secondary neutrons thus produced by the fissioning of the U^{235} nuclei have a high average energy, and must be slowed down to thermal energies in order to be in condition to cause slow neutron fission in other U^{235} nuclei. This slowing down, or moderation of the neutron energy, is accomplished by passing the neutrons through a material where the neutrons are slowed by collision. Such a material is known as a moderator. While some of the secondary neutrons are absorbed by the uranium isotope U^{235} leading to the production of element 94, and by other materials such as the moderator, enough neutrons can remain to sustain the chain reaction, when proper conditions are maintained.

Under these proper conditions, the chain reaction will supply not only the neutrons necessary for maintaining the neutronic reaction, but also will supply the neutrons for capture by the isotope U^{235} leading to the production of 94, and excess neutrons for use as desired.

As 94 is a transuranic element, it can be separated from the unconverted uranium by chemical methods, and as it is fissionable by slow neutrons in a manner similar to the isotope U^{235} , it is valuable, for example, for enriching natural uranium for use in other chain reacting systems of smaller overall size. The fission fragments are also valuable as sources of radioactivity.

The ratio of the fast neutrons produced in one generation by the fissions to the original number of fast neutrons in a theoretical system of infinite size where there can be no external loss of neutrons is called the reproduction of multiplication factor or constant of the system, and is denoted by the symbol K . For any finite system, some neutrons will escape from the periphery of the system. Consequently a system of finite size may be said to have a K constant, even though the value thereof would only exist if the system as built were extended to infinity without change of geometry or materials. Thus when K is referred to herein as a constant of a system of practical size, it always refers to what would exist in the same type of system of infinite size. If K can be made sufficiently greater than unity to indicate a net gain in neutrons in the theoretical system of infinite size, and then an actual system is built to be sufficiently large so that this gain is not entirely lost by leakage from the exterior surface of the system, then a self-sustaining chain reacting system of finite and practical size can be built to produce power and related by-products by nuclear fission of natural uranium. The neutron reproduction ratio in a system of finite size therefore differs from K by the external leakage factor, and by a factor due to the neutron absorption by localized neutron absorber, and the reproduction ratio must still be sufficiently greater than unity to permit the neutron density to rise exponentially with time in the system as built.

Progressive empirical enlargement of any proposed system for which the factor K is not accurately known, in an attempt to attain the overall size of a structure of finite size above which the rate of loss of neutrons by diffusion through the periphery of the structure is less than the rate of production of neutrons in the system, leads only to an expensive gamble with no assurance of success. The fact that K is greater than unity and the fact that the critical size is within practical limits must

HANFORD 1944

Ernest Lawrence constructed the first cyclotron in Berkeley. The accelerated fast protons could be used to produce neutrons in nuclear reactions. Fast neutrons were captured: $n + {}^{238}\text{U} \rightarrow {}^{239}\text{U}$. This neutron rich isotope spontaneously emits an electron, for increasing its number of protons. Edwin M. McMillan³³ identified the first transuranic element *neptunium*: ${}^{239}\text{U} \rightarrow {}^{239}\text{Np} + e^- + \nu$. Glenn T. Seaborg identified the second transuranic element *plutonium*: ${}^{239}\text{Np} \rightarrow {}^{239}\text{Pu} + e^- + \nu$. The ${}^{239}\text{Pu}$ has turned out to be an even better fissionable material than ${}^{235}\text{U}$, because it contains more positive protons electrically repelling each other. Louis A. Turner, a Princeton physicist, proposed this possibility even before the empirical discovery of plutonium. Plutonium is an element different from uranium, so if it is produced in nuclear reactors, it can be separated chemically from the used uranium rods.

The Fermi reactor – operating in Chicago since December 1942 – produced low power; it did not have artificial cooling. In the beginning of 1943 General Groves, the commander of the Manhattan Project, warned, – *You cannot play with fire in the middle of Chicago*. – He ordered Fermi's reactor to be taken apart piece by piece, and to rebuild it in the Argonne Forest. It worked there with a power of 30 kilowatts, without any cooling, till 1946. Another air-cooled uranium–graphite reactor³⁴ became operational in Oak Ridge on 4 November 1943. The Oak Ridge reactor produced a few grams of plutonium by the summer of 1944, enough only to take the first measurements on the new element.

Compton charged EUGENE P. WIGNER to design large reactors with high neutron fluxes, to mass produce plutonium for atomic bombs. (Wigner was the perfect candidate for the job: he was educated as a chemical engineer, and he was at home with nuclear physics.) The planning of large reactors was begun in the first half of 1942, much before Fermi's reactor became operational. Wigner moved from Princeton to Chicago in April 1942. On 18 June 1942 the army completely took over nuclear weapons development under the code name *the Manhattan Project*, with Colonel Leslie Groves as boss: the progress accelerated. The Met Lab became a secret army station.

The Oak Ridge reactor was of low power, being cooled by air. But the nitrogen atoms in the air absorbed the neutrons. To achieve a better

³³They received Nobel Prize for these discoveries

³⁴a cube of graphite with a side length of 8 m, with 5 tons of imbedded uranium rods

neutron balance, helium was proposed: ${}^4\text{He}$ has a closed nuclear shell and does not absorb neutrons at all. Compton liked this idea. But gaseous helium has a small heat capacity, and Wigner considered that to construct the effective cooling of a high power reactor by gas would increase the size of the reactor, and a larger surface meant larger neutron loss. Gas cooling would need brand-new technology, and that would cost too much time, and the war was going on.

If an electric current flows across a conductor, a perpendicular magnetic field exerts a force sideways. In this way liquid metal can be pumped. (In 1927, in Berlin, Szilard – together with Einstein – had patented a refrigerator that was to be cooled by electromagnetically pumped mercury, without any rotating solid component.) LEO SZILARD advocated liquid metallic bismuth as a coolant, because bismuth does not absorb neutrons. – A more conventional technique, a heavy water coolant was also considered, because neither ${}^2\text{H}$, nor ${}^{16}\text{O}$ absorb neutrons. Such a reactor was constructed at Chalk River in Canada. But separating heavy water is very time consuming.

In April 1942 Wigner, a practical man, proposed normal water as a coolant, because the electrical industry had accumulated much experience with water boilers. This was a daring idea from the nuclear point of view, because the neutron absorption by hydrogen takes 1.5 % off the neutron multiplication factor. During the summer it was not yet proven that a uranium–graphite reactor could work at all, even without adding a water coolant. In the summer of 1942, while Fermi's exponential experiments were running, a trial arrangement was assembled by adding aluminum pipes containing water to the uranium–graphite pile. From the measured neutron distribution Alvin Weinberg calculated that a water cooled reactor with natural uranium as fuel and graphite as moderator may realize a neutron multiplication of 104 %. Wigner seemed to be right! In 1942 DuPont Chemical Company was charged with building the plutonium producing reactors.

– *The engineers felt, with some justice, that we physicists were trespassing in their territory.*³⁵ *So the choice of a coolant was a complex matter not only scientifically but politically within the Met Lab. The engineers of DuPont gave my group the friendly label “the Fourth Floor Communists”.* – In the end DuPont accepted Wigner's proposal for using normal water as coolant. By December 1942 (before Fermi's reactor started operating) the plan for the water-cooled reactor was ready. Four

³⁵Wigner said to Szanton

months were enough for the Wigner group of five to design the 500 million watt reactor (17 000 times more powerful than Fermi's reactor). Wigner remembered:

– *DuPont was a chemical factory. We recommended to the engineers of DuPont to use concrete wall as shields in order to prevent the escape of neutrons and γ -photons. The engineers proposed using an iron cage instead. In their plan the cage was so dense that a lamb could not escape through it, but a squirrel or a mouse could. We had to tell them that neutrons are smaller than mice. Since this affair Fermi used to begin his explanations by saying: "The neutron is very, very small."*³⁶

Louis Alvarez argued that it was a waste of time to use Wigner's talent to settle technical details. But several effects had to be foreseen, e.g. thermal radiation and corrosion due to neutron bombardment. Looking through the technical plans proposed by DuPont, Wigner noticed that there was a flaw in the design. He recalculated the reactor control system, and realized that DuPont's plan did not include enough control rods. He corrected the error in time. Szilard said that *Wigner was the conscience of the whole project*. The plutonium producing reactors (with natural uranium fuel, graphite moderator, and normal water coolant) were built in 1943 in the far northeastern corner of the United States, in Hanford. From there the first shipments of plutonium arrived in May 1944. A year later enough plutonium had been produced to make a bomb.

LOS ALAMOS 1944

Oak Ridge was producing ²³⁵U; Hanford was supplying ²³⁹Pu; but how to make them to a bomb? General Groves was charged with organizing this development. He picked Robert Oppenheimer to be the director.³⁷ He was officially involved from 1 June 1942. He let a lieutenant-colonel uniform urgently be made for himself. (The other physicists rejected this possibility.)³⁸ At Oppenheimer's proposal, on 22 November 1942 the

³⁶to the author 1983

³⁷In 1939, after Bohr's lecture in Washington, Louis Alvarez informed Oppenheimer about the news of nuclear fission, but Oppenheimer reacted, – *That is impossible*, – and even offered a theoretical proof of the impossibility. Oppenheimer was unaware of the Manhattan Project, and was only informed about it – by mistake – by the English team in September 1941. Oppenheimer was not present at the start of the Chicago pile.

³⁸Peter Wyden: *Day One* 1984

remote mesa of Los Alamos in New Mexico was selected to be the site of this most confidential *Buck Rogers Project*.³⁹ In January 1943, the work began on the "Hill." For security reasons the bomb was mentioned only as the "gadget."

Oppenheimer asked Hans Bethe (a refugee from Germany and a future Nobel laureate, one of those who had explained the nuclear origin of solar energy) to head the Theoretical Department, and invited also EDWARD TELLER to join. The Tellers moved to Los Alamos in March 1943, bringing with them two important objects: a huge Steinway piano, – *the only possession I really like*, – and a Bendix washing machine. These objects caused the first trouble. The neighbors complained about Teller's playing Mozart sonatas at 3:00 a.m. The Tellers had a baby, and there was no laundry or diaper service available, so Mrs. Teller had to wash a lot, and the only plumbers, able to repair the Bendix from time to time, lived down in Santa Fe, but their coming up to Los Alamos conflicted with security restrictions.

Other problems were related to conflicts of characters. Bethe was very *German*, an excellent orderly theoretician. Teller was very *Hungarian*, emotional, easily becoming very enthusiastic, already thinking far ahead: about a fusion (hydrogen) bomb. But Oppenheimer had to focus on the immediate realization of an ignition for the fission (uranium and plutonium) bomb.

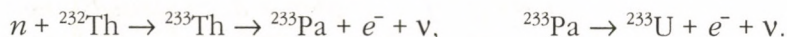
Constructing the ^{235}U bomb proved to be an "easy job." The critical mass can be calculated from measured cross sections. (Wigner's anticipation turned out to be correct: the critical mass of the "gadget" was about the size of a soccer ball, not the size of a wardrobe chest.) One only had to take a subcritical solid cylindrical block and an appropriate subcritical cylindrical tube, and shoot the block into the tube with a "gun" to create supercritical mass. Radium (attached to the block) meets beryllium (attached to the tube) at the same time, and the neutrons emitted by them initiate immediately a fast chain reaction. After the success of the Chicago pile nobody doubted that the ^{235}U bomb would work. But the production of ^{235}U was very slow.

Wigner thought if there were enough plutonium, a gadget could be easily assembled. But already on 11 July 1944 the first samples of plutonium, having arrived from the Oak Ridge reactors, had shown that neutron irradiation of ^{238}U produced not only ^{239}Pu in the reactor but ^{240}Pu as well. In the plutonium samples obtained Emilio Segré discovered that

³⁹Maurice M. Shapiro to the author 1994

^{240}Pu suffers *spontaneous* fission with considerable probability, thereby releasing neutrons. (This problem was noticed in England by Chadwick as well.) If the “gun” technique were applied, the neutrons coming from the spontaneous fissions would initiate a chain reaction too early, before the critical mass is fully assembled. This would not yield a big bang, only a fizzle with a low energy yield.

When LEO SZILARD learned about this problem, he looked for other means. He proposed the fabrication of fissionable ^{233}U out of thorium,



EUGENE P. WIGNER recommended making a reactor by immersing plutonium plates into a water moderator and enveloping this assembly with thorium. The neutron flux will turn a part of the ^{232}Th into ^{233}U , that can be extracted chemically from thorium (like the ^{239}Pu extracted from uranium in Hanford). This could be an alternative way to produce nuclear explosives for the bomb. In his paper (January 1943) Szilard introduced the word *breeder*, to denote a device in which otherwise useless non-fissionable material like ^{232}Th or ^{238}U can be converted to fissionable fuel like ^{235}U or ^{239}Pu .⁴⁰

Seth Neddermeyer, working at Los Alamos, had a better idea for igniting the plutonium bomb. Let us make a hollow spherical shell of plutonium metal, which due to its large surface is stable against neutron chain reactions. (Most neutrons escape throughout the large surface area without initiating a fission chain.) Let us surround it with a layer of chemical explosives. If the chemical explosion is timed and directed correctly, it *compresses* the plutonium bubble to a small compact sphere with critical mass, in which a neutron source will initiate a neutron chain reaction. This is the idea of the much more sophisticated *implosion ignition*. (The word *implosion* became classified from this moment on.)

– JOHN VON NEUMANN, *a professor at Princeton, was far too valuable at war time to be stationed at one place; he was constantly circulating in the United States, helping this project or that project. He visited Los Alamos, too, a typical visit lasted about two weeks at a time.*⁴¹ Let us now listen to EDWARD TELLER’s recollection:⁴²

⁴⁰Alvin Weinberg to the author, Budapest 1989

⁴¹Maurice M. Shapiro to the author 1994

⁴²to the author 1991

– At Neumann Jancsi's first visit to Los Alamos (in September 1943) I took him home for dinner. I explained him the idea of implosion. We were sitting at the fireplace; it was already fall and getting cooler, but the fire did not work well. It created strange noises behind us. Jancsi remarked: – "It would be a real shame if we perished in an inferior chemical explosion." – Jancsi started using formulas. He had the good sense to begin with the simple tasks. – "I calculate with incompressible material: we have to compress it in a spherically symmetric way. As the implosion progresses, more and more material has to pass through one cm^2 per unit time. This means larger and larger speeds, increasing acceleration, higher and higher pressure. The final pressure may reach 100 million atmospheres." – I told Jancsi that the implosion would not go this way. In our seminars at George Washington University I had listened to different kinds of lectures, and learned that at the center of the Earth the pressure was about 10 million atmospheres, and there the iron was compressed by 20%. At 100 million atmospheres metallic plutonium will not behave as Jancsi assumed; it will no longer be incompressible. This was an interesting turn of the story: if the plutonium was compressed to higher than normal density, then the critical mass for a chain reaction would become smaller, because fewer neutrons would escape through the smaller surface. If less plutonium is sufficient for a bomb, then we may have the first plutonium bombs ready a year earlier. The war will be shortened; it may save perhaps 10 million lives. The next day we rushed to Oppenheimer's office. The decision had been made: the main task at Los Alamos would be the elaboration of the implosion. Now Neumann Jancsi started working indeed: he did not only know mathematics, but he was familiar with explosions and computers as well. To make a powerful implosion by the ignition of chemical charges was not a simple task, but before his departure he told us how to do it. He recommended the use of the already available IBM computers, because the necessary calculations of nonlinear shock waves would be beyond the calculational capacity of Bethe, Fermi, and myself. But before Jancsi's departure we had to attend a meeting, at which Oppenheimer gave a report on the outcome of the Churchill–Roosevelt summit. Then the director asked: – "Any questions?" – After a bit of silence someone from the back row asked: – "When will we finally get a shoemaker to Los Alamos?" – After the session Jancsi noted: – "Now I understand the sort of problems left to be solved in Los Alamos!"

The simultaneity of all chemical detonations and essentially their focusing onto the plutonium bubble required acoustic lenses, which meant the full expertise of JOHN VON NEUMANN on shock waves. The

solution of nonlinear differential equations was still in its infancy; it made use of the numerical capabilities of the early IBM machines. The leader of the group was a young graduate student, Richard Feynman. One of his assistants was JOHN G. KEMENY, who arrived in the United States from Budapest in 1940. He fulfilled his military service by punching cards at the calculators on the Hill. PETER LAX was a 15-year-old Hungarian student when he arrived in the United States at the end of 1941. In 1945, as an undergraduate at New York University, he was drafted into the Army, and was instructed to serve in Los Alamos, in the Neutron Department. – *It was like a piece of science fiction: working with an element which was not to be found in the Periodic Table.* – Neumann enjoyed his opportunity to chat with John G. Kemeny and Peter Lax informally in Hungarian.⁴³

The plutonium supply from Wigner's reactors in Hanford began arriving in May 1945 in considerable quantities.

By the time the critical amount of ^{235}U and ^{239}Pu became available for one bomb each, the war with Germany was already over. It had become clear that Germany had been far from making an atomic bomb. After World War II, archives revealed that when Joos and Harteck called the attention of the German leadership to the possibility of nuclear weapons, a Committee was formed headed by Werner Heisenberg. On 26 February 1942, Bothe, Hahn, and Heisenberg reported the possibility of a neutron chain reaction in the Harnack Haus, at Berlin-Dahlem. Heisenberg said that "*an atomic bomb might be as big as a pineapple.*" (It was not a bad guess.) But it was clear that collecting ^{235}U enough would have needed great and long efforts, and Heisenberg was not very enthusiastic to work on nuclear weapons. The German military leadership expected a quick victory, unwilling to invest in any project which could take more than nine months, but Heisenberg's guess was that two years would be necessary for developing a new weapon. Thus it happened that German efforts had concentrated on the construction of a nuclear reactor. Bothe measured that the graphite (supplied by the German chemical industry) had prohibitively large neutron absorption. (It is known now that Bothe's graphite was not pure enough.) Therefore the German task was to build a reactor fueled by natural uranium and moderated by heavy water. Producing so much heavy water by electrolysis required a great deal of time. The German reactor was almost ready in an underground beer cellar at Haigerloch at the time of the military collapse.

⁴³Lax to the author in Budapest, 1994

The British Intelligence Service and the American Central Intelligence Agency were informed of the fact that Germany had given up atomic bomb development but they did not inform the scientists working in Chicago and Los Alamos.⁴⁴ DENNIS GABOR (himself a refugee from Hungary and Germany) wrote:⁴⁵ – *During the war the great scientists, convinced that it was of supreme importance to prevent the Germans from winning, gave their talents to the war efforts in America and developed the atomic bomb. Meanwhile in Germany the great scientists voluntarily withdrew their talents.* – Edward Teller expressed the same conclusion.⁴⁶

After the collapse of Germany Niels Bohr stopped visiting the Hill, and urged President Roosevelt to let the world know that the bomb was being built. He said that only international control could prevent a debilitating postwar nuclear arms race. The motivation of the Central-European refugees – to win the race against Hitler's Germany – disappeared. The Met Lab had already performed its duty by completing the Hanford reactors. LEO SZILARD began to think, – *What's the purpose of continuing the development of the bomb, and how would the bomb be used if the war with Japan were not over by the time we had the first bomb?* – When Compton read Szilard's first memorandum carefully, he said: – *I hope that you will get President Roosevelt to read this.* – Szilard returned to his office and was not there five minutes before there was a knock on the door: Compton's assistant came in, saying that he had just heard on the radio that President Roosevelt had died (12 April 1945).⁴⁷ Truman, the new president, was informed of the atomic weapon (he did not know about it while he was vice-president). To calm the physicists, Compton, the director of the Met Lab, appointed a committee to examine the issue of whether or not the bomb should be used. James Franck (an emigre from Germany) became chairman of the committee. On 11 June 1945 the report of the Franck Committee – influenced by Szilard's memorandum – recommended *not to use* the bomb against Japan but rather *demonstrate* its power with a warning that in case hostilities continued the bombs would be used. The memorandum was signed by J. Franck, D.J. Hughes, J.I. Nickson, E. Rabinowitch, G.C. Seaborg, J.C. Stearn, and Leo Szilard. Compton sent the report via official channels to

⁴⁴Information given at the Pugwash Conference in Hiroshima, 1995

⁴⁵Dennis Gabor: *Inventing the Future*, 1964

⁴⁶Budapest 1993

⁴⁷Leo Szilard: *His Version of the Facts*, 1978

Washington, but it never reached President Truman. High military offices delayed its transfer, and Truman left for the Potsdam summit to meet with Churchill and Stalin.

Szilard also tried to reach the White House in Washington, where Truman's appointment secretary instructed him to discuss his problem with James Byrnes (then to-be-Secretary of State for foreign affairs). Szilard made a long train ride to Spartanburg, armed with a letter of introduction written by Albert Einstein. He presented his reservations about using the atomic bomb against Japan:⁴⁸ – *Byrnes said we have spent two billion dollars on developing the bomb, and Congress would want to know what we have got for the money spent. He explained that a demonstration of the bomb might impress Russia, which might be more manageable if impressed by American military might. When I spoke of my concern that Russia might soon become an atomic power if we used the bomb – his reply was: "General Groves told me there is no uranium in Russia."* – Several years later, when Byrnes met Teller, he said: – *I hope you are not the kind of Hungarian that Szilard is. He is terrible, he told me precisely what I should do.* – Yes, Szilard told everybody what to do, but occasionally he was right.⁴⁹

Szilard did not rely only on official channels. He wrote a memorandum addressed to the President of the United States, and circulated it among scientists for signatures:

"Discoveries of which the people of the United States are not aware of may effect the welfare of this nation in the near future. We, the undersigned scientists, have been working in the field of atomic power. Until recently we had to fear that the United States might be attacked by atomic bombs and that her only defense might lie in a counterattack by the same means. Today, with the defeat of Germany, this danger is averted, and we feel impelled to say that such an attack on Japan could not be justified, at least not until the terms which will be imposed after the war on Japan were made public in detail and Japan given the opportunity to surrender. Using the atomic bomb should not be made at any time without seriously considering the moral responsibilities which are involved. A nation which sets the precedent of using these newly liberated forces of nature for purposes of destruction may have to bear responsibility for opening the door to an era of devastation on an unimaginable scale. If after the war a situation is allowed to develop in the world which permits rival powers to be

⁴⁸Leo Szilard: *His Version of the Facts*, 1978

⁴⁹Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

in an uncontrolled possession of these new means of destruction, the cities of the United States, as well as cities of other nations, will be in continuous danger of sudden annihilation. Its prevention, at present, is the solemn responsibility of the United States, singled out by virtue of her lead in the field of atomic power. The added material strength which this lead gives to the United States brings with it the obligation of restraint. If we were to violate this obligation, our moral position would be weakened in the eyes of the world and in our own eyes. It would then be more difficult for us to live up to our responsibility of bringing the unleashed forces of destruction under control..."

In the Met Lab the petition was signed by 68 scientists. Szilard sent copies of the memorandum to Oak Ridge and Los Alamos. EUGENE P. WIGNER remembered:⁵⁰ – *Szilard sent me his memorandum, asking me to circulate it for signatures. When I took it to Oak Ridge, the military commanders scolded me: "Now you have made it known that the explosion is possible." I answered: "But here everybody knows it." Then they: "Nobody knows it." I was worried when I returned to my friends. Then Alvin Weinberg said: "But General Groves gave a speech to us, saying that the bomb would explode over Japan!" – So at the next scolding I said: "We had to do something to keep the secret." The army people asked: "Who revealed the secret?" I answered: "General Groves!" So they were astonished. – Wigner expressed his views about using the bomb also on other occasions:⁵¹*

– I never wanted the bomb dropped on Japan. Once Germany surrendered, I hoped the atomic bomb would be made public. I was very sorry to see our country set a precedent in using atomic bombs as regular weapons of war. We could not blame any country for trying to build a bomb that we had developed ourselves. So the atomic bomb became a terrible disappointment for me.

Szilard mailed copies of the memorandum to EDWARD TELLER, to be circulated in Los Alamos. Now let us listen to Teller:⁵² – *I would have signed the Memorandum, but I did not dare collect any more signatures without asking Oppenheimer, the director of the Laboratory. Oppenheimer was a good physicist – we all knew that. He was involved in politics as well. As head of the Laboratory he organized an enormous amount of*

⁵⁰to the author 1983

⁵¹as Andrew Szanton quotes

⁵²Budapest 1993

work. Our results depended on the ideas of thousands of people and on the realization of those ideas. Oppenheimer knew the strengths and weaknesses of each person. He knew what they had inside behind the successes and failures. His character had a strong effect on every individual. I showed him Szilard's letter. Oppenheimer was normally a careful person who expressed himself with moderation. But this letter annoyed him very much: – "So what does Szilard know? What does Franck know to interfere with political issues like that? In Washington first class people are working, they understand the Japanese, they know what to do. We, the technical people – engineers, scientists – should stay with our own business, we should not interfere with politics." – I very much regret having allowed Oppenheimer to persuade me on that occasion. I wrote Szilard a letter: – "I have spent some time thinking about your objections for immediate military use of the weapon we may produce. I decided not to do anything. First of all let me say that I have no hope of clearing my conscience. The things we are working on are so terrible that no amount of protesting or fiddling with politics will save our souls. I did that kind of work because the problems interested me and I would have felt a great restraint not to go ahead. Should you succeed in convincing me that your moral objections were valid, I would quit working, but I do not feel that there is any chance to outlaw any one weapon. If we have a slim chance of survival, it lies in the possibility of getting rid of wars. The more decisive a weapon is, the more likely it will be used in a real conflict, and no agreements could prevent it. Our only hope is getting the facts of our results before the people. This might help to convince everybody that the next war would be fatal. In the end the responsibility must be transferred to the people as a whole and that can be done only by making the facts known." – Our letters were censored. I knew my letter would most likely go first to Oppenheimer's desk, therefore I did not mention my discussion with Oppenheimer.

– These events meant a lot to me personally. I saw how many people died in Hiroshima. A few months later I learned that Oppenheimer participated in a closed official meeting.⁵³ This meeting later figures in Compton's book: "Atomic Quest." It is described how at this meeting

⁵³In Washington an "Interim Group" was appointed on 2 May 1945, to advise the Government on the use of the atomic bomb. With Conant's recommendation a Scientific Panel was created to assist the Interim Group. The invited scientists were Arthur Compton, Enrico Fermi, Ernest Lawrence, and Robert Oppenheimer. They met in the Pentagon on 31 May 1945. They had received the Franck report.

Fermi was very cautious; he generally thought that he had to stick with the majority, because he was no expert in American politics; thus Fermi kept silent. Compton, and Lawrence even more so, had the thought that the bomb had to be demonstrated to the Japanese. In the end, Oppenheimer persuaded everyone to report that "according to the opinion of the Scientific Panel the atomic bomb has to be used immediately." To me Oppenheimer had recommended that myself and other scientists should not interfere with the decisions. This influenced me. In the meantime he held a very definite view of using the bomb and he represented that view very actively in high places! I need add two remarks to all this. One is: nothing that I would have done at that time would have mattered. The other one (less clear but certain): what Oppenheimer, what these four physicists had recommended, never reached President Truman's desk. What they proposed – so I believe today – was a great mistake, but what happened, happened independently of this mistake. Another friend of mine, Lewis Strauss (banker, then rear admiral, later appointed to head the Atomic Energy Commission) wrote his book: "Men and Decisions." It features a chapter on Hiroshima. It is sufficient to quote the title of the chapter: "A thousand years of regret." Lewis Strauss generally supported development of weapons, but was against this bombing. On the other hand Oppenheimer, who following the war wanted to stop all nuclear weapons research and development, was for using the bomb.⁵⁴

Neither the Franck Report, nor Szilard's Memorandum reached the President. The Memorandum was kept by General Groves from 25 July until 1 August, then he sent it to the office of the Secretary of War, Henry L. Stimson. Washington decided not to disturb the President on his way to the Potsdam Summit. Seeing the failure of the Memorandum of the atomic scientists, Szilard was not willing to give up: he decided to make the Memorandum public. But Captain James S. Murray, intelligence officer of the Corps of Engineers at the Manhattan Project informed him in an official way, that General Groves decided to consider the Memorandum a classified text.

Some historians interpret these events to mean that the atomic bomb was considered to be a trump card, not against Germany, not even against Japan, but against the Soviet Union. Oppenheimer testified: – *We were under incredible pressure to get the Alamogordo test done before the Potsdam Meeting. I don't think there was a time when we tried harder to speed up our work than in the period after the German surrender.*⁵⁵

⁵⁴Teller, Budapest 1993

⁵⁵Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

ALAMOGORDO 1945

There was a general understanding that the uranium bomb would work, but the sophisticated ignition of the plutonium bomb made an experimental test necessary. This test was performed in the desert of Alamogordo at Trinity Point on 16 July 1945. (The local name of the site was Jornada del Muerto, "Trip to Death," due to the total absence of drinking water, but Oppenheimer wanted to immortalize the experiment by choosing the new name "Trinity.") We all know from history that the first nuclear explosion succeeded. EDWARD TELLER was also present:

– We went out at night and the test was to occur before sunrise. But it was raining in the desert! The test was postponed. It was performed at dawn – just as it was becoming light in the east. I was involved with predicting what could happen, and I felt that we should be prepared for a bigger explosion than the one we had calculated, although I felt sure it would not be by many orders of magnitude bigger. I took some personal precautions. I wore gloves, and on the exposed parts of my skin I used a suntan lotion. We were given welder's dark glass eye shields, but in addition to that I put on dark sunglasses. Then I used the gloves to hold the welder's glass in such a manner that no light could reach my eyes, except through the welder's glass and the sunglasses. Then I saw a very faint light point which divided into three: a high point and two lobes, which was the inception of the mushroom. I remember the feeling of disappointment: "is this all?" Then I remembered within a fraction of a second that I had all those glasses between me and the event. So I tipped the welder's glass slightly to take a peek over the side. The impression I got was one that you have if you're in a completely darkened room and you raise the curtains and sunlight comes streaming in. That may have been a few seconds later, twenty miles away. I was impressed of course. It faded. I took off the glasses, and we saw the mushroom developing. The golden cloud grew to an altitude in excess of 10000 meters.

– In Potsdam President Truman was informed by cable that the atomic bomb existed and had been tested successfully in Alamogordo:

OPERATED ON THIS MORNING. DIAGNOSIS NOT YET
COMPLETE BUT RESULTS SEEM SATISFACTORY.

After the Trinity explosion Robert Oppenheimer reached into the Hindu script of the Bhagavad Gita to mourn: – *"Now I have become Death, the destroyer of worlds."* – JOHN VON NEUMANN dryly commented: – *Some people confess guilt to claim credit for the sin.*

HIROSHIMA 1945

In the meantime the targets were selected. General Groves recommended Kyoto, vetoed only by Henry L. Stimson, Secretary of War, due to the unique cultural heritage of the town which he had visited three times. Thus Hiroshima became Target One. The most important person in Japan was Emperor Hirohito, and he opposed the continuation of the war. In May 1945 a Japanese message reached the Soviet Government: Emperor Hirohito wishes to send one of his relatives, Prince Fomamiro Konoye to Moscow, to negotiate about peace. The Japanese offer barely differed from what the end result turned out to be: *"We have only one condition, that the Emperor remain on his throne. Otherwise, we in Japan are ready to do anything the Americans want."* Unfortunately, the Soviets wanted to pick up a piece of the victory in the Pacific war. The Soviet authorities informed the Japanese ambassador that Prince Konoye should not come to Moscow, and the Soviet Union entered the war on the next day and attacked the Japanese army in Manchuria.⁵⁶ In his lecture Teller said:⁵⁷

– Even before the war the American Navy achieved a major success: they had succeeded in deciphering the secret code of the Japanese. This code was later changed by the Japanese command, but when the rules were changed all units had to be notified, and this could happen only by using the old secret code. Thus throughout the war the American Navy was able to follow what the Japanese were saying to one another. At that time Lewis Strauss was serving in the Navy. The Navy and Strauss knew that Fomamiro Konoye was about to ask for peace in Moscow. I know from a reliable sources that neither the recommendations of the Oppenheimer group, nor this information the Navy possessed, ever became known to President Truman. He learned in Potsdam that our first experiment with the atomic bomb was successful. He knew that following a terrible war, Europe was facing a terrible winter. Perhaps the whole of Europe would become communist. America had to help, but that would be almost impossible to help while fighting the Japanese. America had a new weapon at hand, and it had to be used to end the war quickly. Thus the decision was made to use the bomb. I regret that. Let us imagine, as I did, too late though, without the possibility of having any influence on events, that the first atomic bomb was dropped

⁵⁶Kazuhiko Nishijima to the author 1996

⁵⁷*Hiroshima – the Psychology of a Decision*, lecture in Budapest 1993

over the Tokyo Bay, and it exploded at an altitude of 10000 meters. We could have done that. Had we done this during the evening hours, ten million Japanese would have seen how evening darkness is turned into noontime brightness – and no deaths would have occurred.

– We also know, having dropped the bomb on Hiroshima on 6 August 1945, what effect that had on Japan. At that time Japan was governed by a small cabinet of six people. Following the battle of Okinawa everybody knew that Japan had lost the war. Three cabinet members wanted peace without any preconditions, the other three wanted to “continue fighting for a more favorable peace.” And Hiroshima did not change a single vote; the split stayed at 3:3. This was the opinion relayed to the Emperor. He wrote a speech with the intention of delivering it to Japan and the world. Pro-war generals, however, carried out a coup’d’état: they detained the Emperor, and searched for the text of the speech, but did not find it. The head of the attacking group wanted war, but was loyal to the Emperor, and withdrew his soldiers.

– Prior to the bombing of Nagasaki (9 August 1945) Emperor Hirohito had already written his cease-fire speech. I believe there was no need to drop the bomb on Hiroshima. I am certain there was no need to bomb Nagasaki.

– The speech of the Emperor was delivered (15 August 1945): – “We, the Japanese should do the unimaginable: we ask for peace.” – The commander who had withdrawn his troops from the Imperial Palace went home and committed suicide. Had the Emperor seen the demonstration of the effects of the atomic bomb, had we warned the Japanese that two such weapons would kill people in two weeks unless they surrender, I am convinced that we could have achieved peace without loss of life.

– After bombing Hiroshima and Nagasaki we did not have to invade Japan. The terrible World War came to an end without the loss of perhaps 100000 American lives in Japan. Japanese deaths did not have to amount to unbelievable counts. This made the Americans to forget all other problems. But years passed and people began to be afraid. Prior to Hiroshima, perhaps a thousand people knew what would happen. After Hiroshima, billions of people did not understand how the miracle of the atomic explosion could have happened in Hiroshima. It was impossible to explain it to them, since people were made to believe that things that cannot be understood in five minutes, cannot be understood at all. And it would have taken no more than two hours to understand what an atom is and what a nucleus is. From a little fear more fear arose: people began to fear atoms and radiation. President Roosevelt had already

said during the depression, "We need not fear anything but fear." This is why I believe Hiroshima was a serious mistake.

President Truman was aboard ship in the Atlantic, returning from Potsdam, when the ^{235}U bomb exploded above Hiroshima on 6 August 1945. Fifty years later, when information was declassified, it became known that General Marshall, Chief of Staff, General MacArthur, Chief of the American forces in the Pacific, and General Eisenhower, Chief of the Allied Forces, objected the use of nuclear weapon against cities and civilian population. Dwight Eisenhower said:

– I objected, because Japan had already been defeated: therefore the use of the atomic bomb was unnecessary. The United States could have avoided the antipathy of the world against using a weapon of mass destruction, which was not needed to save American lives.

OBNINSK 1946

Lev Landau had already speculated about the neutron chain reaction in 1934. After the discovery of uranium fission, Georgi Flerov and Lev Ruzinov observed the neutrons produced in the fission in April 1939, just a few weeks after Szilard, Fermi, and Joliot. In the summer of 1939, Yakov B. Zeldovich and Yurii Khariton lectured about the nuclear chain reaction in Moscow. In the autumn they studied the possibility of a controlled chain reaction with the application of a neutron-moderator; they considered helium, heavy water, and graphite. (They might not reach, however, the idea of the inhomogeneous reactor.) In 1940 a Uranium Commission was formed under the chairman Igor Kurchatov. (His friends called him the "Beard," but later, behind his back, among his coworkers his nickname was the "General," like Szilard's.) Georgi Flerov and Constantin Petrzak observed the spontaneous fission of the uranium nucleus at first in the world.

On 22 June 1941 Germany attacked the Soviet Union. During one of his leaves from the front, Flerov, rushing through the recent scientific literature, noticed that publications concerning nuclear fission had disappeared from Western journals. – *I smell nuclear powder!* – he said. Like Szilard and Einstein, also Flerov was afraid of a possible German nuclear weapon. In 1942 he wrote a letter to Stalin, calling his attention to the possibility of nuclear weapons for mass destruction. Stalin charged Igor Kurchatov to lead the nuclear energy program. (Kurchatov was only in his 30s.) On 22 March 1943 Kurchatov reported that *eka-osmium* (what the Americans had named plutonium) would be the most

appropriate fissionable material for the bomb. Even imprisoned physicists had to work on nuclear weapon research. Forty km from Moscow a top secret research center was established, but this research was interrupted by the siege of Moscow.⁵⁸

The atomic bomb explosions above Hiroshima and Nagasaki initiated a new kind of chain reaction in 1945: The United States had made nuclear bombs due to a fear of (non-existing) German nuclear weapon development. The Soviet Union undertook nuclear armaments due to a fear of American military supremacy. England, France, and China made their own bombs because they were afraid of the Soviet Union. India produced a nuclear blast, being afraid of China. Pakistan initiated a nuclear program, due to the fear of India. Israel's nuclear program is due to the fear of muslim countries. Iraq claimed that her nuclear development is a response to Israeli armament. South Africa had made bombs to defend itself against Black Africa. (Later, after a reconciliation, South Africa disarmed her nuclear bombs.) North-Korea hints at the U.S. Ukraine made nuclear claims, being afraid of Russia. (But in 1995 she transferred her nukes to Russia.) The Cold War and the nuclear arms race represent a chain reaction of fear.

After World War II Stalin accelerated the nuclear program. The first nuclear reactor started working near Moscow in the town later named Obninsk on 25 December 1946. Kurchatov selected a remote region in the Urals, where he used to spend his holidays: Chelyabinsk became the site of the first large Soviet plutonium producing reactor designed by Nikolai Dolezal. The reactors started operating on 10 July 1948. The idea of implosion – as a precondition for the operation of a plutonium bomb – might arrive through intelligence channels from the U.S. The first Soviet plutonium bomb was tested in the desert of Kazakstan, at Semipalatinsk on 28 August 1949. (The American code name was “Joe One,” after Joseph Stalin.) After the successful test Berija rushed to the phone and woke up Stalin with the news: – *Everything went right.*

– *The atomic sword is already in our hands. It's time to think about the peaceful use of nuclear energy!* – Kurchatov exclaimed. The first nuclear power plant of the world started to produce electricity in Obninsk on 27 June 1954. Kurchatov received the proud title: *Hero of the Soviet Union.*

The first Soviet reactor, the plutonium producing reactors, and the power plant used uranium fuel, graphite moderator, and water cooling.

⁵⁸Richard Rhodes: *The Dark Sun*, 1995

BIKINI 1954

The historical experiences and political sensitivity of the Hungarians made them especially eager to find an escape route to avoid the risks of the nuclear arms race. *Saving the world* has remained their main obsession, occasionally even at the expense of their scientific research. To the American public they have become known as the fiercest fighters in the nuclear arena. According to their differing personalities they proposed different solutions to the problems of the nuclear arms race.

EDWARD TELLER advocated originally an *open world* policy, on the line of Niels Bohr, in the style of the science fiction writer H.G. Wells: in *The World Set Free*, after a nuclear world war set in 1956, the World Government was established. But the Hiroshima bomb initiated a Cold War, even before World War II came to an end, and that made the idealistic dream of a unified humankind unrealizable. As predicted by Leo Szilard, the nuclear arms race between the two remaining superpowers became unavoidable. Before the war, Teller had worked on the thermonuclear power of the stars with George Gamow. One afternoon in the September 1941, walking together at Columbia University, Fermi asked Teller whether one could ignite a thermonuclear fusion with the heat of a fission bomb. Teller's calculations indicated that the temperature of the fission bomb may be enough to produce fusion chain reaction in heavy hydrogen ($^2\text{H} + ^2\text{H} \rightarrow ^3\text{He} + n$). He reported the possibility of the "super" to Bryan Conant. –

Teller knew this field well, and predicted that the Soviet Union would soon develop fission and fusion bombs. Ritchmeyer and Teller circulated a design tendentiously named "Alarm Clock," consisting of alternate layers of uranium (to supply neutrons by fission) and deuterium (to undergo fusion). In 1949, after the explosion of the Soviet plutonium bomb, at the recommendation of Edward Teller, President Truman ordered to develop the fusion bomb. Ulam proved that the first design of Teller, based upon the thermonuclear fusion of heavy hydrogen, would not work, due to heat loss by thermal radiation. He proposed another design: the shock wave of a plutonium bomb should be focused onto superheavy hydrogen ($^3\text{H} + ^2\text{H} \rightarrow ^4\text{He} + n$). The first successful American thermonuclear experiments were carried out in the Southern Pacific in the Summer of 1951. The first portable American hydrogen bomb exploded on an atoll of the Pacific, named Bikini, on 11 March 1954.

As Teller predicted, the Soviets were also coming up: on 12 August 1953 they tested a thermonuclear device, designed by Andrei Sakharov and Yakov B. Zeldovich.

JOHN VON NEUMANN had a highly logical mind that used mathematics even for the game of poker. Neumann developed the theory of games, which would be successfully applied to economics and military strategy as well. As Neumann described it: – *For America the German submarines caused the greater harm not by sinking ships, but by forcing the ships to sail in convoys under the protection of warships. In submarine warfare a particular kind of equilibrium between measures and countermeasures had developed to such a degree that after about one year the damage actually done by mines to the enemy was smaller than the economic damage caused by effort the enemy had to exert in order to defend itself against mines. This had been true in the past, most specifically in aerial warfare. The enemy came out with a new trick, then you just had to take your losses until you developed countermeasures, which may have taken weeks. A particular radar trick was countered by the Germans in four days, but, nevertheless, these four days cost them the city of Hamburg. The difficulty with missile-carried atomic weapons will be that they can decide a war. Therefore it will not be sufficient to know that the enemy has only fifty possible tricks and that you can counter every one of them, but you must also invent some system of being able to counter them practically at the instant they occur.*⁵⁹ – For President Eisenhower, John von Neumann designed a superpower game called nuclear deterrence. He insisted on always to be one step ahead of the Soviet Union in the race. According to *Life* magazine, Neumann said: – *If you tell me to bomb Russia tomorrow, I will tell you to bomb them today. If you tell me to bomb them at 5 o'clock p.m., I will tell you to bomb at noon.*⁶⁰ – From among the Martians, Neumann might be the fiercest fighter. (As of today, the Cold War has become a part of the political history of mankind. It was fought with technique and with much bluffing, and was won by the U.S., based on the mathematical design invented by Neumann. The story is vividly described by Norman Macrae.)

EUGENE P. WIGNER'S mild temperament guided him towards a more passive solution: civil defense. He learned from the experience of World War I that trenches played a role almost as important as guns, and during World War II air raid shelters had been effectively utilized in Europe. Stalin developed the deep subway system in Moscow to serve also as a public shelter in the case of a World War III. Thus, instead of *Mutually Assured Destruction* (MAD) Wigner advocated *Mutually Assured Surviv-*

⁵⁹Neumann: *Defense in Nuclear War*

⁶⁰Paul Erdős to the author 1996

al (MAS). He urged President Kennedy to invest in planning for the mass evacuation of cities and in building public shelters. As the head of the Harbor Project – a six-week long brainstorming session held in Woods Hole, Massachusetts – he elaborated a detailed proposal. His program, however, was attacked by those who claimed that – as a result of developing an effective civil defense – the American leadership might conclude that nuclear war was not so terrible after all. Thus America’s civil defense remained underdeveloped. – Later on Edward Teller also turned to advocating the option of Mutually Assured Survival: he championed the Anti-Ballistic Missile Defense, a concept that triggered President Reagan’s Strategic Defence Initiative (nicknamed *Star Wars*).

LEO SZILARD understood that nuclear warfare was an unacceptable alternative. He argued that 10000 nuclear warheads would assure a horrible overkill: no military or civil defense would be adequate to protect people against such a massive attack. Only a *Mutually Assured Disarmament* can solve the problem: reducing the number of warheads to 100 or to 1000. That may make *Mutually Assured Survival* possible. The official objection to Szilard’s proposal was that any disarmament agreement can be cheated. Sensing that any mutual disarmament was made impossible by mutual distrust, Leo Szilard participated in the Pugwash Movement of scientists fighting against nuclear armament, and turned directly to First Secretary Khrushchev. Even Russian scientists considered him to be “*the leading conscience of humanity.*”⁶¹

ALBERT SZENT-GYÖRGYI, a Nobel laureate in biology and participant in the antifascist resistance movement during 1944, left Hungary after the communist takeover, and experienced later the demoralizing effects of the Vietnam War in America. He no longer believed in the possibility of convincing either the American administration or the Soviet rulers of the fact that in the Nuclear Age humankind cannot afford a World War. At the time of the Vietnam war, during Lyndon Johnson’s presidency he wrote his bestseller *The Crazy Ape*. He placed his hopes in young people: he proposed a rational science education for upcoming generations, as a means of securing human survival:

– *Our hypocritical world, one of false pretenses, is now being rejected wholesale by our youth. The young have broken away; they teach themselves and are creating a world of their own. Our youth is our hope for the future.*



⁶¹Richard Rhodes: *The Dark Sun*, 1995, p. 515

The radioactivity released during the atmospheric test of a modern hydrogen bomb is about 1 EBq. (1 exabequerel means 10^{18} radioactive decays per second.) Such a test was performed on 11 March 1954 on Bikini. The power of the explosion was twice as high as expected. A Japanese fishing boat, the *Fuku Ryu Maru* (Lucky Dragon), sailing unnoticed near the perimeter of the prohibited zone, was reached by the fallout of the explosion. The Japanese fishermen and some of the natives living on the Marshall Islands became seriously ill. K. Kimura and Sakae Shimizu, investigating the ash found on the Lucky Dragon upon arrival in Japan, became puzzled by the presence of the ^{237}U isotope in the ash. This was how the world learned about the existence of a new Fission–Fusion–Fission bomb. In such bombs plutonium *fission* provides the ignition, initiating the *fusion* of lithium deuterid:



and the escaping fast neutrons induce *fission* once again in the surrounding ^{238}U mantle. High neutron flux also produces tell-tail ^{237}U isotopes in the reaction $n + {}^{238}\text{U} \rightarrow {}^{237}\text{U} + 2n$.⁶² The largest 100 megaton FFF bomb (with a destructive capability equivalent to 60 million tons of trinitrotoluol) releases as much as 10 EBq activity. The cumulative release of the atmospheric tests performed during the 1950s and 1960s amounted to over 100 EBq. A fraction of their fission fragments is still present in the biosphere. (The Northern Hemisphere is polluted predominantly from Soviet and Chinese tests, the Southern Hemisphere from American and French tests.)

This is why responsible nuclear scientists, including Andrei Sakharov and Leo Szilard, worked for a complete ban of all atmospheric nuclear testing, for the conclusion of the atmospheric test ban treaty (1963). The recent international agreement has banned all kinds of nuclear weapon tests (1996).

A test ban does not mean elimination of nuclear weapons; it is intended to slow down their proliferation. The Pugwash Movement of scientists works now for complete elimination of nuclear weapons; this Movement received the 1994 Peace Nobel Prize. The world has been at the verge of nuclear conflict at least twice. During the Vietnam War, a decision to drop an atomic bomb on Dien Bien Phu was made by the U.S. Security Committee, only Eisenhower's veto prevented it (1954).⁶³

⁶²Shimizu to the author, 1991

⁶³Dennis Gabor: *Inventing the Future*, 1964

– *And the most terrifying moment in my life was in October 1962, during the Cuban Missile Crisis. I did not know the facts – we have learned only recently how close we were to war – but I knew enough to make me tremble. The lives of millions of people were about to end abruptly. It all hung on the decision of one man, Nikita Krushchev: would he or would he not yield to the U.S. ultimatum?*⁶⁴

The press considered EDWARD TELLER, JOHN VON NEUMANN, EUGENE P. WIGNER as *hawks*, while LEO SZILARD, ALBERT SZENT-GYÖRGYI, JOHN G. KEMENY were considered to be *doves*. The two groups conducted heated public press and TV debates against the ideas of each other. But in spite of these differences they remained good friends, respecting each other, and understanding that they were all trying to reach the same final goal even if the means differed. This mutual respect did not diminish the sharpness of their emotions, however, because the stakes were high, perhaps the highest imaginable: human survival. The Cold War between the winning superpowers began in 1945, and terminated eventually in the late 1980s, with America winning. The fact remains that our heroes all became actors not only on the stage of World War II but also in the Cold War as well. History may eventually decide which of them was right. (By developing nuclear deterrence and by building bridges possibly they contributed together to the prevention of a global nuclear holocaust.) As LEO SZILARD said:

– *Let your acts be directed towards a worthy goal, but do not ask if they will reach it; they are to be models and examples, not means to an end.*

WINDSCALE 1957

To make fission and fusion bombs one needs plutonium. Plutonium-producing military reactors used graphite moderators to slow down the fast neutrons released in fission. This neutron bombardment knocks out carbon atoms from the graphite lattice and produces crystal defects. These defects gradually accumulate. If the lattice is heated up, the carbon atoms are set in motion, and they may fall back into their proper lattice sites, liberating energy. In this way a small warming of the disturbed crystal may liberate a great deal of energy, possibly causing the graphite to catch fire. This effect has been studied by EUGENE P. WIGNER during the design of the Hanford reactors; that is why it is called the *Wigner-effect* (nicknamed

⁶⁴Nobel lecture of Joseph Rotblat, Pugwash' president, 1994

wigneritis). It can be prevented by warming up the graphite in the reactor at regular intervals, ensuring a controlled reordering of the lattice. This technique is used in all graphite reactors in the U.S.

Windscale is in England. A reactor accident happened there at a plutonium producing reactor: the intended warming was not performed carefully enough, so the graphite caught on fire. The reactor was confined and the English personnel behaved cautiously. They did not pour water onto the fire because the expanding steam would have spread radioactivity. The fire was extinguished by carbon-dioxide, thus the catastrophe was averted.

Wigner was unhappy when people called this effect the *Wigner-effect*: he stated that the Windscale accident had not been caused by him but by the uncontrolled behavior of carbon atoms. He would prefer to call the phenomenon the "*Windscale effect*."⁶⁵

CHERNOBYL 1986

After World War II, the nuclear industry underwent fast development in America. A Reactor Safeguards Committee had been established (1947), chaired by EDWARD TELLER. The usual practice of engineers had been to build any new device soon after its invention. Only later, if an accident happened, would the designers begin to think about the safety of their creation. The eventual outcome of all this would be a safe design. Enter Teller:

– *We said at the beginning: nuclear reactors have to operate perfectly because a single accident may be enough to prevent any further utilization of nuclear power. Those who applied for permission to build a new reactor were requested to think about all possible malfunctions in advance. Such preventive investigation of the worst possible conceivable accident is now an accepted procedure worldwide. But at that time our work was kept secret. Only reactor engineers knew of our work, and they started calling us the "Reactor Prevention Committee." I was asked: – "Dr. Teller, why don't you get out of the Brake Department and begin to do something in the Engine Department?" – We accepted most of the proposed reactor designs. But there was an important exception. Lilienthal, chairman of the Atomic Energy Commission, asked us to check the safety of the plutonium producing reactors in Hanford, remarking that*

⁶⁵Budapest 1983

experience had showed them to be safe. (The reason for the request was, that the Atomic Energy Commission wanted to decrease the safety zone around the Hanford reactors, to allow more agriculture.) And our Committee has come to the conclusion that they represented a safety risk!

Due to the scarcity of uranium, the Hanford reactors contained the minimum amount of uranium and plenty of graphite moderator, to serve as neutron reflectors as well. Due to the graphite, the neutrons slow down to the speed of the thermal motion, even without the presence of water. In these reactors the produced heat is removed by circulating water. If in a pipe for any reason the water becomes locally overheated, it starts boiling, creating bubbles. Light water is a neutron absorber: $n + {}^1\text{H} \rightarrow {}^2\text{H}$. Thus a loss of water, the formation of bubbles (voids) means less absorbed neutrons, increased neutron multiplication: a *positive void coefficient*. In this way a local temperature rise results in increasing power production, further rising temperature, in short: a positive feedback. This means that the chain reaction may escalate indefinitely.

– Learning of our objections the Atomic Energy Commission simply declared that our Committee consisted of mere professors, who had no practical expertise in technology. Therefore, in 1950 another Committee was established. It consisted of administrators and engineers. They were all inexperienced in reactor construction, therefore they asked for permission to attend our meetings as observers. Their request was granted. They listened, learned, discussed among each other, and came within a year to similar conclusion: the Hanford reactors, being inherently unstable, must be shut down! It was not easy to convince the Atomic Energy Commission, but finally the Hanford reactors were closed. Thereafter no more uranium-fueled, graphite-moderated, water-cooled reactors were built anywhere in the world – except in the Soviet Union, for the production of plutonium. That eventually caused the problem: such a reactor was commissioned in Chernobyl.⁶⁶

The Chernobyl power reactors (and 15 other power reactors in the Western Soviet Union) are upscaled versions of the original plutonium-producing reactors, using uranium fuel, graphite moderator, and light water cooling. They have *positive void coefficients*. The neutron chain reaction is controlled by a special system of electronics. In Chernobyl, in order to supply 1 billion watts of electricity, each reactor produces 3.2 GW⁶⁷ of heat. To remove the heat, 10000 liters of water are pumped

⁶⁶Teller's lecture in Budapest 1993

⁶⁷3.2 billion watts

through the reactor per second by electric pumps. For safety reasons, Diesel engine driven pumps are also available in reserve, to take over in case of an electric network failure. But for the Diesel engine it takes about *one minute* to rev up, a delay much too long! Some young and enthusiastic engineers had a great idea: by milking the rotation energy of the huge turbine wheels, one could generate sufficient electricity for the pumps during the transient one minute. They decided to perform an experiment. As spring came and the demand for power dropped, a weekend offered a good opportunity.

25 April 1986, Friday, 1:00 a.m. Decreasing the 3.2 GW thermal power begins.

13:05 p.m. The power is at 1.6 GW. One of the two turbines is turned off.

14:00 p.m. The emergency cooling system (serving for flooding the reactor with boronated water in case of need) is disconnected by the operator.

14:05 p.m. An unexpected power demand is indicated by the energy authority. The reduction of power is interrupted. The reactor works on at 1.6 GW thermal power.

23:10 p.m. The public demand of electric power drops. Permission is given to turn off the reactor.

26 April, Saturday, 0:28 a.m. With 24 hours of delay the experiment begins. Local electronic controls are turned off, only global control operates. To be "on the safe side," the speed of water circulation is increased above permitted level, the water does not have time to cool, is near boiling. The reactor indicates signs of instability: instead of the intended 0.7 GW the power suddenly drops to 0.03 GW.

1:07 a.m. The reactor is stabilized at 0.2 GW. Water circulation is reduced.

1:22 a.m. The last computer printout indicates 0.2 GW thermal power. Problems have accumulated, however. During the long operation at low power *xenon poisoning* has been built up. (Fission of ^{235}U produces ^{135}I as well, that decays to ^{135}Xe , which is PPP, a *prodigious pile poison*, already studied by John Archibald Wheeler under EUGENE P. WIGNER in Hanford in the 1940s.⁶⁸ The ^{135}Xe nucleus, with a half life of 6.7 hours, absorbs neutrons with million times higher probability than others, due to its deficient nuclear shell. When the reactor works at high power, ^{135}Xe is eliminated by $n + ^{135}\text{Xe} \rightarrow ^{136}\text{Xe}$. When the power (and the neutron density) drops, however, the ^{135}I present produces more and more

⁶⁸Maurice M. Shapiro to the author 1994

^{135}Xe by decay, and the accumulation of ^{135}Xe is not prevented by the neutron flux. In this situation a sudden *increase* in neutron number eliminates the poison, consequently the neutron number further *increases*. A xenon poisoned reactor is highly unstable.) Due to xenon poisoning, the control rods have been pulled high up, beyond the permitted height. In this case the time needed for their re-entering the reactor, even by free fall, through 10 meters is longer than one second. As a Soviet investigator later said: “*At this state of affairs not even the prime minister can allow to go on.*”

1:23, 04 seconds. Power is at 0.2 GW. The experiment begins. The operator wants to have the upper hand and turns the automatic SCRAM off. The valves feeding the second turbine have been closed.

1:23, 21 seconds. Control rods gradually move in. Their lower part is made of graphite. Graphite replaces water (which is a weak neutron poison) in the reactor core, increasing the neutron multiplication there by a few percent. But the reactor is in the state of *positive feedback*.

1:23, 40 seconds. The thermal power increases to 0.32 GW in half a minute. The operator pushes the SCRAM button.

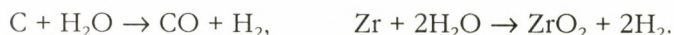
1:23, 43 seconds. The power is already at 1.4 GW and doubles every second. Locally the reactor becomes overcritical; the sudden rise of temperature results in uneven thermal expansion, deforming and fracturing the channels of the control rods. The descending control rods are stopped halfway. Alarm signal sounds.

1:23, 45 seconds. 3 GW thermal power. The cooling water boils away, the “Teller effect” sets in. Global runaway of the reactor happens.

1:23, 47 seconds. Uneven thermal expansion opens up the uranium rods. The chain reaction stops. Water pipelines fracture.

1:23, 49 seconds. The steam of the boiling water produces a (thermal) explosion, opening the core of the reactor.

1:24. The water and the zircon coating of the reactor come into contact. Above 1000 °C chemical reactions start:



The flammable hydrogen and carbon-monoxide gases mix with the outside air, resulting in a second (chemical) explosion. The graphite burns on open air; its smoke contaminates the environment with radioactive fission products.

On this Saturday and Sunday the wind was blowing towards the northwest, carrying the radioactive cloud out of Ukraine towards Poland, Finland, Sweden, and Great Britain. A week later – with the graphite pile still on fire – the wind changed direction and began blow-

ing contaminated aerosol towards Kiev and Romania. (Hungary was protected by the chain of the Carpathian Mountains.) The number of direct victims of this accident within the power station was 32. The total amount of the radioactivity that has escaped from Chernobyl is generally estimated to reach a few EBq. This may be contrasted with the activity 0.01 EBq released by the Hiroshima bomb, and with the 0.001 EBq released in the Windscale accident. The amount of the global radioactive fallout from Chernobyl was comparable to that of a large hydrogen bomb test.

The most dangerous fission fragment, ^{131}I , has only a half life of 8 days, but cows eating the grass affected by the fallout concentrate ^{131}I in their milk, and babies drinking that contaminated milk concentrate ^{131}I in their iodine-hungry thyroid. As the expert team of the International Atomic Energy Agency predicted, till today the only observable health effect is the highly increased incidence of thyroid cancer in children of the region. (Within a decade 800 cases were registered, three children died. Under appropriate medicare, over 90 % of thyroid cancer cases can be cured by surgery.) The ^{131}I has already decayed. Another radioactive fission product, ^{137}Cs , is chemically similar to potassium, can also be incorporated in living organisms. Its physical half life is 27 years, but its biological half life time is less than a year in the body, due to biological metabolism. Soviet authorities evacuated altogether 125000 people from the affected region. Later an international team (led by Japanese and American radiation experts) reinvestigated the situation and concluded that the mass evacuation was the result of over-caution, causing more psychological harm among the local farm population than the risk suppression benefit would have warranted.

The delayed cancer risk of a radiation dose may be estimated by taking the Nagasaki experiences into account, *assuming direct proportionality* between dose and risk: 5 % cancer risk per 1 joule ionizing radiation absorbed per kilogram of body mass. For low level doses this is probably an overestimation, because recent experiences (in Japan and in radon contaminated regions elsewhere) seem to indicate, that the risks of small doses are much smaller (perhaps even zero) than the values obtained from linear extrapolation, thanks to the immune defense of the human organism. But if we use this overestimation, it can be calculated that in Europe the fallout from the Chernobyl accident may cause maximum 20000 additional cancer cases during the coming years. But about 20 % of the people die anyway of cancer, we shall never be able to find out whether the actual number of victims will grow to thousands in the years to come or not. We know, however, that in Western Europe

in 1986, in the months following the Chernobyl accident, the number of surgical abortions jumped by about 40000. These abortions were not justifiable medically; they were caused by simple panic. We can see that both *incompetent technology* and *ignorant anxiety* may kill. Let's quote from a lecture of Teller (1994):

– *Recently I was told a story by a brilliant Hungarian school teacher, Esther Tóth. She taught her children how to measure radioactivity in the class room. One day, in the spring of 1986 the excited class said: – “Well, we learned from TV that the radioactive cloud has arrived from Chernobyl! Let’s measure the radioactivity of the air now!” – So they did. It was three times more than the value observed two month earlier! And a little boy stood up: – “Let’s open the windows, then we shall get more radioactivity coming in!” – So they opened the windows and the radioactivity dropped to the previous normal value. The explanation was simple. During the weekend the windows were shut. The higher activity observed early in the morning was due to radon gas emanating from the soil and bricks, having accumulated in the unventilated class room during the weekend; it wasn’t Chernobyl fallout that they had originally thought.*⁶⁹ – This was an experience these students will never forget.

THREE MILE ISLAND 1979

In 1943, simultaneously with the construction of the Hanford reactors, other alternatives were also searched for. EUGENE WIGNER asked his theoretical group to look for other possible moderator materials: Be, BeO, heavy water, and he added: – *Don’t forget about common water!* – So Alvin Weinberg investigated H₂O. He found that natural uranium fuel and a common water moderator could achieve a 98 % neutron multiplication factor – almost enough for a chain reaction. Weinberg said:⁷⁰

– *Wigner was the scientific director of the Oak Ridge Laboratory after 1945. He proposed a research reactor based on natural uranium fuel, a heavy water moderator, and light water cooling. In 1945 Colonel Abelson from the Navy came to me with the question of how reactors could be used to operate submarines.*⁷¹ *In my report I answered: “These reac-*

⁶⁹Budapest 1993

⁷⁰to the author, Budapest 1989

⁷¹Driving ships by nuclear power was an old idea of Szilard. The advantage of nuclear propulsion in submarines is obvious: the nuclear reactor does not consume oxygen.

tors must be compact. The simplest solution is to use water as moderator, and as coolant as well." For simplicity, we left heavy water off. The first reactor with enriched uranium as fuel, light water as moderator, and light water cooling was built in Idaho. But due to the low boiling point of the water, only 17 % thermal efficiency could be reached. This is why in submarines the reactors are moderated and cooled by pressurized water, boiling at a higher temperature. This type of power reactor is now in worldwide use. Although Wigner did not design a nuclear power plant, we can nevertheless say: he was the grandfather of water-moderated and water-cooled power reactors.

The great advantage of using light water for both moderating and cooling, is that in case of overheating the water boils away. Without a moderator the neutrons are not slowed down, they don't split ^{235}U nuclei, but are mostly eaten by ^{238}U nuclei. At the loss of the moderator the neutron chain reaction stops immediately. Such water-moderated reactors, using ^{235}U -enriched uranium for fuel, were developed in Oak Ridge. Due to negative feedback (the negative void coefficient) these reactors are inherently safe: they cannot run away.

In September 1977 a minor incident happened at the David Besse Nuclear Plant (Ohio, U.S.): In a water-moderated reactor one of the valves (used for preserving the water in case of a pump malfunction) did not close when the water supply failed, so the reactor started losing water and warming up. The operator noticed the error and stopped the reactor, mended the valve, and reported to the Nuclear Regulatory Commission, concluding: – *If we had misinterpreted the event, it could have caused trouble.* – The report was shelved, because it was assumed that the automatic controls of the reactors were fool-proof anyway.

On Tuesday, 28 March 1979 at 4:00 a.m. a simple engine failure occurred at the Three Mile Island Nuclear Power Plant near Harrisburg (Pennsylvania, U.S.): *one of the main pumps of the primary water cycle stopped working.* The automatic control system shut the reactor down. The water in the primary cycle began warming up rapidly due to the heat released by the radioactive decay of the fission products in the fuel rods. But *the valve which controlled the exit of steam failed to close,* therefore the escaping steam caused a loss of 450 liters of water per minute, and this loss went on for two hours. The operator did not notice the failure because *the lamp indicating the state of the valve showed, incorrectly, that the valve was closed.* Three minor engine troubles occurred one after the other, but never mind: the control system worked perfectly: it directed fresh cold water into the reactor zone. *Everything*

was thus automatically under control. But now a human intervened: the operator noticed the noise produced from the flowing water stream and concluded that the pumps of the emergency cooling system were working. He decided to override the control system and reduced the water inflow, later closing it completely.

As a result, water was lost and the core of the unoperational reactor became uncovered. When a new shift operator came on duty, he immediately suspected that the pressure control valve was open and manually ordered it to be closed at 6:18 a.m. But before this action occurred, the zircon cladding of the fuel rods reacted with the overheated steam ($\text{Zr} + \text{H}_2\text{O} \rightarrow \text{ZrO} + \text{H}_2$), producing hydrogen gas. The cladding weakened, eventually ruptured, allowing radioactive fission products to enter the coolant water. Pumps were restarted only at 7:50 a.m. In the meantime, radioactivity contaminated the primary water cycle and escaped into the reactor building.

A general emergency was declared and government officials were notified. The reactor was completely ruined, causing a considerable financial loss to the company. A small amount of radioactivity was released into the environment in the form of active noble gases. The released activity was about 0.000001 EBq at Three Mile Island, little compared to 0.001 EBq in Windscale and 4 EBq in Chernobyl.

Let's recall what happened in the meanwhile *outside* the power plant. On Wednesday the 9:00 a.m. news audiences were informed nationwide that an accident had happened at Three Mile Island, that there had been no radioactive releases, and a general emergency had been declared. On Wednesday at 7:00 p.m. CBS television news became more dramatic: "It was a first step in a nuclear nightmare, nothing less than that. The radioactivity is so strong inside the atomic power plant that after passing through a meter-thick concrete wall, it can be measured a mile away."

Thursday morning even more dramatic reports came on the air: "Radiation had penetrated through 1.5 meter thick walls and had spread to distances of 10 to 16 miles away." On Friday schools were closed. At 10:00 a.m. a *malfunction* caused the warning sirens to go off in Harrisburg. The Governor of Pennsylvania recommended that pregnant women and small children voluntarily leave the region. Thousands tried to escape from the imagined ill effects of the accident. On Saturday, due to a misunderstanding at a press conference held by the Nuclear Regulatory Commission, the media reported that an explosion of the hydrogen released from the cooling water might rupture the containment building. (In fact there was no such danger.)

In the following investigation of the malfunction of the valve an essential part was played by EGON OROWAN, a physicist turned to become mechanical engineer, working in plastic deformation of materials.⁷²

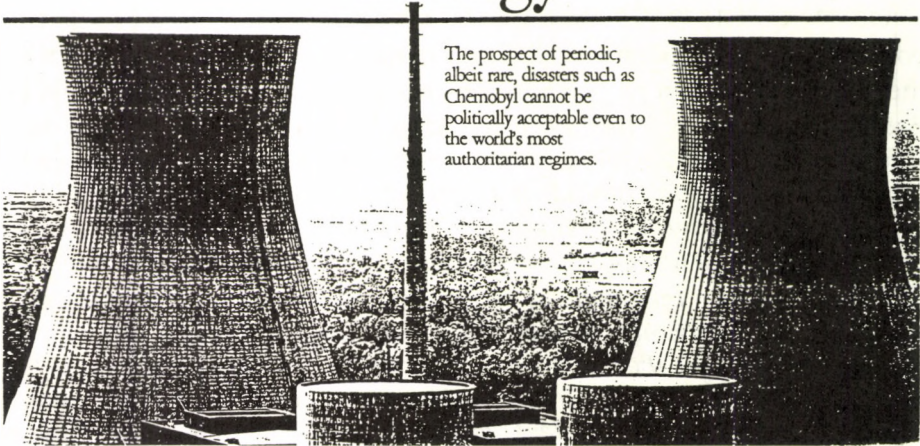
On 11 April 1979 President Carter, who had been trained in science while serving in a military nuclear submarine, invited JOHN G. KEMENY to the White House and named him the chairman of a Committee to investigate the lessons of Three Mile Island accident. (Kemeny worked beforehand with John von Neumann in Los Alamos.) The Kemeny Committee prepared a report within half a year. The main conclusions were:

– The machines were good enough. If no human errors had occurred, the nuclear accident might have remained a small incident. Having understood this, our investigation soon changed direction. It became evident, that the machines did not fail – but humans did. We pressed the operators hard, but they kept repeating that they were not prepared for such a sequence of events. They had obtained only a “push that button” type of training. Larger accidents demand immediate intervention; these have to be performed by the machine itself. Smaller incidents usually build up slowly; their control may be permitted to depend on human decisions. Such sequences of minor incidents occur more frequently than larger accidents, therefore they deserve proper attention. Operators are needed who thoroughly understand the operation of the whole power plant, consequently are able to properly react to a sequence of small incidents. – Citizens and the media were primarily worried about radiation contamination. This part of the report was written by Kemeny himself:

– According to our estimates, the radioactivity released during the two critical weeks produced a collective population dose of 20 Sievert · capita within a 50-mile radius; this was less than 0.1 % of the dose the population received from natural sources. Expressing this in terms of cancer risk, one can say that the estimated number of cancer casualties in the decades to come due to this power plant accident is 0.7. Because a Poisson distribution can be used, this means that there is a 50 % probability that not a single person will die of cancer, 35 % probability that one victim will die, and 12 % that two persons will die from it. Two million people live within the 50-mile radius zone, an estimated 325000 of them will die of cancer anyway – maybe a 1000 more or less. There is

⁷²Beforehand he investigated the real causes of the disastrous Scott expedition to the Antarctica. Later he worked for the Presidential Commission investigating the ill-fated Challenger disaster in 1986: he thought the cause was due a short-transverse brittleness in the main rocket casing.

Energy



The prospect of periodic, albeit rare, disasters such as Chernobyl cannot be politically acceptable even to the world's most authoritarian regimes.

no way to find out actually how many casualties will be caused by the Three Mile Island accident, if any. We have to conclude that the most serious health effect was the psychological stress caused by the behavior of the authorities and the media.

President Jimmy Carter personally thanked Kemeny for the superb job his Committee did preparing the report. As a result of this work, John G. Kemeny became one of the most respected scientists in America in 1979. After returning from Washington, D.C. to Dartmouth College where he was president, his students asked him to tell the story. His videotaped lecture on "American democracy in the era of high technology" was circulated in America and around the world, a profound message to mankind, emphasizing that in a democratic society scientific ignorance and technological incompetence of citizens, journalists, and decision-makers is incompatible with the acceptance of comfort offered by high technology:

— As I followed the work of our Committee, I asked myself: how will people solve the complex problems of today? These cannot be solved bit-by-bit. Their solution requires broad public consensus. We cannot make it without the cooperation of the media. But television commentators today try to tell complex issues in one minute or less. I've learned what "in-depth-treatment" means: you get a full five minutes, with only two commercial interruptions. The most responsible newspapers may print the entire story, and you get it only if you read to the bottom of page 79 (or whatever). If you stop halfway through, you still have read only the headlines and you may get a totally biased view of what actually happened.

– *The media love controversy. I left Washington fully expecting to read the following story someday in one of our newspapers: – “Three scientists by the names of Galileo, Newton, and Einstein have concluded that the Earth is round. However, the New York Times has learned authoritatively that Professor John Doe has conclusive evidence that the Earth is flat.” – And then the report will go on, perfectly unbiased, giving equal space to both sides of the issue. This is a caricature, of course, but I saw such extreme examples, again and again on both sides of the nuclear debate and I don’t blame the American people for being totally confused.*

– *Another problem is the choice of visual images, something our commission got more and more upset about while investigating Three Mile Island. Those cooling towers [facsimile] were featured everywhere as horrible scary towers, and many papers depicted them as sources of radiation. But in the entire plant, the cooling towers are probably the least important features. They are not connected to the nuclear part of the plant, and plain, ordinary, harmless steam comes out of them.*

– *On nation-wide issues the decisions will have to be made possibly by the members of Congress. Indeed, I had a horrible nightmare one night in Washington: the House of Representatives, by a vote of 215 to 197, had repealed Newton’s Law of Gravitation.*



The Nuclear Power Plant in Paks supplies almost 50 % of the electricity used in Hungary. The pressurized water-moderated reactors (possessing negative void coefficients) were designed in Russia, and were improved by electronics and a simulator made in Finland and Hungary. As EUGENE WIGNER and Alvin Weinberg had done beforehand, EDWARD TELLER, after his visit in 1990 also agreed with the opinion of the International Atomic Energy Agency, that these reactors are perhaps the safest and cleanest in Eastern Europe. They are frequently among the TOP TEN on the list of the international nuclear industry [facsimile]. After having visited Paks, Teller said:⁷³

– *When I landed in the United States in 1935, technological progress was glorified there. I considered this enthusiasm to perhaps be excessive. But now the media suggest that progress conflicts with humanity. I hope the people of the future will look back on fears of nuclear power as absurdities, like we look back on past fears of witches. I have learned in school that around 1100 A.D. Coloman Beauclerc, King of Hungary⁷⁴ promulgated a law:*

⁷³Budapest 1991

⁷⁴Könyves Kálmán, meaning Coloman of the Books

DE STRIGIS VERO, QUAE NON SUNT, NULLA QUESTIO FIAT.

(Witches – because they don't exist – must not be discussed.) *Witches used to be feared and burned around the world (even in America) while the Hungarians remained sober. I would like to imagine that the same will happen to the fear of radioactivity. In that case at least the Hungarian teachers will be able to teach: "While the others remained superstitious, we made good use of the power of the nucleus." What we need again is the wisdom of Coloman Beauclerc.*



AECL **EACL**











AECL CANDU

EACL CANDU

The Top Ten

Lifetime World Power Reactor Performance to March 31, 1991*

from among 343 reactors over 150 MW

Country	Ranking	Unit (in-service date)	Type	Capacity Factor %†
 Germany	1.	Emsland (4/88)	PWR	91.8
 Canada	2.	Point Lepreau (9/82)	CANDU	90.7
 Germany	3.	Neckar 2 (1/89)	PWR	90.0
 Germany	4.	Grohnde (9/84)	PWR	87.6
 Canada	5.	Pickering 7 (11/84)	CANDU	86.9
 Belgium	6.	Tihange 3 (6/85)	PWR	86.8
 Hungary	7.	Paks 4 (8/87)	PWR	86.7
 Hungary	8.	Paks 3 (9/86)	PWR	86.6
 Finland	9.	Loviisa 2 (11/80)	PWR	86.4
 Canada	10.	Bruce 5 (12/84)	CANDU	86.4

*Source: Nuclear Engineering International

†Capacity Factor = $\frac{\text{actual electricity generation}}{\text{perfect electricity generation}}$

Information out of Chaos

In 1946, Neumann happened to meet his friend Gleb Wathagin. "Hello, Johnny," said Wathagin, "I hear you are now thinking about nothing but bombs." – "That is quite wrong," replied von Neumann, "I am thinking about something much more important than bombs. I am thinking about computers!"

(Freeman Dyson)

INTELLIGENCE

Energy is conserved, as expressed by the First Law of Thermodynamics. A hot body cools spontaneously in the cold world. At the end of the 19th century this everyday experience had been formulated as the Second Law of Thermodynamics, and interpreted as dissipation of energy, increasing disorder, i.e. *growing entropy*. James Clark Maxwell, however, raised an objection. Let's take a gas cylinder, with a dividing wall in the middle. Let's imagine a demon, who opens a tiny door on this wall, when a *fast* molecule approaches from the *left*, lets the molecule pass through, then quickly closes the door. He also opens the door when a *slow* molecule approaches from the *right*, lets it pass through, then quickly closes the door. In this way, fast molecules will be collected in the right half, slow molecules accumulate in the left half of the cylinder. Due to the activity of Maxwell's smart demon, the left-hand side of the cylinder cools down, the right-hand side warms up. The emerging pressure difference may perform work. Intelligence seems to win over the Second Law. *Information* seems to win against *disorder*. As Smoluchowski, a pioneer of statistical physics formulated this idea (1914):

– As we know today, in spite of the fluctuating motion of molecules, one cannot construct a machine which would be able to transform heat to work, but perhaps a machine operated by an intelligent being could work in this way.

Such a statement by an authority was enough to excite the imagination of LEO SZILARD. He discussed the influence of an intelligent being on the overall disorder (entropy) of nature. He speculated about a cylinder containing only one single molecule. A movable piston can be placed in

the cylinder. An observer somehow finds out whether the molecule is in the left half of the cylinder or not. If it is there, a *yes* signal flashes up, thus the observer pushes the piston into the middle of the cylinder and keeps the piston moving slowly to the right. The molecule, by hitting the moving cylinder from the left several times, transfers energy to the piston, thus performing work. As the piston reaches the right end of the cylinder, it will be removed. The *yes* signal is switched off, the *no* signal flashes up, and the observation begins again, looking for the molecule. If it is again in the left side, the *yes* signal appears and the piston will be inserted and moved rightwards, extracting more energy from the colliding molecule.

Szilard noticed that this system has necessarily to contain memory: the operator or the machine has to remember the *yes* signal and has to move the piston to the right for a definite time interval. He speculated about the possible realization of such a memory. By constructing a thought machine he proved that at a temperature T the prize to be paid for storing one bit of information (*yes* or *no*) is $E = kT \ln 2$ amount of energy. In this way Boltzmann's constant $k = 1.38 \cdot 10^{-23}$ joule/centigrade per bit has got a meaning: it connects *entropy* and *information*. Szilard's conclusion was that according to the Second Law, the observer has to give off heat elsewhere while creating order *locally*, therefore the *overall disorder* (entropy) cannot be reduced by intelligence. A thinking human has to consume food, a computer needs electric power. Szilard's paper (written in 1926, printed in 1929) was later acknowledged by Leon Brillouin and Claude E. Shannon as the cornerstone upon which modern information theory was built. In his late years Szilard expressed his admiration with respect to a masterpiece of art:

– *This painting efficiently reduces the entropy of the Universe.*

MICROSCOPES AND TELESCOPES

RICHARD ADOLF ZSIGMONDY was a typical cosmopolitan interdisciplinary character. His family can be traced back to 1630 in Hungary, several ancestors having been engineers. His father, Adolf Zsigmondy, and his wife, Irma Szakmáry, were Hungarians. They settled in Austria and Richard Adolf, born in Vienna, spoke both Hungarian and German fluently. He was interested in physics, chemistry, and medicine, studied engineering in Vienna and Munich, completed his Ph.D. in organic chemistry in Erlangen (Germany, 1889) and became the assistant of the physicist August Kundt in Berlin (1891). Zsigmondy then habilitated at

the University of Graz (Austria), studying mainly silicon compounds. This brought him an invitation to Jena (Germany). At the Zeiss factory with H. Siedentopf he made the first ultramicroscope, which enabled him to observe the heterogeneous nature of colloids. His research on the coagulation of disperse systems made him professor in Göttingen (Germany, 1907), and member of the Austrian Academy. Finally the 1925 Nobel Prize in chemistry was given *“for proving the heterogeneous nature of colloidal solutions and for the methods used which have laid the foundation of modern colloid chemistry.”* In his Nobel lecture he recalled his discussions with Smoluchowski, and emphasized the merits of his Hungarian student G. Varga in performing the experiments. At the occasion of the Nobel Prize he told a Hungarian journalist, – *Do not think that I have forgotten my Hungarian origin.* – He rests in Göttingen (Germany). Another branch of the family still lives in Hungary.



One afternoon in 1928 DENNIS GABOR and LEO SZILARD were sitting in Café Wien in Berlin, discussing the new quantum theory and the wave nature of electrons. Szilard raised the question: could an electron beam accelerated to such a high energy that its short wavelength made the structure of organic molecules visible? Gabor answered that *one could not place living matter into a vacuum, and anyway everything would burn away to a cinder under the intense electron beam.* – Years later he noticed, – *Who would have then dared to believe that the cinder would preserve not only the structure of microscopic bodies but even the shape of organic molecules!* – Later Gabor wrote a book on the electron microscope (1944). Let us listen to his recollection:

– *In 1947 I was very interested in electron microscopy. This wonderful instrument had at that time produced a hundredfold improvement on the resolving power of the best light microscopes, and yet it was disappointing for me because it had stopped short of resolving atomic lattices. The practical limit at that time stood at about 1 nm, and this limit was given by the necessity of restricting the aperture of the electron lenses to about 1/2 degree of arc, at which angle the spherical aberration error is about equal to the diffraction error. If one doubles this aperture so that the diffraction error is halved, the spherical aberration error is increased eight times, and the image is hopelessly blurred. I pondered this problem for a long time.*

– *On a fine day, Easter 1947, at a tennis court a solution suddenly dawned on me. Why not take a bad electron picture, but one which contains the whole information, and reconstruct the object by optical*

means? It was clear to me that this could be done only with coherent electron beams which have a definite phase. But an ordinary photograph loses the phase completely, it records only the intensities. No wonder we lose the phase if there is nothing to compare it with. Let us see what happens if we add a standard to it: a coherent background! The interference of the wave coming from the object and of the standard reference wave will then produce interference fringes. There will be intensity maxima where the phases of the two waves were identical. Let us make a record that indicates the maxima, and in this way the phase differences are captured.¹

Just as a first check of this new idea, Gabor decided to use a coherent light beam instead of electron beam to produce the record. He used the narrow light beam of a mercury lamp, passing through a tiny pinhole of 3 μm diameter. The object was a microphotograph of 1 mm size. The pattern, produced by the interference between the light scattered from the object and the monochromatic reference light has been recorded on a photographic plate. By illuminating the recorded pattern with coherent monochromatic light the reconstruction of the picture of the object had succeeded!

The idea can be understood easily with a bit of mathematics. Let the light wave ψ_s scattered by the object interfere with a direct monochromatic light beam ψ_d . Where the sign of both waves are the same, there the addition of the two waves amplifies the light intensity. In case of opposite signs they weaken the intensity:

$$I = (\psi_s + \psi_d)^2 = |\psi_s|^2 + |\psi_d|^2 + 2 \psi_s \psi_d$$

Using the known ψ_d as *reference wave*, the intensity distribution I (stored on a photographic plate) supplies information also about the sign of the scattered wave ψ_s that carries information about the *object*. In this way the photographic plate can store the full information content of ψ_s . Later the stored information content can be regained by illuminating this photographic plate with monochromatic light. This is how Dennis Gabor came up with the name *hologram* (holos: complete, grafein: writing). By looking at an appropriately illuminated hologram, by moving the head a bit sideways one may even peep behind the object. Gabor's paper "*Microscopy by Reconstructed Wavefronts*" described the new invention (1951). Practical application, however, had to wait till the discovery of a powerful source of a *wide* beam of *coherent* monochromatic light: the

¹Nobel lecture 1971

laser.² Dennis Gabor had to wait until 1971 to obtain the Nobel Prize “for his invention and development of the holographic method.”

Gabor’s dream about seeing atoms has been realized. The classical theory of the microscope does not allow for seeing objects smaller than the wavelength. But any object distorts the wave, even if it is smaller than the wavelength. By registering both, *amplitude* and *phase* by holography, also objects smaller than the wavelength can be seen. The holographic microscope later made the electron cloud of single atoms visible down to the resolution of 0.008 nm. Szilard and Gabor would feel happy seeing this.



The 20th century is the era of telephone, radio, and television. The wide spectrum of electromagnetic waves has made possible to observe objects and phenomena beyond the limits of human senses. Microscopes observed tiny structures within human cells, even within molecules. Telescopes (working in optical, ultraviolet, X-ray, γ -ray, infrared, radio-wave regions) explored the structure of the Universe. The History Office of NASA (National Aeronautics and Space Administration, Washington D.C.) published the history of planetary radio astronomy under the title *To See the Unseen* (1996). Let’s quote the first sentences of the book:

– *During the 1940s, investigators in the United States and Hungary bounced radar waves off the Moon for the first time. These experiments constituted the initial exploration of the Solar System with radar.*

In a certain period of their life both DENNIS GABOR and ZOLTAN BAY knew each other, worked at Tungstam, the leading Hungarian industrial firm in lighting and radio communication. Dennis Gabor moved towards shorter and shorter wavelengths in order to observe tiny details in the structure of matter. Zoltan Bay went towards longer (cm) wavelengths to observe attacking aeroplanes. His group developed radar for the air defense of Budapest. (The radar station *Borbala* worked on a hilltop near Budapest in the last months of World War II.) Then within a year Bay turned his transmitter towards the Moon, and detected radar echos on 6 February 1946, just a few weeks after the analogous American experiment performed by J.H. DeWitt in America on 10 January 1946. On this occasion Dennis Gabor wrote to Zoltan Bay [facsimile]:

²Optical holography has become much more important than electron holography. As Gabor noted, the advantage of speculating about electron microscopy at first was that the British electronic company payed him and supported his research, which terminated finally in optical holography.

GILSHAW LODGE,
BILTON ROAD,
RUCBY.

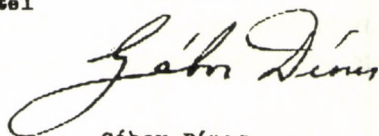
1948 február 23

Kedves Professzor Ur!

Ma érkezett meg a különlenyomata a holdról visszavert mikrohullámokról, azonnal elolvastam és szeretek hogy kifejezzem őszinte bámulatomat. Mint fizikai-technikai teljesítmény olyan színvonalen áll amelyet Európában csak nagyon ritkán értek el, de ha hozzáveszi az ember hogy a számításokat az összeomlás alatt végezték el, a kísérleteket pedig a csaknem tönkretett országban, egyidejűleg az Egyesült Izzó csudálatos fölépítésével, csaknem hihetetlen. Osodás hogy milyen serkentően hathatnak a katasztrófális külső körülmények, másutt is megfigyelhető volt, a francia fizikusok is különböző kísérleti munkát végeztek a háboru alatt mint előtte. Mi itt Angliában ugy látszik nem kaptunk elég nagy pofont, kissé bágyadtak vagyunk, és szeretném látni mit szólna a főnököm ha ezt proponálnám hogy a holddal akarok érintkezésbe lépni! Még azt sem tudom, keresztül tudom-e vinni a terveimet hogy Amerikával érintkezésbe lépjek kábeltelefonon?

Erről, és más újabb munkáimról mellékelek néhány különlenyomatot. Szigeti György jelen volt egy előadásomon, és talán már előszóban referált róla. Nagyon örültem hogy végre beszélgethettem vele az Önök nagyjelentőségű galvanolumineszcencia kísérleteiről. Remélem hogy nemsokára alkalmuk lesz ezeket folytatni, azt hiszem ez az egyetlen komoly kilátás további jelentős haladásra az elektromos világítás terén.

Meleg üdvözzlettel



Gábor Dénes

23 February 1948, Gilshaw Lodge, Bilton Road, Rugby.

Dear Professor, the reprint, in which you give an account of Moon echo experiments with microwaves arrived today. I read it through at once and am now hurrying to express my sincere amazement. As a physical-technological achievement it represents such a standard which has only rarely been reached in Europe; but, if one adds moreover that the calculations were made during the political-military-societal collapse, and the experiments were performed in a country almost in ruins – simultaneously with the wonderful reconstruction of Tungsram – it is almost incredible. It is marvelous what a stimulating effect catastrophic external circumstances can have, as has been observed elsewhere, too. The experimental work of French physicists was also of higher standard during the war than before it. Here in England, perhaps we have not been slapped enough: we are slightly listless, so I would like to hear what my superior would say if I expressed to him that I wish to make contact with the Moon! I don't know even whether I shall manage to realize my plan to make contact with America by cable phone! I enclose some reprints about this and other, more recent works of mine. György Szigeti was present at one of my lectures and has perhaps given you an oral account of it by now. I was very glad that, on this occasion, I could at last speak to him about your important experiments on galvano-luminescence. I do hope that you will soon have the opportunity of continuing those and believe that this is the only serious prospect for further significant progress in the field of electric illumination.

With warm wishes, Gábor Dénes

The noise at information transfer through long distance phone lines made GEORGE VON BÉKÉSY interested in the physics of hearing, and that brought him a Nobel Prize in physiology. When the transatlantic cable was running out of transmission capacity (1946), DENNIS GABOR wrote a paper on *Communication Theory*. In order to solve this practical problem, Gabor turned to the basics. He analyzed the necessary requirements for the signals to be able to convey information, then he formulated the minimum conditions of the ear for intelligibility, and as a conclusion, he described the technique of compressing speech into a narrow frequency band without the loss of intelligibility. Gabor developed the ideas further with his biologist brother, in *An Essay on the Mathematical Theory of Freedom*, read at the Royal Statistical Society (1954), intending to show that *in the vast domain covered by this powerful but vague idea*

there exists an important field, which is amenable to quantitative discussion based on the statistical concept of communication. This enables comparisons between different systems which otherwise would remain incommensurable. – Eight years later, lecturing on *Communication Theory and Cybernetics*, he argued:

– *The theory of information is going to become a powerful driving force in the future development of the techniques of communication and control.*

MODELS

– *Before the 20th century, the narcissistic creation of the human mind, that we call today pure mathematics, did not exist. Today mathematics is considered to be a logical enterprise, in which the human mind follows laws created by itself, independently of the events happening in the physical universe. But history shows something else! In ancient Egypt and Greece there was a strong correlation between mathematics and its application to the physical universe (called natural philosophy at that time). For Pythagoras, for Greek geometry, initiative was provided by experience. Galileo said that Nature speaks to us in the language of geometry. Newton would not have been interested in the calculus that he discovered, if it had not have been connected so miraculously to the physical universe. It is a recent development that today we look at mathematics as a logical game, that we teach mathematics even in school in this way. But one may rightly ask: why do we use just these postulates and not some other postulates which also are logically consistent? The real answer would be: we consider those mathematical postulates relevant which fit the physical universe. All the great discoveries originate not from the self-glorification of the human mind, but from the desire for understanding: what happens around us.* – These words³ express the feelings of CORNELIUS LANCZOS, who was a student of Roland Eötvös and assistant of Albert Einstein. After having emigrated to America, he could not follow his dream of finding the geometry of Nature. Rather, he took up applied mathematics, working for the Army during the war, later at Boeing, then the National Bureau of Standards. He considered mathematics to be a servant of natural philosophy (in short: science). In order to *use* mathematics, he developed the *fast Fourier trans-*

³taped at the University of Manchester

form and the *Lanczos algorithm* for numerical calculations. PETER LAX developed numerical methods for calculus. PAUL ERDŐS revitalized discrete mathematics. They did it just at the right time. It has turned out that the computers – developed about this time – like Lanczos' and Lax's methods. Erdős' obituary in the *International Herald Tribune* appeared under the heading (1996) [facsimile]:

PAUL ERDOS, WHOSE MATH GAVE COMPUTERS A FOUNDATION, DIES

Another Hungarian, JOHN VON NEUMANN arrived in America at about the same time as Lanczos. His aim, too, was not so much to *make* mathematics but to *use* it. He lost the great youthful illusion in pure mathematics; his first love for the axiomatization of set theory and Hilbert space was already over. This is how Neumann enjoyed the practicality of the American way of living more than any other European immigrant scientist. This is why Neumann agreed with Lanczos:

– *All mathematical ideas originate in empirics, although the genealogy is sometimes long and obscure. But once they are so conceived, the mathematical subject begins to live a peculiar life of its own, governed almost entirely by aesthetical motivations, not by empirical science. As a mathematical discipline travels far from its empirical source, or still more, if it is a second or third generation only indirectly inspired by ideas coming from reality, it becomes more and more purely l'art pour l'art. But there is a grave danger of "inbreeding." At the inception the style is usually classical. When it shows signs of becoming baroque, then the danger of degeneration signals up. In any event, whenever this stage is reached, the only remedy seems to me to be the rejuvenating return to the source: the reinjection of more or less directly empirical ideas. I am convinced that this was the necessary condition to conserve the freshness and vitality of the subject and that this will remain equally true in the future.*

Curious it may be but the kiss of the Muse arrived from the U.S. Army. In 1937 John von Neumann became a citizen of the U.S. As a good citizen he applied to become a lieutenant in reserve at the Ordnance Department of the U.S. Army, and was willing to take the required examination. His strange love can be explained by his interest in the nonlinear dynamics of shock waves (in military language: explosions). When the Aberdeen Artillery Proving Ground needed more accurate firing tables, Neumann presented a report on "*The Estimation of the Probable Error from Successive Differences*" (in short: where to aim when you have missed several times). As World War II erupted, Lieutenant von Neumann was perhaps the greatest American expert in bombing.

INTERNATIONAL

Paul Erdos, Whose Math Gave Computers a Foundation, Dies

By Gina Kolata
New York Times Service

Paul Erdos, 83, a world-famous mathematician who was so devoted to his subject that he lived as a mathematical pilgrim with no home and no job, died of a heart attack Friday in Warsaw, a friend said. Mr. Erdos was attending a mathematics meeting in Warsaw.

Ronald L. Graham, the director of the information sciences research center at AT&T Laboratories, said, "I'm getting E-mail messages from around the world, saying, 'Tell me it isn't so.'"

Never, mathematicians say, has there been an individual like Paul Erdos. He was one of the century's greatest mathematicians, who posed and solved thorny problems in number theory and other areas and founded the field of discrete mathematics, which is the foundation of computer science. He was also one of the most prolific mathem-

aticians in history, with more than 1,500 papers to his name. And, his friends say, he was also one of the most unusual.

Mr. Erdos, "is on the short list for our century," said Joel H. Spencer, a mathematician at New York University's Courant Institute of Mathematical Sciences. Another said, "He's among the top 10."

Ernst Straus, who worked with both Albert Einstein and Mr. Erdos, wrote a tribute to Mr. Erdos shortly before his own death in 1983. He said of Mr. Erdos: "In our century, in which mathematics is so strongly dominated by 'theory doctors,' he has remained the prince of problem solvers and the absolute monarch of problem posers."

Mr. Erdos, Mr. Straus continued, is "the Euler of our time," referring to the great 18th-century mathematician, Leonhard Euler, whose name is spoken with awe in mathematical circles.

Stooped and slight, often wearing socks and sandals, Mr. Erdos stripped

himself of all the quotidian burdens of life: finding a place to live, driving a car, paying income taxes, buying groceries, writing checks. "Property is nuisance," he said.

Concentrating fully on mathematics, he traveled from meeting to meeting, carrying a half-empty suitcase and staying with mathematicians wherever he went. His colleagues took care of him, lending him money, feeding him, buying him clothes and even doing his taxes. In return, he showered them with ideas and challenges — with problems to be solved and brilliant ways of attacking them.

Laszlo Babai of the University of Chicago, in a tribute written to celebrate Mr. Erdos' 80th birthday, said that Mr. Erdos' friends "care for him fondly, repaying in small ways for the light he brings into their homes and offices."

Mathematicians like to brag about their connections to Mr. Erdos by citing their "Erdos number." A person's Er-

dos number was 1 if he or she had published a paper with Mr. Erdos. It was 2 if he or she had published with someone who had published with Mr. Erdos, and so on.

At last count, Mr. Erdos had 458 collaborators. An additional 4,500 mathematicians had an Erdos number of 2. A friend said so many mathematicians were still at work on problems they had begun with Mr. Erdos that 50 to 100 other papers with Mr. Erdos' name on them were expected to be published after his death.

Born in Hungary in 1913, he discovered negative numbers for himself at age 3 when he subtracted 250 degrees from 100 degrees and came up with 150 degrees below zero. A few years later, he amused himself by solving problems he had invented, like how long would it take for a train to travel to the sun.

When Mr. Erdos was 20, he made his mark as a mathematician, discovering an elegant proof for a famous theorem in

number theory. The theorem, Chebyshev's Theorem, says that for each number greater than one, there is always at least one prime number between it and its double.

A prime number is one that has no divisors other than itself and 1.

Mr. Erdos, like many mathematicians, believed that mathematical truths are discovered, not invented.

And he had an evocative way of conveying that notion. He spoke of a Great Book in the sky, maintained by God, that contained the most elegant proofs of every mathematical problem.

Neumann was invited to England in 1943 to study underwater blasts, in order to make anti-submarine warfare more effective. There he met his former Princeton student, Alan Turing, who was interested in artificial intelligence to decipher the cryptograms of German submarines. In a way Neumann enjoyed this “rejuvenating” return to experience, but an urgent message called him back to America (1943). He had to go to Los Alamos in order to calculate the appropriate technique of implosion as well as the appropriate height of explosion for the atomic bomb in order to achieve the widest effect. As Norman Macrae put it with some exaggeration:

– *Most of the physicists were used to doing experiments, but it was not easy to do an experiment on how to blow up the world. Johnny was therefore part of the team who invented modern mathematical modeling in Los Alamos.*

Strange fellows like Hans Bethe, Theodore von Kármán, Edward Teller had already tried to make calculations concerning the nonlinear addition of direct and reflected shock waves. But John von Neumann was the best in mathematics. He saw that the human brain was insufficient to solve the nonlinear partial differential equations of aerodynamics. Therefore he ordered mechanical calculators with punch card sorting to Aberdeen, later to Los Alamos. But mechanical switches and punch cards turned out to be far too slow for performing hundreds of multiplications. One had to look for something much faster. In the 1940s Alan Turing already used such a device.

COMPUTERS

In the early 20th century a party game had become popular in Budapest: one person has to guess a word chosen by the others. He or she could ask any questions but the party could answer only with *yes* or *no*. If one was able to identify a fancy word (like “immortality” or “Achilles’ heel”) with, say, twenty smart questions, that player deserved praise. ARTHUR KOESTLER told about the legendary origin of the game:

– *“Bar Kokhba” was a question-and-answer game much in vogue at that time in Budapest, an early variant of the “Twenty Questions” game known in America nowadays. The name of the game is derived from a legendary event: Bar Kokhba, leader of the Galilean insurrection against Rome, sent a spy to the enemy camp. The Romans caught the spy and cut out his tongue, then let him go. He nevertheless managed to convey what he had seen to his leader by answering Bar Kokh-*

*ba's questions with blinks of the eye signifying yes or no.*⁴ – The last battles of Bar Kokhba were near Massada in 135. Abraham Goldfaden's (1840–1908) drama *The Son of the Star* (Bar Kokhba) was staged in 1900 and in 1906 in the theaters of Budapest and that may explain the popularity of the binary game.

Animals and primordial humans handled information by continuous (analogous) signals: sound and light. The invention of writing and printing introduced characters (digital signals) which reached their peak in the computer era: now we express information in digital form. A twenty-binary-digit (shortly 20 bit) information like 11000101110101000011 is equivalent to a specific sequence of *yes* or *no* answers given to twenty questions: *yes–yes–no–no–no–yes–no–yes–yes–yes–no–yes–no–yes–no–no–no–no–yes–yes*. The advantage of this system is that digital (discrete) signals are less distorted by noise than analogous (continuous) signals. This is why complex computer systems (performing millions of operations with the input information) use digital codes.

DENNIS GABOR understood that in the long run the character recognition (in the interest of an *analog* → *digital* conversion) might become the most important application of holography (1965). And it so happened: in order to recognize characters, computers nowadays compare the real picture with the ideal character shape by using the holographic method. Just recently a powerful technique has been developed to compress a huge amount of informations to a simple hologram picture (1996).



On a sunny day in August 1944, JOHN VON NEUMANN was waiting for the train at the Aberdeen railway station. Herman Goldstine noticed and approached him. Goldstine told Neumann that Presper Eckert had just built an electronic computer, the ENIAC (Electronic Numerical Integrator And Calculator). That machine was a smart monster: 30 meters long, 1 meter wide, and 3 meters high. It consisted of 17000 vacuum electron tubes, 70000 resistors, 10000 capacitors and 6000 switches.⁵ Goldstine recalled his meeting with Neumann:

– *When it became clear to von Neumann that I was concerned with the development of an electronic computer capable of 333 multiplications per second, the whole atmosphere of our conversation changed*

⁴Arthur Koestler: *The Invisible Writing*, New York 1954, p. 180

⁵The ENIAC is now on exhibit at the Smithsonian Museum of Science in Washington D.C. The 50th birthday of the ENIAC was celebrated recently in the presence of vice-president Al Gore.

from one of relaxed good humor to one more like the oral exam for the doctor's degree in mathematics.

The invitation to see the ENIAC in Philadelphia was accepted. The historic encounter of the first kind between the electronic computer and John von Neumann happened on 7th August 1944. As Eckert, the architect of ENIAC, said,

– I told Goldstine that I would be able to tell whether von Neumann was really a genius by his first question. If it was about the logical structure of the machine, I would believe in von Neumann, otherwise not. Of course that was his first query!

Thus in August 1944, Neumann became a frequent visitor at ENIAC and soon noticed its disadvantages as well. In case of a *new* differential equation, the rewiring of the ENIAC required a quarter of an hour, followed by a computation time of three seconds. Speculating about this in late August 1944, Neumann had got the idea that not only the initial data but even the program of the calculation should be introduced and stored *electronically* in the computer.

The daughter of ENIAC was named EDVAC (Electronic Discrete Variable Computer). Neumann wrote a "*First Draft of a report on EDVAC*" in March 1945, – *the most important document ever written on computers* – according to Goldstine. The 101 page draft described the proposed structure of what is today called the "von Neumann computer":

– The logical control of the device, that is, the proper sequencing of its operations, can be most efficiently carried out by a central control organ [processor]. If the device is to be all-purpose, then a distinction must be made between the specific instructions given for a particular problem, and the general control organs which see to it that these instructions – no matter what they are – are carried out in proper sequence. – His completely elaborated plan illustrated the idea of the electronically stored program.

The architects of ENIAC were interested in commercializing and patenting also the EDVAC ideas, but Neumann disagreed. He was convinced that progress might be so rapid that EDVAC would be obsolete by the time it was ready; therefore he immediately made his ideas widely known. The *First Draft* was sent out to several institutions because Neumann believed in the Darwinistic evolution of computers. He turned out to be right. The EDVAC itself became operational in late 1945. The computer era had begun soon after the end of World War II. As JOHN G. KEMENY has put it,⁶

⁶John G. Kemeny: *Man and the Computer*, 1972

– *The ability to program computers has been the single major breakthrough that differentiates a modern computer from an old-fashioned calculating business machine.*

The other great innovation of Neumann was of introducing the binary code (Bar Kokhba's 0 and 1, *yes or no, on or off*), fitting to the electronic system.

At this time Neumann was already interested in building *his own* computer for use in solving tasks which were far beyond the actual reach of exact science, like forecasting – even controlling – the weather, and all those nonlinear problems which dominate the scientific scene in the second half of the 20th century. He said that our mathematics had developed by adjusting itself to the limits of the human brain. But he was convinced that the advent of computer would set “*entirely new criteria of what is mathematically simple or complicated, elegant or clumsy.*”

– *Neumann was undoubtedly a genius. This meant among other things that he was able to learn a new subject in an incredibly short time. Before designing the computer, he took two weeks off to learn electronics, thus became able to supervise the construction of the hardware.*⁷

In order to speed up the access to the memory to millions of steps per second, Neumann looked for appropriate electronic devices, like Vladimir Zworykin's selectron (a cathode ray tube with a grid built in) or ZOLTAN BAY's multiplier (a sequence of plates with high voltages between them, in order to create a shower of secondary electrons at the impact of a single incoming accelerated electron). Neumann wrote to Bay (1948):

Dear Zoltan, you may perhaps know that recently I started working with high speed automated computing machines. Just now we are building one at the Institute for Advanced Studies in Princeton. The present, even more the future technology of these machines have several touching points with your high-speed counters and amplifiers. I would be delighted if we could speak about these possibilities.

Your Neumann Jancsi

Prominent universities competed for getting Neumann and his electronic computer (California, Chicago, Columbia, Harvard, MIT), but he decided to convince his ivory tower, the Institute for Advanced Studies in Princeton, to let the machine in. Besides the “*Princetintute,*” he made the emerging electronic industry, as well as the U.S. Army and Navy interested in the project. The Princeton Machine was completed in five years,

⁷Maurice Shapiro to the author 1994

but during these years Neumann reported openly about the principles and plans; thus it happened that the sisters of the Princeton computer JONIAc were born before him: the MANIAC (Los Alamos National Laboratory), AVIDAC (Argonne National Laboratory), ORDVAC (Aberdeen Proving Ground), ORACLE (Oak Ridge National Laboratory), ILLIAC (University of Illinois), and IBM's 701. The latter would pervade research, industry and the economy in the decades to come, making the Big Blue dominate the new world market.

Neumann did not stop there. In the early 1950s he was already speculating about speeding the computers up by using light instead of electrons (realized in the 1990s).



In the early 1960s the author learned a clumsy machine language to program an exponential function into the Russian URAL computer in Budapest, then studied the sophisticated ALGOL computer language in the Silicon Valley. Some people, however, were already thinking about simplifying the human-machine interface.

JOHN G. KEMENY, the Budapest-born mathematician, student of Neumann at Princeton, former member of the computing staff at Los Alamos, then professor at Dartmouth College, brought the first computer to the College in his own car in the early 1960s. That computer was as big as a freezer, with a memory of 60K and a speed of 60 operations per second. But Kemeny was the most unhappy about the way of using the computers:⁸

– These computers were huge and expensive beasts. The directors of computer centers considered their duty to be keeping the user at a safe distance from the computer itself. The user punched the code onto cards and handed the batch to the operator in the morning. The operator collected about a hundred batches, then fed them to the computer. The machine performed all the operations one after the other according to the instructions of the code, then printed the outcome on a page. Then the next batch might come. On the next day the user might obtain a page with a message like ERROR ON CARD 27. Or the page was empty because the user forgot to add the instruction PRINT X to the program. Then the search for errors followed, a new batch, a new day...

Kemeny speculated about how to make the computer available to several users at the same time. While a user types or the printer prints, the processor does not do anything! This is why *time sharing* was introduced: each user works on his/her own terminal, and the central computer shares

⁸Kemeny to the author 1988

the working time of its processor among the users. In this way each fraction of a second will be utilized, each user is satisfied. Sharing the time is done not by the users but by the central computer. The time sharing protocol was first established at Dartmouth College (1963):

– *It was one of the happiest moment in my life: I did not have to punch cards any more* – Kemeny remembered. He was awarded the first Robinson Prize from IBM for his pioneering work in the time sharing system (1990).

In this way the chance was given to each student to touch the computer with fingers. But FORTRAN – the most common language at that time – was not didactic enough. Kemeny recognized that an *interactive language* had to be developed, at which the machine reacts to the instruction immediately allowing the user to build up the program by *trial and error*, a method so efficiently used by kids. Kemeny formulated the required properties:⁹

1. The computer language should be versatile to satisfy different purposes.
2. The language should be easy for beginners.
3. The higher level instructions could be learned by the user at a later stage.
4. The language should be interactive between user and computer.
5. It should give error messages which are easily understandable.
6. It could be used without the knowledge of the specific computer architecture.
7. It should protect the user from the problems of the operating system.

This is how the *Beginners' All-purpose Symbolic Instruction Code* was born in the hands of John G. Kemeny and Tom Kurtz: – *I did not invent BASIC just to make one more computer language. I made it because I felt that the computer has to be made available for all students. The first BASIC program ran at 5:00 a.m. on 1 May 1964.*

Kemeny and Kurtz registered the trademark BASIC but everyone was welcome to use or adopt the language freely. BASIC has become the most widely used computer language, and is one of the languages that most people understand. – *The first personal computers were dwarfs. MICROSOFT managed to put BASIC at first into 4K memory, that was considered at that time to be as a miracle* – Kemeny said.

⁹John G. Kemeny – Thomas E. Kurtz: *Back to BASIC*, 1985

– In Dartmouth College each student uses a PC, the Faculties of Humanities, Economics, Medicine included. And each student has access to the mainframe computer of the College with time-sharing. Now 90 % of the students are computer literate.¹⁰

– In the 1960s the computer at Dartmouth College was connected e.g. to the computer of the Manhobian College in Massachusetts, 200 miles away, and Kemeny communicated with his wife – working there – by computer. I studied applied mathematics at Dartmouth College in the 1960s; we were communicating with our lovers by computer already 30 years ago. Kemeny introduced and used e-mail as early as in the 1960s.¹¹ – On the 6 August 1974 all the networked computers stopped working for the users and an inscription announced on the screen:¹²

PRESIDENT NIXON RESIGNED.

When Henry Ford created the model T, he wanted each American to have a car. BASIC, time sharing, and e-mail have achieved something similar: making computers available practically for everyone, creating millions of young hackers.

Fifteen years ago each Hungarian school received computers. The teachers did not know how to use them but the students made immediate good use of JOHN VON NEUMANN's and JOHN G. KEMENY's heritage. Now the number of personal computers exceeds one million in Hungary (a country with a population of ten million). In 1996 Hungary hosted the International Olympiad in Computer Science for high school students. The IBM slogan has become a reality: COMPUTERS ARE FOR KIDS.



In Budapest the Russian-made URAL computer consisted of 2000 vacuum tubes. In the mornings, when the URAL was turned on, due to overload a few tubes frequently burnt out. In the 1960s high school students were hired to take the position of night custodian, in order to avoid turning off the URAL during the night. In these long nights, the young Charles Simonyi had his first encounters with computing, and the clumsy way of accessing them. In 1966 he sailed to America via Denmark, graduated from the University of California in Berkeley, and took a job at XEROX in the Silicon Valley. There the user-friendly ALTO com-

¹⁰Kemeny to the author 1988

¹¹Michael Jerry Antal to the author 1996

¹²Huba Brückner to the author

puter was under development, and Simonyi constructed the BRAVO word processor for the machine, which was able to show on the screen, what the printed page would look like. But the ALTO costed about \$20000; it was not yet for the people. This is why Charles Simonyi joined Microsoft on 6 February 1981.

Bill Gates created the MICROSOFT software company in 1976. The PCs were digital computers, communicating with users by words and characters, like GOTO 32. In a way the first computers imitated typing machines. But human brains receive most information by seeing shapes and colors. In October of 1980, when Microsoft already had 32 employees,¹³ Bill Gates met a young Hungarian, CHARLES SIMONYI. – *Already at our first meeting it was clear for us that graphics would play the central role in the contact between the computer and the outside world. This is the real precondition to the universal public acceptance of personal computers.*¹⁴ – At that time Simonyi was already an ardent prophet of the MENU interface:

– *Let's imagine that we are in France, and, not speaking French, enter a restaurant. I feel uncomfortable in the alien environment and am afraid of losing my face. The waiter starts speaking Moliere's language. My palms begin to sweat. This could be the feeling of a bookkeeper sitting in front of a computer for the first time. What will happen to him? In the restaurant I can always open the menu card and make my choice. In the worst case I will get something quite different from what I intended. The waiter may bring snails instead of lamb, but at least I will have avoided embarrassment. The same situation occurs with software. We have to offer a menu. Everybody can see the options, and simply point to one of them. One should not need to study thick books to find out what he has to do.* – Simonyi introduced the so-called *Hungarian naming* in programming. Instead of using nonsense short names like *blabla* and instead of lengthy explanatory notations, the Hungarian slang indicates *the type of data* as prefix and then *the meaning of data* like *int cbname*. This style has been strongly recommended for use e.g. by Peter Norton.¹⁵

The first great creation of Simonyi was the MULTIPLAN spreadsheet with menu. By making use of the BRAVO experiences, Simonyi in 1981 began developing WORD, a user-friendly word processor with a mouse, offering several styles of characters, and opening several windows to

¹³Today 20000 people work for Microsoft

¹⁴Charles Simonyi to the author 1996

¹⁵Peter Norton: *Borland C++ Programming for Windows*, edited by Bantam

look at the text. Bill Gates, director of Microsoft, declared: – *We shall create the most beautiful spreadsheet in the world!* – Thus Charles Simonyi and Jabe Blumental created EXCEL. Soon after this, Scott McGregor and Charles Simonyi developed WINDOWS. Through these interfaces the user can look into the “mind” of the computer. Its great advantage is that WINDOWS works on computers anywhere, available from hundreds of companies. Now 90 % of the PCs use Microsoft software. Microsoft spends \$2 billion on research and development a year.

In the early 1980s under close cooperation between APPLE and MICROSOFT (directed by Steve Jobs, Bill Gates, and Charles Simonyi), the friendly MACINTOSH computer with a mouse pointer and color graphics was born. From this point on, the computer no longer imitated typing machines, but communicated to the user with icons and pointers: graphics have taken the role played earlier exclusively by abstract characters. On 23 January 1984, at the introduction of MACINTOSH, the lyrics of Bob Dylan came from the loudspeaker:

– *The times, they are a-changing.*



Simonyi is at present the *chief architect* of MICROSOFT, responsible for showing people that computers are not meant only for number crunching and word processing, but can communicate with the user with icons, serve humans by steering cars and navigating space ships. And they may create virtual realities with interactive graphics capabilities. In the Neumann computer the calculations are performed by the central processor, which *thinks* while the other parts store, visualize, or print the information. But animation demands high speed microprocessors.

Fifty years ago the ENIAC consisted of 17 000 vacuum electron tubes. In 1982, the 286 microprocessor chip of INTEL contained 130 000 transistors. Three years later (October 1985) the 386 microprocessor contained 275 000 transistors. Three years later again (April 1989) the 486 microprocessor contained already 1 200 000 transistors. Three years later (March 1993) the 586 microprocessor, nicknamed PENTIUM, was equivalent already to 3 100 000 transistors. The latest 686 microprocessor (advertized as PentiumPro, November 1995) is equivalent to 5 500 000 transistors. The progress accelerates, the 786 microprocessor is already under development at INTEL, it will be equivalent to more than 10 000 000 transistors, thousand times greater than the whole ENIAC was. INTEL owns about 75 % of the microprocessor market, its sale exceeds \$20 000 000 000 and its profit made \$5 000 000 000 in a year. And the driving force behind this spectacular rise in ANDREW S. GROVE, a boy from Budapest who arrived in America forty years ago.

The first (American) computer companies (Hewlet-Packard, Xerox, Texas Instruments, Apple, IBM) were vertical structures: they produced everything from chips and computers to the operating system and software. But it's hard to become *Number One* company simultaneously in so diverse fields! Then in 1981 Grove led the *Operation Crunch* to conquer the computer market, and he succeeded: IBM has decided to use INTEL chips and MICROSOFT software in its personal computers.¹⁶ But MICROSOFT and INTEL did not give privilege to the Big Blue: they sold MS-DOS and INTEL microprocessors also to the competitors. This strategy resulted in a complete rearrangement in the computer industry in the 1980s: the previous *vertical* structure was transformed to a *horizontal* structure: nowadays the chips are produced by INTEL, the software by MICROSOFT for the vast majority of personal computers, and this accelerated the development in computer performance tremendously. There are hundreds of millions of operations performed per second, and there is INTEL INSIDE more than 100 millions of personal computers. Companies like APPLE tried hard to resist this trend by defending their independence, but became soon unable to stand the competition. Bill Gates' MICROSOFT and Andy Grove's INTEL don't rest on their present success but look ahead toward *future*. As Andrew Grove put it (1996),

– *We take processors that are still perfectly good and replace them with better processors. In fact, we never reap the full benefit of the development: We obsolete our own products long before somebody else does. For the year 2011 we shall have microprocessors equivalent of 1 000 000 000 transistors. INTEL has to induce the demand!*

By investing billions of dollars in research and development every year, the INTEL–MICROSOFT alliance has succeeded in overcoming even IBM. INTEL relies on the cycles of development and sale, about \$2 000 000 000 being pumped into each step of development. If this cycle had broken, that could mean the end of the booming computer industry. The *Dream Team* looks ahead; Grove says,¹⁷

– *Consider that there are only about one-third as many PCs as TVs installed worldwide. While present shipments of new PCs roughly equal those of TV sets, we still have a long way to go before we win this war for the eyeballs of billions of people. Our factories have been built upon our dreams. We build them in the hope that people will come to meet us.*

¹⁶MS-DOS: MicroSoft Disk Operating System

¹⁷*International Herald Tribune*, 19 November 1996

GAMES

JOHN C. HARSANYI received the 1994 Nobel Prize in economics. At the Nobel banquet in Stockholm City Hall he was one of the speakers:

– Your Majesties, Your Highnesses, Ladies and Gentlemen. I would like to say a few words on behalf of John Nash, Reinhard Selten, and myself. Of course, we all feel greatly honored. But from a more general point of view, we also feel great satisfaction with the fact that, by the Nobel Prize, game theory has now received international recognition as an important branch of economic analysis. This year game theory is exactly 50 years old because it was von Neumann and Morgenstern's book published in 1944 that established it as a separate discipline. After its publication, virtually all economic journals and many important daily newspapers published reviews of this book, most of them extremely positive about this new discipline of game theory. Many of them predicted that the advent of game theory would give rise almost immediately to truly revolutionary changes in economic theory, and would also have far-reaching implications for economic policy in many fields. Yet, in actual fact, in its first 30 years of existence, up to the mid 1970s, the practical applications of game theory were very limited, probably as a result of excessive preoccupation by game theorists with cooperative solution concepts. Indeed, game theory was so little known by the educated public that one of the very distinguished university libraries actually classified von Neumann and Morgenstern's book under the surprising heading of "Games and Physical Exercises."

– Yet, in the last twenty years, starting with about 1975, game theory has become an important part of mathematical economics so that a high proportion of Ph.D. dissertations and of journal articles now make extensive use of game-theoretic methods. Likewise, government agencies and business firms now make considerable use of game theory in their analysis of auctions, collective bargaining, and international-trade policy. Thus, the optimistic predictions of the reviews of von Neumann and Morgenstern's book in 1944 are coming to be gradually confirmed by the facts.

It happened in 1928, at a summer vacation of JOHN VON NEUMANN in Budapest, that NICHOLAS KALDOR – a former student of the Minta Gymnasium, later knighted by the Queen of England – asked for Neumann's advice on the problem: how to get maximum economic growth with minimum prices? At the request of Neumann, Kaldor offered a few books on theoretical economics. Neumann rushed through them, and found their weak points. He understood that instead of strict equations

one has to use inequalities to handle such a problem. This was the beginning of *the theory of games*, which was further developed in his Princeton lectures. The copies of these lectures changed the spirit of economics completely. Out of these roots the classic book of John von Neumann (the Hungarian–American mathematician) and Oscar Morgenstern (the Austrian–American economist) emerged (1944): “*The Theory of Games and Economic Behavior*” is the greatest paper in mathematical economics that was ever written.¹⁸ Neumann’s models – including some aspects of his game theory – emphasized the advantages of the free market: everyone produces as much as he can, everyone buys as cheap as he can. Equilibrium may be achieved only by uninterrupted growth. Any intervention (cartels, protective customs, central planning) leads to loss of efficiency, stagnation, recession, crisis.

But it did more. Under Presidents Eisenhower and Kennedy Neumann’s mini–max theory of games had become part of American political and military strategy, one of the guidelines for the Cold War policy. As Neumann’s biographer, Norman Macrae said:

– *Neumann’s mini–max strategy of the two-person zero-sum game might be important for saving the world. Thinking like this was wisely chosen at the Cuban missile crisis in 1962: to declare a blockade against the Soviet ships approaching Cuba with nuclear weapons but to offer Krushchev ladders to climb down. It clearly gave minimum loss to Krushchev and maximum gain to America.*



JOHN C. HARSANYI attended the same Lutheran Gymnasium in Budapest that Neumann had. After the Cuban crisis he wrote from America to Budapest:

– *A mathematician – in search of a proof for a theorem – tries several possibilities. What are the heuristic criteria for recognizing the promising chance for a chess game (or mathematical proof), even before exploring all the possibilities? One tried to build computers to prove mathematical theorems, and other ones to play chess. If one recognizes the heuristic criteria used by a good chess player, then the performance of the computer will approach human achievements.*

Oscar Morgenstern (co-author of John von Neumann in *Game Theory and Economic Behavior*) created a consulting company called *Mathematics*. Morgenstern was a good businessman, accepting different assignments even from the U.S. Government. His company checked for example the efficiency of the American Navy in the Mediterranean.

¹⁸Professor E.R. Weintraub’s words 1980

In the 1960s the U.S. Government tried to negotiate nuclear disarmament with the Soviet leadership. The superpower game needed expert advice. The Government asked Mathematics Company to develop an appropriate strategy for dealing with the Soviets. The company hired young mathematicians for the job. Harald Kuhn had been the student of JOHN VON NEUMANN in Princeton. In Berkeley he called Harsanyi's attention to Neumann's papers about game theory. Neumann elaborated *the theory of games with complete information* (like chess where the positions and the rules were completely known for both players). But the disarmament negotiations were more like playing poker, where the cards of the other player were unknown and bluffs might play an important role. This is how and why Harsanyi had to develop *the theory of games with incomplete information*. In the Nobel lecture Harsanyi emphasized:

– In principle, every social situation involves strategic interaction among the participants. Thus, proper understanding of any social situation would require game-theoretic analysis. I realized that a major problem in arms control negotiations is the fact that each side is relatively well-informed about its own position with respect to various variables relevant to the actual negotiations, such as its own policy objectives, its peaceful or bellicose attitudes towards the other side, its military strength, its own ability to introduce new military technologies, and so on – but may be rather poorly informed about the other side's position in terms of such variables. I came to the conclusion that finding a suitable mathematical representation for this particular problem may be very well a crucial key to a better theory of arms control negotiations. Similar problems arise also in economic competition and in many other social (political) activities.

The theory of games with incomplete information assumes that the enemy may apply any of the possible strategies, with different probabilities. In order to optimize our pay-off, we elaborate our most advantageous responses. But the enemy may make a similar evaluation of our options, therefore one can calculate second order expectations, etc. Using appropriate probability distributions, the theory of games with incomplete information can be traced back to Neumann's mathematics of games with complete information. Harsanyi's 1968 paper on the theory of games with incomplete information has made game theory effective both in economic and political planning. It is used by the U.S. Government at GATT negotiations, at the distribution of frequencies for mobile phones, or at auctions of sites for off-shore oil drilling.



THE BATTLE FOR RUGBY'S SOUL

JULY 10, 1995

TIME

INTERVIEW

The Billionaire Who Would Save the World...

and can almost
afford to

Investor and
Philanthropist
George Soros



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After game theoreticians, it's appropriate to speak about the player. George Soros, undoubtedly a successful player on the stock market, said, – *In the 1990s I have met many important players on the stage of history. I wished I could spend more time with some of them. And I don't mean so much people in power, but people of consequences.*

– *Traditionally we think of understanding as essentially a passive role, and participation is an active role. In truth, the two roles interfere with each other both in politics and finance, which makes it impossible for the player to base any decision on pure or perfect understanding. I think that a thinking participant is in a very difficult position because he is trying to understand a situation in which he is one of the actors.*

– *The first thing we have to understand is that social partners cannot confine their thinking to facts. They must take into account the thinking of all the participants including themselves. That introduces an element of uncertainty in the sense that the participants' thinking does not correspond to the facts – yet it plays a role in shaping the facts. Instead of correspondence, there is always a discrepancy between the participants' perceptions and the actual state of affairs, and a divergence between the participants' intentions and the actual outcome. This divergence is the key to understanding historical processes in general and the dynamics of financial markets in particular. In my opinion, misconceptions and mistakes play the same role in human affairs as mutations do in biology.*

This is, how George Soros speaks about GEORGE SOROS, “the billionaire who would save the world, and can almost afford to do it,” as the cover of the *Time* magazine described him [facsimile]. Soros said: – *I attribute this imperfection to the fact that we are part of the world we are trying to understand and at the same time we participate in making what it is.* – These words may remind us of another philosopher, Teilhard de Chardin:

– *In the Game of Nature we are the players, but also are the cards and the stakes as well.* – Soros tells of his strategy: – *I don't play the game according to a particular set of rules. I look for changes in the rules of the game.* – Then he explains how to win occasionally one billion dollars in the game played in the market:

– *As a student of economics I found it strange that classical economics theory, particularly the theory of perfect competition should assume the greatest advantage to all the participants. This model presupposes perfect knowledge. I cogitated and concluded that economic theory is based on false premises. That is how I developed my theory, which recognizes a two-way interaction between thinking and reality.*

– On the one hand, reality is reflected in people's thinking (cognitive function). On the other hand, people make decisions that affect reality and these decisions are based not on reality, but on people's interpretation of reality (participating function). These interfere with each other. Their interaction results in a two-way reflexive feedback mechanism. In certain circumstances the two functions work in opposite directions.¹⁹ – Let x indicate the present state of the market. The participants' understanding of this state is indicated by the cognitive function $y = f(x)$ (passive aspect). On the other hand, the thoughts y of the participants influence the state x of the market, and this can be described by a participation function $x = g(y)$ (active aspect). The *reflexivity* is expressed by the equation

$$x = g(f(x))$$

which serves as a recursive function to follow the course of events on the market. But the interplay of the market indicator x and the player's mind y happens simultaneously. Under certain conditions this nonlinear equation may result in an unstable solution.

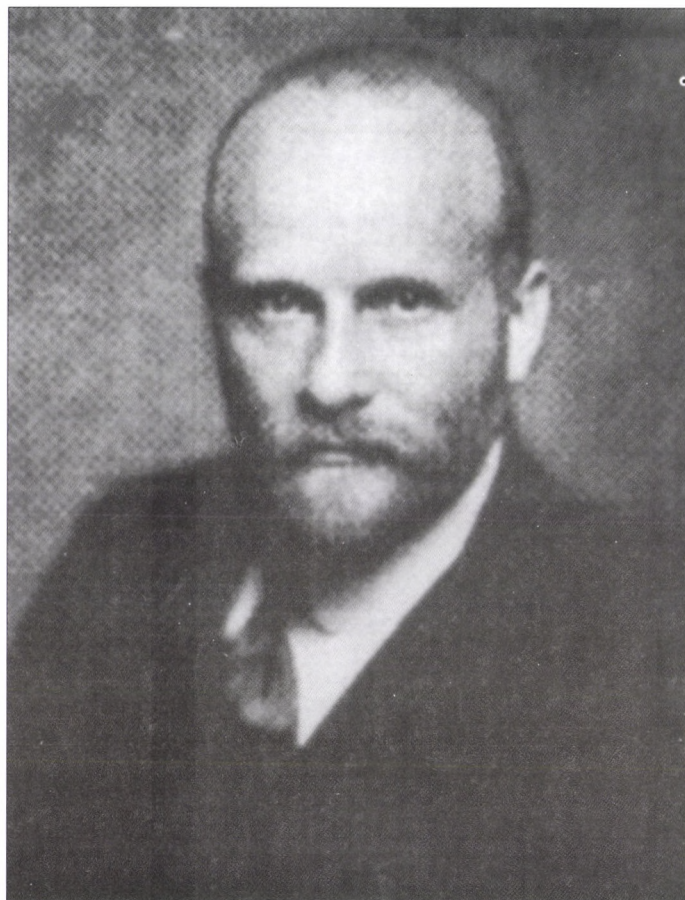
– *There has been a recent development in science, called the science of complexity, or evolutionary system theory, or chaos theory. To understand historical processes, this approach is much more useful than the traditional analytical approach. Unfortunately, our view of the world has been shaped by the determinism of analytical science to a greater extent than is good for us. But all historical processes, including financial markets, are complex and cannot be understood on the basis of analytical science.*

– *Classical economic theory tries hard to imitate classical physics, in order to become an analytical science. Classical economists took Newton as their model – forgetting that Newton lost a fortune in the South Sea Bubble. States far from equilibrium are, however, especially sensitive to the reflections of the participants, but states far from equilibrium occur rarely, therefore traditional models of economics fail only occasionally. Anyway, it is high time to liberate social phenomena from the straight-jacket of classical physics, especially as science is undergoing a radical change. Analytical science is superseded by the study of complexity in open evolutionary systems. It does not expect to produce deterministic predictions. All it seeks is to build models, run simulations – this has been made possible by the development of computers. I believe this approach is*

¹⁹from the book *Soros on Soros*, 1995



Nobel laureate George von Békésy



Nobel laureate Robert Bárány



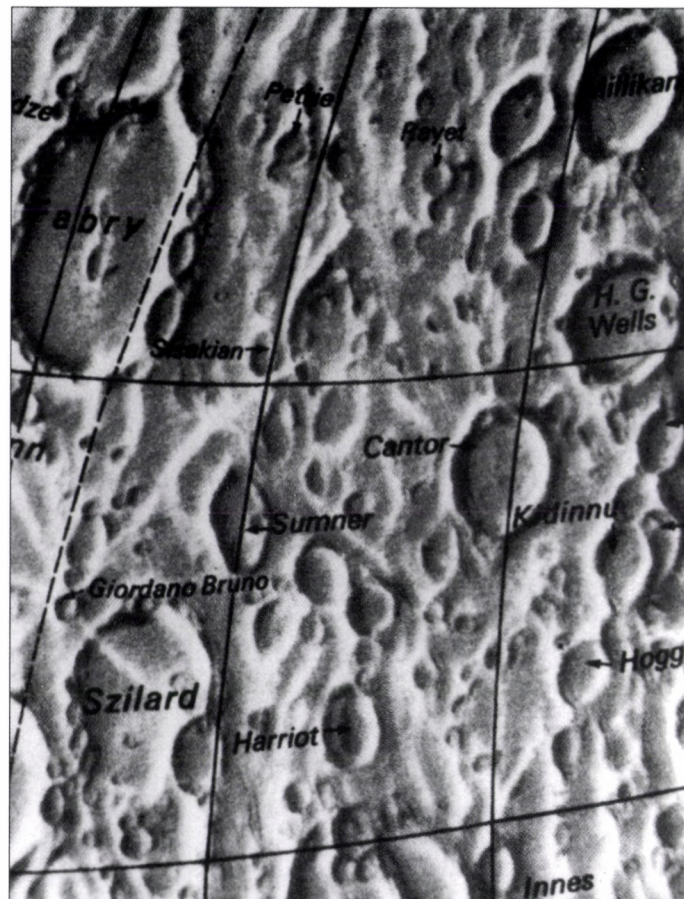
Nobel laureate Richard Zsigmondy



Nobel laureate Carleton Gajdusek



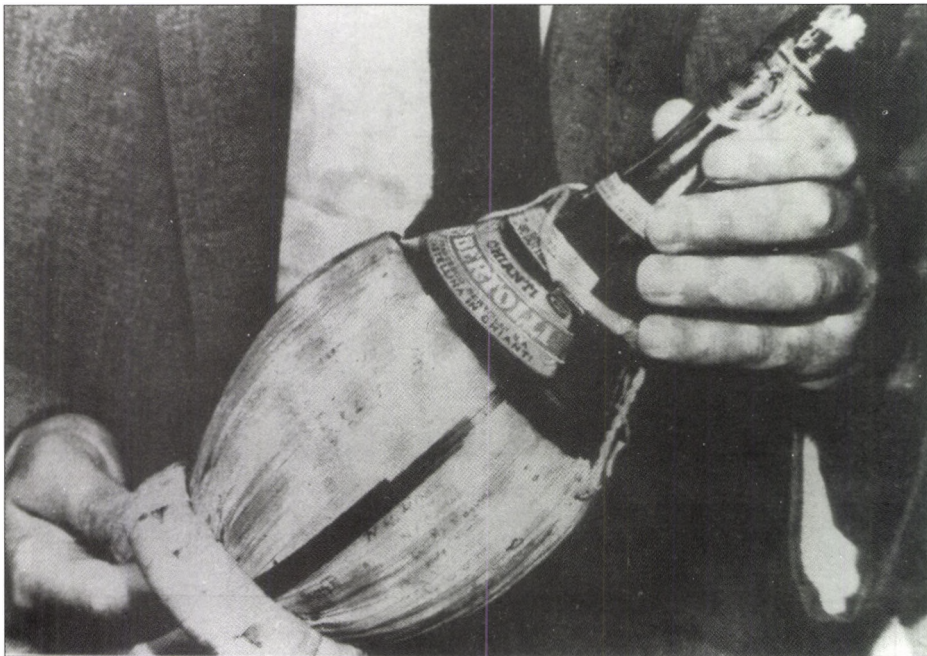
Red light at Southampton Row



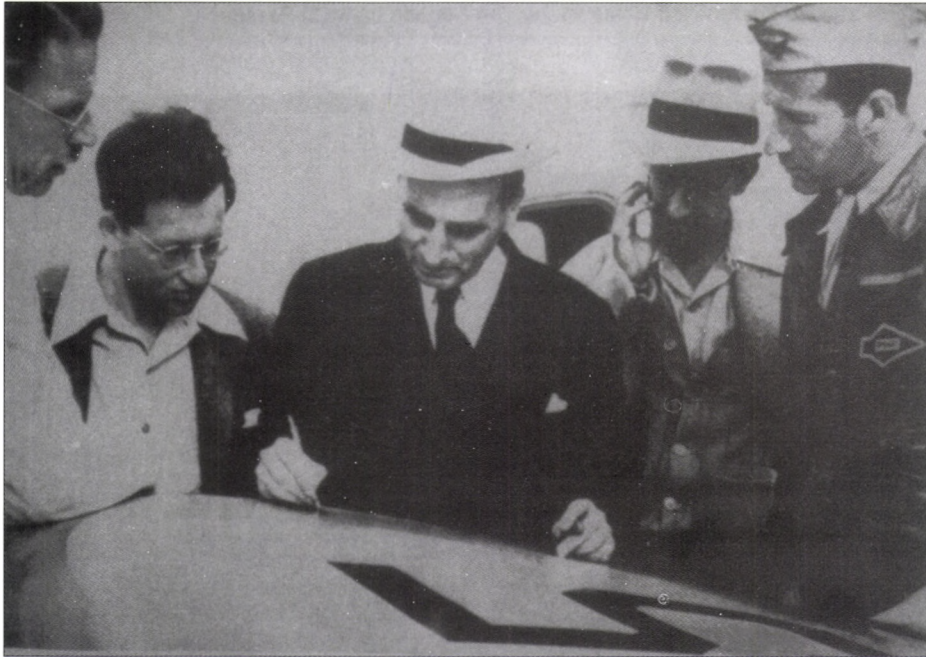
H.G. Wells and Leo Szilard have reached the Moon



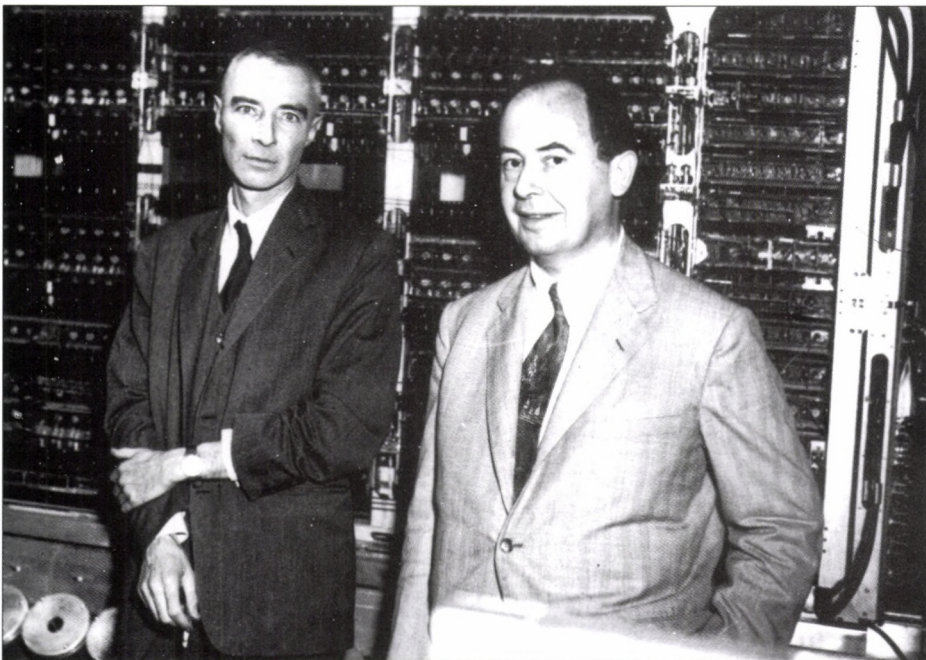
Einstein and Szilard writing the letter



A bottle of Chianti from Wigner to Fermi



Theodore von Kármán advising the U.S. Air Force



John von Neumann with Robert Oppenheimer at the Princeton Computer



Neumann receives the Freedom Award from President Eisenhower



Kármán receives the first National Science Award from President Kennedy



John G. Kemeny with President Carter



Edward Teller with President Reagan (courtesy of the White House)



Edward Teller shakes hands with Robert Oppenheimer



Mushroom cloud over Hiroshima



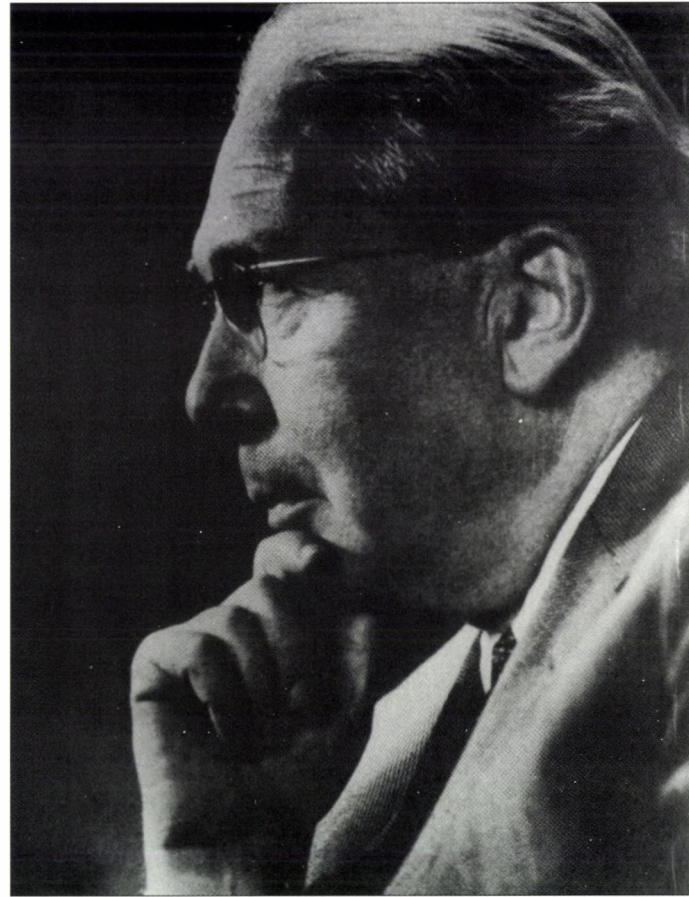
Hevesy working at home in Tura



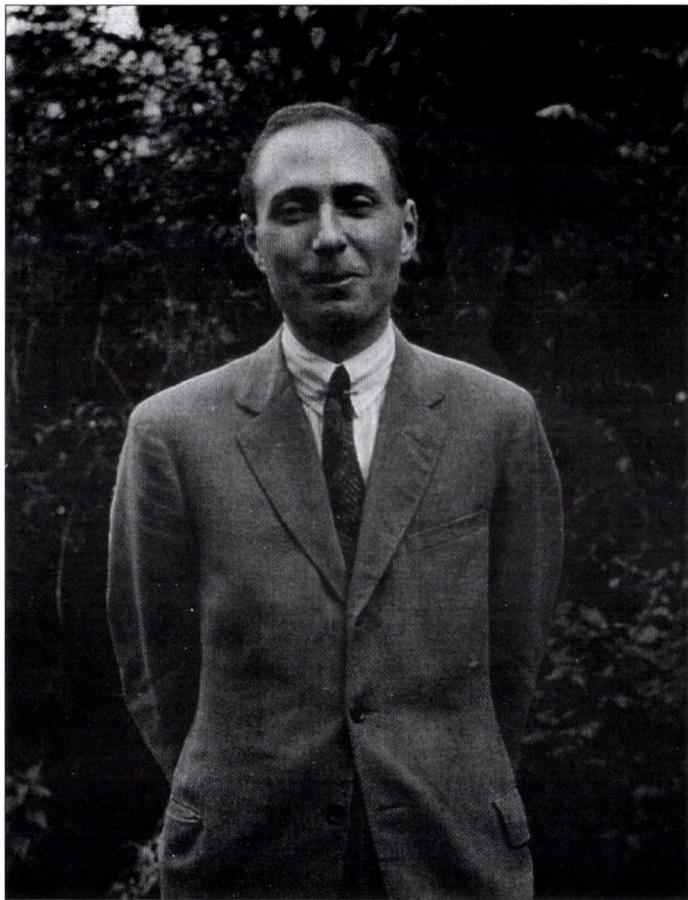
Nobel laureate George de Hevesy



Edward Teller in the Control Room of the Paks Nuclear Power Plant



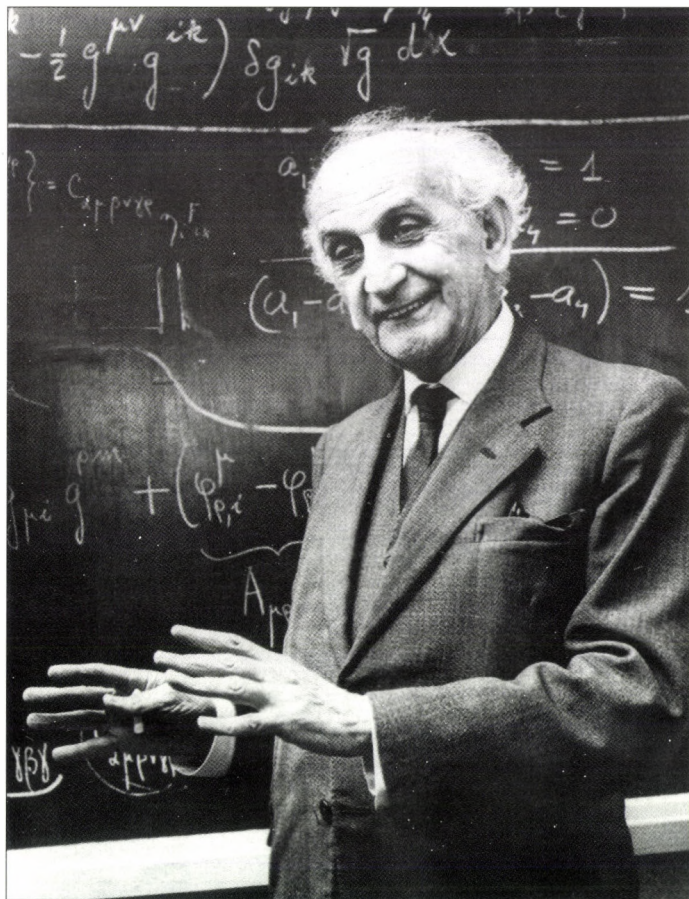
Leo Szilard, winner of the Atoms for Peace Award



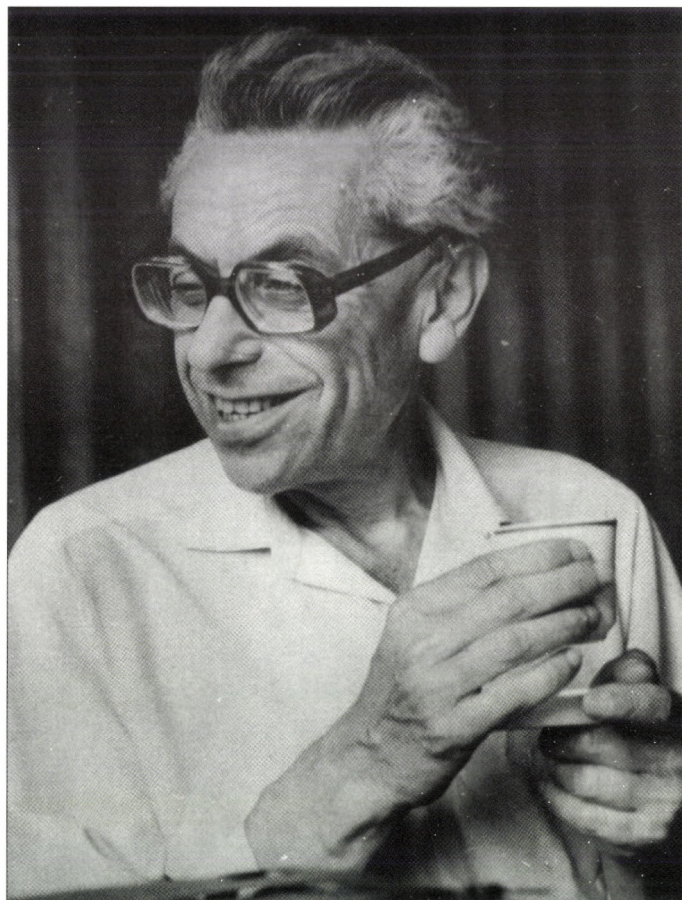
Nobel laureate Eugene P. Wigner



John G. Kemeny, winner of IBM's first Robinson Award



Cornelius Lanczos



Wolf Prize laureate Paul Erdős



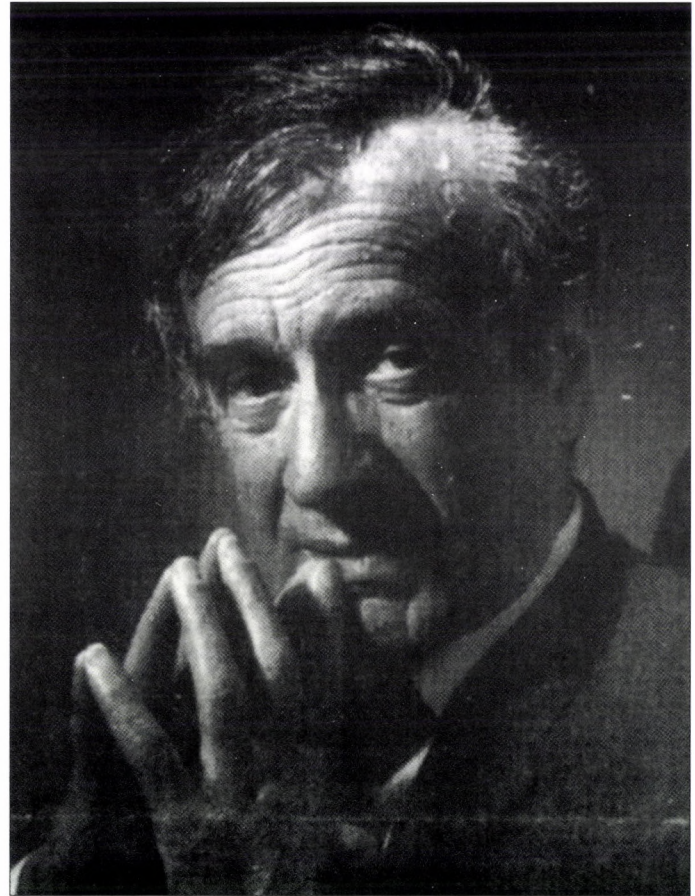
Zoltan Bay



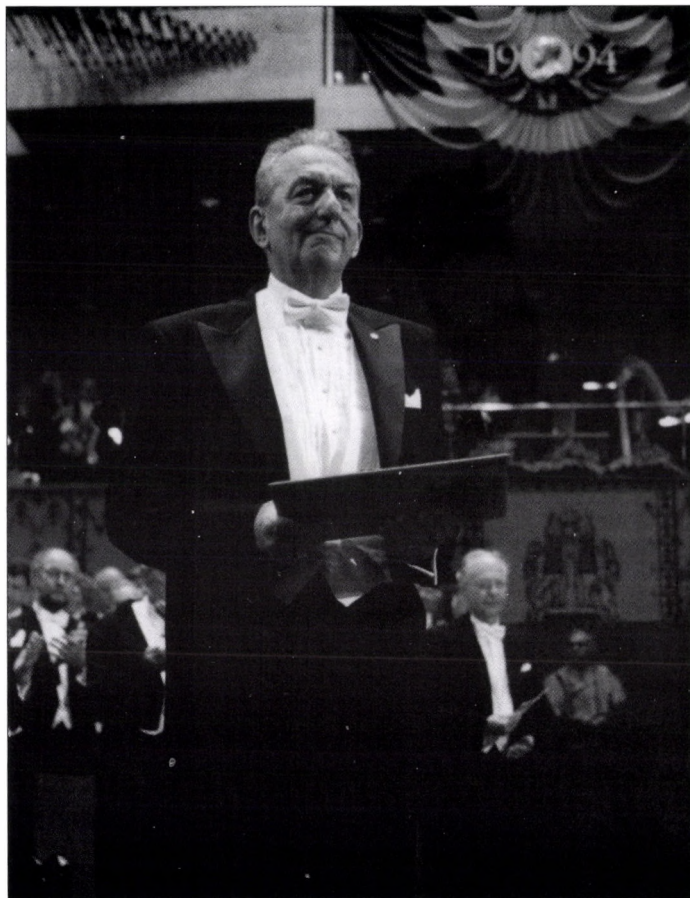
Nobel laureate Albert Szent-Györgyi



Eugene P. Wigner receives the Nobel Prize



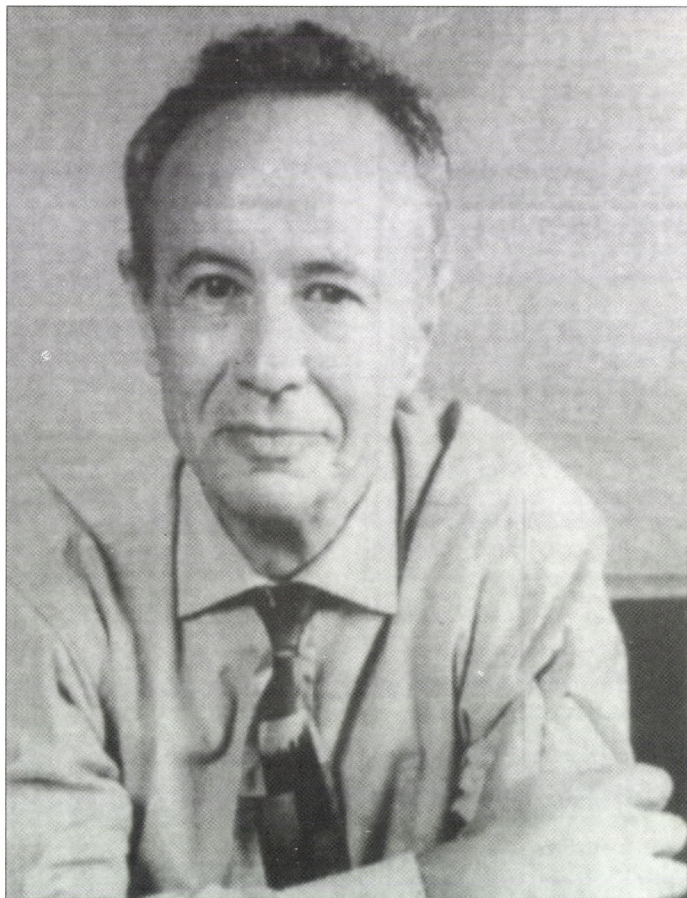
Nobel laureate Elie Wiesel



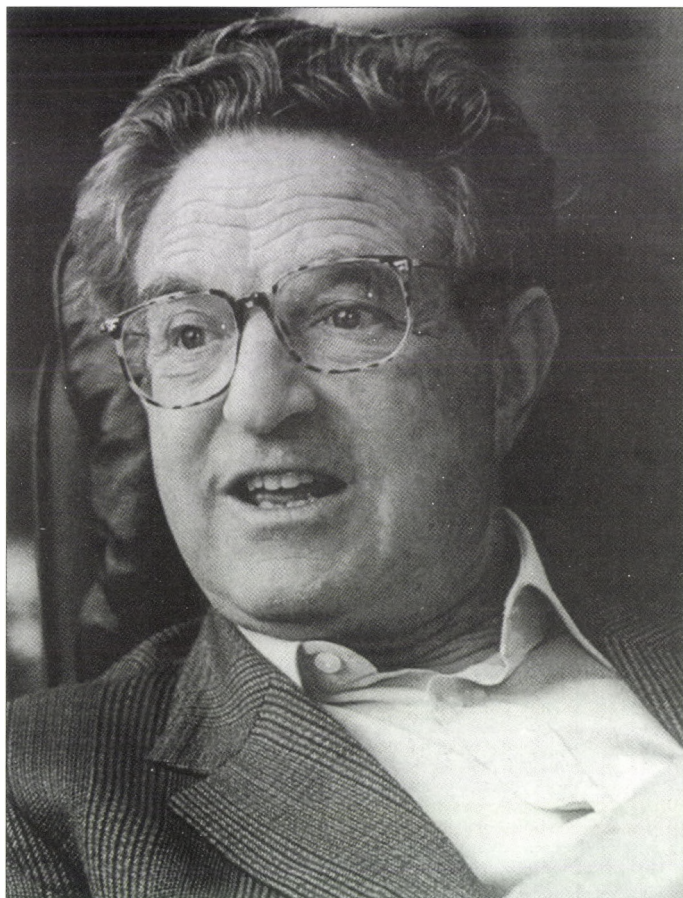
George Olah receives the Nobel Prize (courtesy of the Nobel Foundation)



John Harsanyi receives the Nobel Prize (courtesy of the Nobel Foundation)



Andrew Grove



George Soros

more relevant to the study of social phenomena than analytical science. To understand historical processes, chaos theory is much more useful. – I look for the flaw in every investment thesis. My sense of insecurity will disappear when I discover where the flaw is. Then I can play with greater confidence because I know what is wrong with it while the market does not. Thus I am ahead of the boom/bust curve. I watch for telltale signals that indicate that the trend may be exhausted. Then I disengage from the herd. If I think that the trend has been carried to excess, I may probe going against it. Most of the time we are punished if we go against the trend. Only at an inflexion are we rewarded.

George Soros summarized his views in *Alchemy of Finance* (1987): – *Alchemists made a big mistake by trying to turn bare metals into gold by means of incantations. With chemical elements, alchemy does not work. But it does work with financial markets, because incantations can influence the decisions of the people who shape the course of events.*

Near equilibrium the difference between *belief* and *reality* is small and can be corrected gradually by trial and error, which may result in a boom. But after a period of smooth acceleration the *moment of truth* arrives: the divergence between *belief* and *reality* becomes so large that the participants recognize it themselves. A twilight period (stagnation) follows, then a very steep bust comes. The *boom/bust curve* is highly asymmetric in time, because the components of the system under study are people, who don't forget about their previous experiences. This fact brings in the basic uncertainty.

When the whole process is completed, it does not repeat itself. A change of the regime (or even a revolution) follows. Reality has offered splendid examples to demonstrate Soros' philosophy. Soros has become the great alchemist of the financial market. When Soros bought a large share of the Newmont Gold Mines, others considered Soros' decision as an indication of changing trends, and the price of gold jumped. Now he bets on real estate, possibly due to his expectation of worldwide inflation.

After the oil crisis petrodollars were deposited in banks, the banks offered favorable loans, but later some countries with weak economies were unable to pay back the collected debt. (Hungary is still paying; Poland "rescheduled" her payments.) The debt crisis resulted in the collapse of the Mexican economy (1982).

The unification of the two Germanies directed German investments from the world market to East-Germany, shaking the European monetary coordination, hurting the currencies of the countries which were in recession. Soros applied his alchemy to shake the English sterling. He

made a profit of one billion dollars, and earned the fame as “*the man who broke the Bank of England.*” – He was attacked by the press for “stealing the money of the British taxpayers,” but economists say that *he liberated the British people from recession* (1992). Soros excuses,

– *I operate within the rules. If there is a breakdown in the rules, that is not my fault but the fault of those who set the rules.*

– *I have used financial markets as a laboratory for testing my theories. The quantitative scientific methods of economics are generally constructed on the assumption of the efficient market hypothesis. I don't believe them. I think that those methods work 99 percent of the time, but they break down 1 percent of the time. I am most concerned with that 1 percent. The generally accepted theory of economics is in conflict with my theory of imperfect understanding. I see a certain systematic risk that cannot be encapsulated in those assumptions that generally assume a continuous market. I am generally interested in discontinuities.*

Soros has recognized the close analogy between the *boom and bust* process of the financial market and the *rise and fall* of the Soviet Empire. This made him actively involved in the revolution that was going to take place in Eastern Europe (“*and what the Western politicians never fully understood*”). He knew that the communist dogma was false *because it was a dogma*. Experiencing the twilight, he started using his alchemy: in the 1980s, he created Open Society Foundations in 25 countries, in order to accelerate the changes in Eastern Europe, China, South Africa. Among these, Soros considers himself to have succeeded in Eastern Europe. His policy was to offer open access to the *variety of ideas* by education, by offering western scholarships, by creating the Central European University in Budapest, by donating western journals, by supporting the publication of a spectrum of local books and periodicals, by distributing photocopy machines under the condition that they will not be controlled by the police. These “free” machines enabled the emergence of underground press in Hungary in the 1980s.

– *Historical change is the outcome of the interaction between the cognitive and participating functions.²⁰ A change will become of historical importance due to influencing the course of events by the experiences of the participants; this is why the future cannot be simply a repetition of the past.²¹*

²⁰between facts and opinions

²¹*Soros on Soros*, 1995

In an interview given to Connie Bruck,²² Soros concludes in "his distinct Hungarian accent":

– *By creating my foundations, I was sort of able to play God, right? I was something above the world, outside of the world, benevolent, farsighted, godlike. But if I am an investor, I come down to Earth. I'm just a player. In a way, it's the ultimate challenge: to accept the human condition.*



From Antiquity throughout millennia brave people sailed and have taken great risks to obtain *gold*, a symbol of *unchanging eternity*. Timeless geometry has served as the appropriate model of the world.

Five hundred years ago Galileo, Monteverdi, and Shakespeare discovered the beauty of *change*: in dynamics, music, and drama. Motion turned out to be valuable; *industrial revolution* replaced marmor and gold, these symbols of eternity, with *steel*, to build engines, and *coal*, to keep the engines moving. These materials had become worth of sailing and fighting for. In the 19th century *energy* was considered to be the central concept in science, industry, economy, and war, just because energy can be converted to motion.

In second half of the 20th century, however, *information* has become the key concept. Arthur W. Burks recalled JOHN VON NEUMANN saying:

– *In the past, sciences dealt mainly with the problems of forces and energy. I foresee that in the future science will focus on the problems of regulation, guidance, programming, data processing, communication, systematization, and organization.*

Today the value of industrial products (chips or videocameras) is not given by the weight of iron contained, energy consumed, but by the knowledge built into them. There are strict conservation laws for materials and energy. Information, however, can be created even out of chaos. Information can be quickly handled by *electrons* and *light*, freely available everywhere. As people began sailing in cyberspace (by e-mail and INTERNET), Hungarians were also aboard. This is a strange journey: it leads far beyond pure mathematics, physics, and engineering. Economic competitions as well as cold and hot wars are fought today by computers and telecommunication. The INTERNET is about transforming our way of living, bringing electronical banking, interactive television, possibly a new kind of entertainment industry. ANDY GROVE said (1996),

– *I felt that INTERNET was the biggest change in our environment over the last years. We need to update our own genetic makeup, to be*

²²*The New Yorker*, 23 January 1995

more in tune with the new environment. The personal computers connected by the INTERNET could, in fact, become a significant alternative to televisions.

While speaking about his efforts to create democracy in Eastern Europe, GEORGE SOROS said (1995),

– We are currently working to make the INTERNET available not only to the scientific community but to all users: schools, universities, libraries, the media. I shall preserve with the INTERNET program because I consider it so important for establishing the pre-conditions of an open society.

It's appropriate to conclude our historical overview with EDWARD TELLER's words:

– I believe that of all the inventions of the 20th century, the one with the most lasting influence will turn out to be the electronic brain, and Johnny von Neumann was its prophet.

The Myth of the Martians

A saying circulated among us that two intelligent species live on Earth: Humans and Hungarians. (Isaac Asimov)

THE BIRTH OF A LEGEND

– Enrico Fermi was a man with outstanding talents, he had many interests outside his own particular field. He was credited with asking famous questions. There are long preambles to Fermi's questions like this: – The universe is vast, containing myriads of stars, many of them not unlike our Sun. Many of these stars are likely to have planets circling around them. A fair fraction of these planets will have liquid water on their surface and a gaseous atmosphere. The energy pouring down from a star will cause the synthesis of organic compounds, turning the ocean into a thin, warm soup. These chemicals will join each other to produce a self-reproducing system. The simplest living things will multiply, evolve by natural selection and become more complicated till eventually active, thinking creatures will emerge. Civilization, science, and technology will follow. Then, yearning for fresh worlds, they will travel to neighboring planets, and later to planets of nearby stars. Eventually they should spread out all over the Galaxy. These highly exceptional and talented people could hardly overlook such a beautiful place as our Earth. – “And so,” – Fermi came to his overwhelming question, – “if all this has been happening, they should have arrived here by now, so where are they?” – It was Leo Szilard, a man with an impish sense of humor, who supplied the perfect reply to Fermi's rethoric: – “They are among us,” – he said, – “but they call themselves Hungarians.” – This is Francis Crick's version of the myth.¹

Hans Bethe wondered quite “seriously” whether *a brain like von Neumann's does not indicate a species superior to that of man.*² Rich-

¹This quote is the first page in Francis Crick: *The Life Itself*, Macdonald, London 1982

²Norman Macrae: *John von Neumann*, 1992

ard Rhodes³ has reported: – *At Princeton a saying gained currency that Neumann, the youngest member of the new Institute for Advanced Studies, twenty-nine in 1933, was indeed a demigod but that he had made a thorough, detailed study of human beings and could imitate them perfectly.* – The myth of the Martian origin of the Hungarian scientists who entered world history on American soil during World War II probably originated in Los Alamos. Leon Lederman, director of the Fermilab, reported possible hidden intentions:⁴ – *The production of scientists and mathematicians in the early 20th century was so prolific that many otherwise calm observers believe Budapest was settled by Martians in a plan to infiltrate and take over the planet Earth.* – As a matter of fact, these suspicious Hungarians (Kármán, Neumann, Szilard, and Teller) enjoyed the myth. EDWARD TELLER became especially happy of his E.T. initials, but he complained about indiscretion, – *Von Kármán must have been talking.* – *Yankee* magazine⁵ reported this landing in detail:

– *Gabor, Kemeny, von Neumann, Szilard, Teller, and Wigner were born in the same quarter of Budapest. No wonder the scientists in Los Alamos accepted the idea that well over one thousand years ago a Martian spaceship crashlanded somewhere in the center of Europe. There are three firm proofs of the extraterrestrial origins of the Hungarians: they like to wander about (like gypsies radiating out from the same region). They speak an exceptionally simple and logical language which has not the slightest connection with the language of their neighbors. And they are so much smarter than the terrestrials. (In a slight Martian accent John G. Kemeny added an explanation, namely, that it is so much easier to learn to read and write in Hungarian than in English or French, that Hungarian kids have much more time left to study mathematics.)*

At this point it seems worthwhile to quote Laura Fermi, Enrico's wife:⁶ – *Hungary, with a total population of 10 million, had about the same impact on the scientific evolution in the U.S. in 1930–1950 as Germany, with 60 million.* – VALENTINE TELEGDÍ recalled his youth:⁷ – *For a young Hungarian abroad it may be good to hide his Hungarian descent, because if it*

³Richard Rhodes: *The Making of the Atomic Bomb*, 1986

⁴Leon Lederman: *The God Particle*, Boston, 1993

⁵March 1980

⁶Laura Fermi: *Illustrious Immigrants*

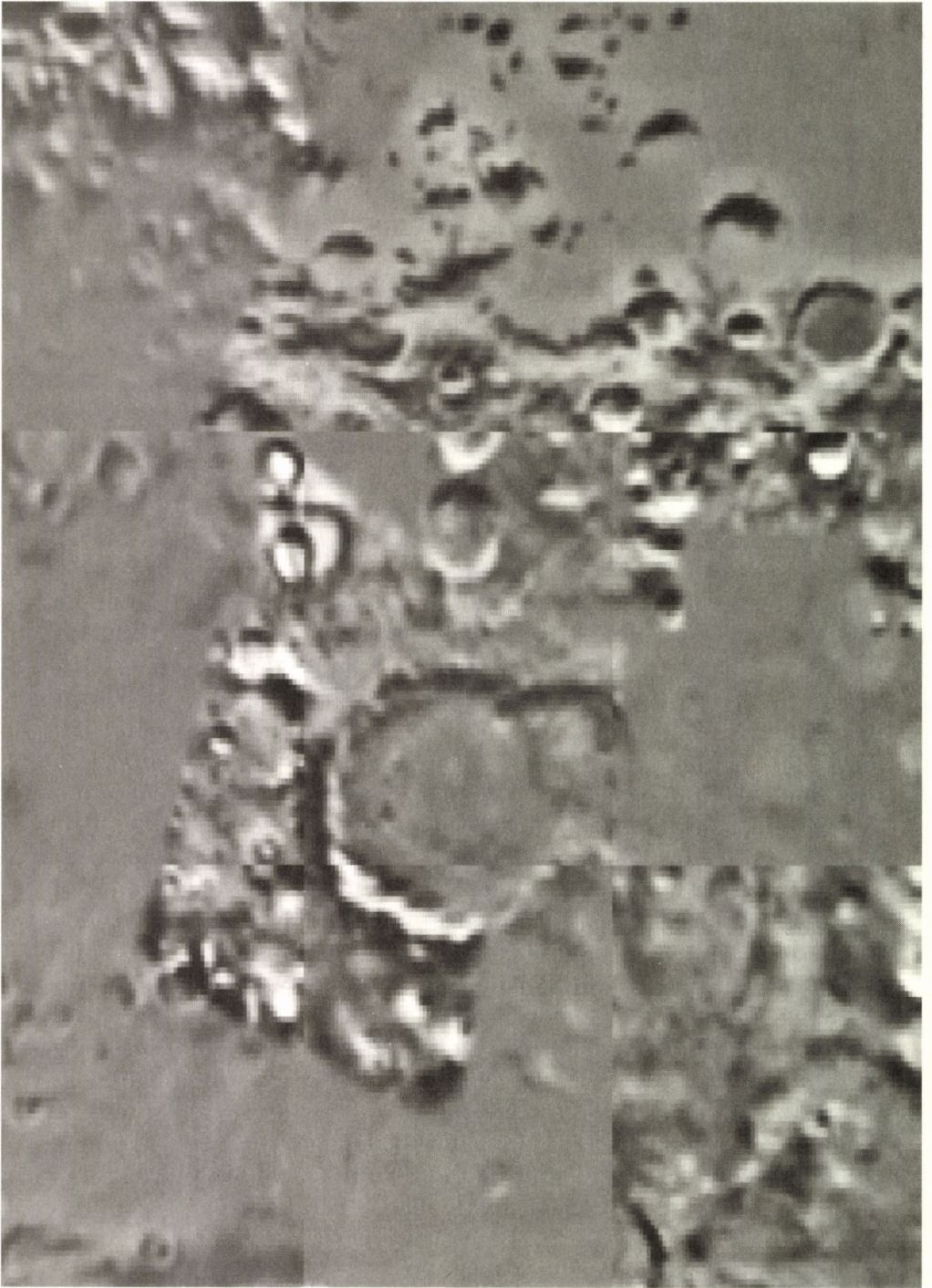
⁷Budapest 1989

is made known, too much will be expected of him. People will know that he is one of the Martians of exceptionally high intelligence who use that incomprehensible language. There was another profession besides science which was crowded by Hungarian talents, the cinema, an art emerging from the successful marriage of traditional drama and modern technology.

LANDING IN HOLLYWOOD

Legend has it that Hollywood was founded by Hungarians. (At least in part.)⁸ Sándor Korda was born in Hungary, in the fateful year 1919 he emigrated to Germany, from there to Hollywood, but reached the peak of his career in England (*The Private Life of Henry VIII* and *Lady Hamilton*) and became SIR ALEXANDER KORDA. The names of Hungarians in Hollywood make a long list, from Adolph Zukor – born in Ricse (*Paramount Pictures*) to William Fox – born in Tolcsva, near Tokaj (*20th Century Fox*) as founders; from Michael Curtiz – born in Budapest (*Casablanca* and *The Adventures of Robin Hood*) to Andy Vajna – born in Budapest (*Rambo* and *Evita*) as directors; from Menyhárd Lengyel (*Typhoon* and *Ninotsbka*) to Joe Esterhas – born in Csákánydoroszló (*Flashdance* and *Basic Instinct*, working now on a script about the 1956 revolt of Hungary) as screenwriters; from Laszlo Kovacs – born in Budapest (*Easy Riders* and *Free Willy*) to Willy Zigmund (*Close Encounter of the Third Kind* and *The Dear Hunter*) as cinematographers; from Bela Lugosi – born in Lugos (*Frankenstein* and *Dracula*) to Zsa Zsa Gabor – born in Budapest (*Moulin Rouge* and *A Nightmare on Elm Street*) as actors, and so on. A special attraction to atoms has been shown by Cicciolina – born as Ilona Staller in Budapest (in her *Orgia Atomica*). There is also a list of second generation Hungarian actors like Tony Curtis – fluent in Hungarian (stylishly the *Lobster Man from Mars* and *The Boston Strangler who Likes it Hot*) through Paul Newman (*The Sting*, then *Exodus*, followed by a *Long Hot Summer*) up to Leslie Howard – born László Steiner (*A Free Soul*, later *The Scarlet Pimpernel*, to be *Captured!* and then *Gone with the Wind*). (Howard was wounded in World War I; in World War II he was shot down in action, according to myth at the direct order of Hitler, while flying an airplane near Gibraltar on a secret mission.) Hungarians have been laureated by Oscar Awards: George Cukor (director), József Rufusz (cartoon director), Vil-

⁸*Hungarians in Film*, p. 6.



mos Zsigmond (cinematographer), Adolph Zukor (for life's work). On the wall of Zukor's office there was an inscription:

IT IS NOT ENOUGH TO BE A HUNGARIAN,
YOU MUST BE TALENTED TOO.

In a low voice Adolph added: – *But it may help.* – There were also non-Hungarians in Hollywood but they used to say, – *If you have a Hungarian friend, you don't need an enemy.* – According to Norman Macrae, the biographer of John von Neumann,

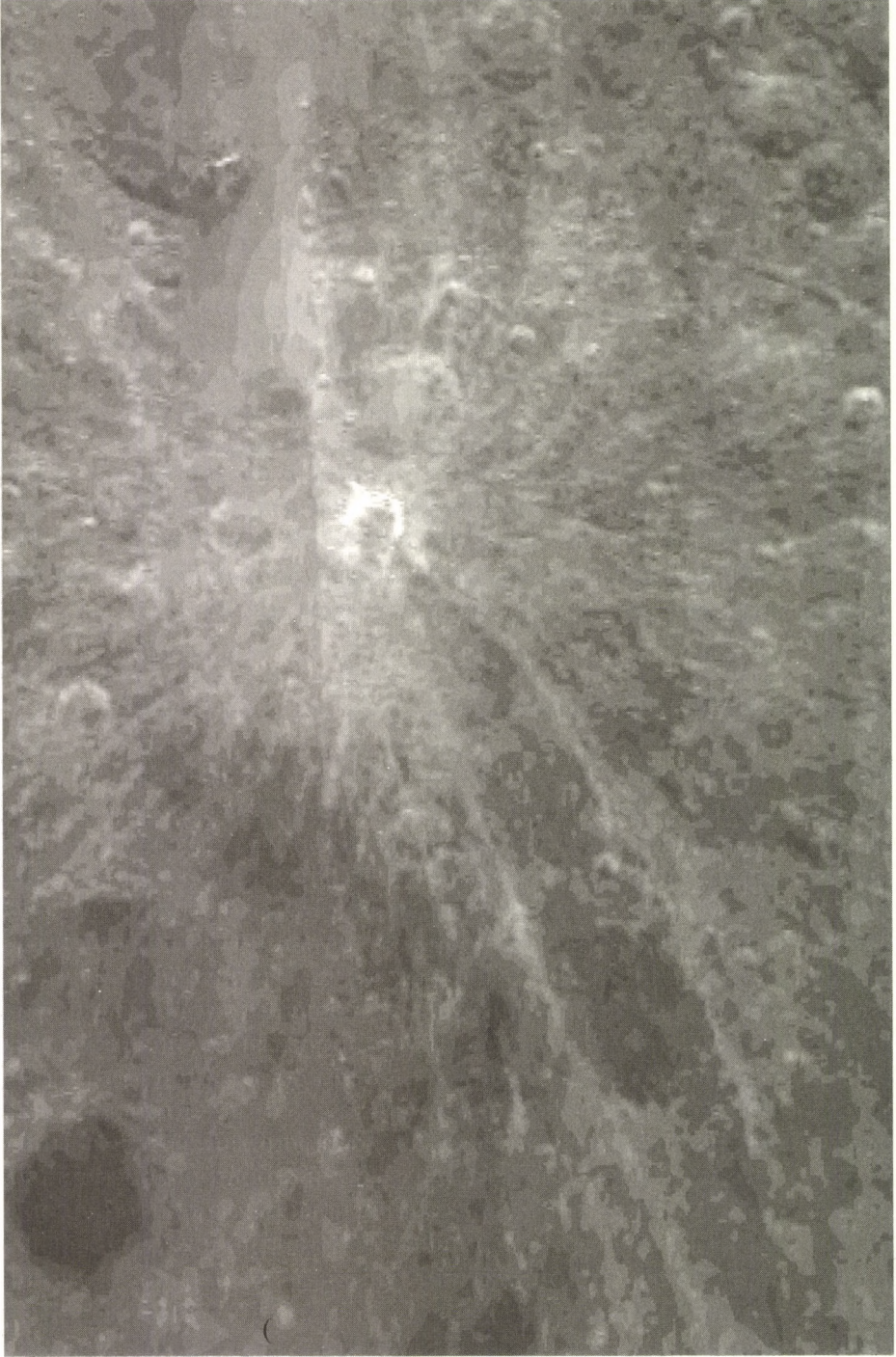
– *The American word "movie" probably derived from the Hungarian "mozi." Cynics says that Hungarians created America's Hollywood before other Hungarians less destructively created America's A-bomb.*

István Szabó (1938–), the Oscar winner Hungarian director, recently made a film for the BBC about the capital city of Hungary.

– *I called this film "Staying Afloat" because to me Budapest is like a boat trying not to capsize as it is buffeted by waves from all directions. We've been lashed by history and we mustn't let it suck us under. The very air of Budapest exudes this daily struggle for survival, this feeling that we're clinging to the rails; this is why I love my city.*

COMING FROM OUTER SPACE

There is only one single factual piece of evidence about the descent from planet Mars: there is a mount named *Von Kármán Crater* on the Red Planet [picture]. Hungarians left more traces on the Moon: a huge ring in the southern part of the far side of the Moon has also been named *Von Kármán Crater*, honoring the pioneer of supersonic flight. East of it is the tiny crater honoring *Imre Izsák*, the Hungarian–American expert of celestial mechanics of the Space Age (1929–1965). In the North-West, near the lunar Terminator Line, halfway between H.G. Wells and F. Joliot is the great *Szilard Crater* of 122 km in diameter [picture on the next page]. East of it astronauts may find the *Von Neumann Crater*. Further 19th century Hungarians, who did not cross the Ocean, also deserved place on the Lunar Map: in the southern part of the far side are *János Bolyai* (pioneer of non-Euclidean geometry, 1802–1880); a bit east of it is *Roland Eötvös*. A tiny crater represents *Gyula Fényi*, the Jesuit solar astronomer (1845–1927), another one the Austro–Hungarian Nobel laureate, *Richard Zsigmondy*. But there is a Martian who proved that the craters on the Moon are not products of lunar volcanism but had been created by impacts of meteors from outside: EGON OROWAN, while working on plasticity and fractures



in solids, studied high resolution photographs brought back by the Apollo missions.⁹ (There is indeed an asteroid named Teller orbiting around the Sun, discovered by E.F. Helin in 1989.)

Another Hungarian, *Steve Mende* was a researcher of polar light (working in Palo Alto, California) and his results have justified the name of *Mount Mende*, 1500 m high in Antarctica, at 74° 50' southern latitude, 71° 36' western longitude on Earth. A shorter distance from Budapest is *Eötvös Peak* in the Alps, named after *Roland Eötvös*, who was an enthusiastic mountaineer and climbed this peak.

SPEAKING AN ALIEN TONGUE

It is well known that it was the U.S., and soon thereafter the Soviet Union, England, France, and China, where nuclear power was accomplished. In addition, a number of highly talented physicists of other nations contributed to the success, e.g. Germans (Hans Bethe, Felix Bloch, Otto Hahn, Rudolf Peierls), Austrians (Otto Robert Frisch, Hans Halban, Lise Meitner, Victor Weisskopf), Italians (Eduardo Amaldi, Enrico Fermi, Bruno Pontecorvo, Emilio Segré). Teller used to emphasize: – *It was the work of many people*. – Why are just Hungarian scientists considered to be, in some sense, “aliens”?

An obvious reason may be their strange language: its grammar and vocabulary are quite distinct from those of the Indo-European languages. KÁRMÁN and BÁRÁNY proudly accented the *á* in their names at all times, in spite of the opposition of computerized word processors. (The Báránys did so through generations.) When polyglott TELEGDI decided to learn Japanese, he rushed to Budapest to buy a Japanese language book written in Hungarian, because Hungarian grammar is similar to Japanese, while for an English author it is difficult to explain how Japanese think and speak. (Chinese, Japanese, Koreans put *family name* first, *given name* as last; in Europe only the Hungarian language follows this rule.)

According to myth, at a top secret meeting of the Manhattan Project General Groves left for the gents' room. Szilard then said: – *Perhaps we may now continue in Hungarian!*¹⁰

⁹*Proceedings of the Royal Society* A336 (1974) 141

¹⁰Fermi once asked Telegdi for help: – *What could be the meaning of the special Hungarian expression which I have heard in Chicago so frequently: “Te piszkos disznó”?* – Telegdi had to translate: “*You dirty swine!*” – Telegdi to the author 1996

TELLER did not visit Hungary for half a century but when he returned he confessed, – *I speak German and English, but I can think only in Hungarian.* – Hungarian emigrees enjoyed speaking their mother tongue whenever a chance offered itself. This has made them look suspicious. Los Alamos was a place of top security. General Groves was annoyed that NEUMANN and WIGNER had frequent telephone conversations in Hungarian. He also complained in the cafeteria: – *Don't speak Hungarian!* – Who spoke Hungarian? – *Kids on the street!* – But there were no Hungarian children in Los Alamos. It turned out that the sons of Felix Bloch spoke Schwitzerdütsch, which the suspicious general mistook for Hungarian.¹¹ The “thick Hungarian accent” was often heard even in the corridors of the Pentagon. (The Lugosi accent made the alien power of Dracula, the count from the faraway Transylvania, even more realistic.)

This explanation of the myth, however, is certainly not sufficient. The present book originated in an attempt to search for an answer. Let us quote now GEORGE VON BÉKÉSY:

– *If a person traveling outside Hungary is recognized as a Hungarian due to his accent, something which – beyond a certain age – is impossible to drop, the question is asked almost in every case: “How is it possible that a country as small as Hungary has given the world so many internationally renown scientists?” There are Hungarians who have tried to give an answer. For my part: I cannot find an answer, but I would mention one thing. When I lived in Switzerland, everything was peaceful, quiet and secure; we had no problems earning a living. In Hungary, life was different, and we all were involved in an ongoing struggle for almost everything which we wanted, although this struggle never caused anybody's perdition. Sometimes we won; sometimes we lost; but we always survived. It did not bring an end to things, not in my case anyway. People need such challenges, and these have existed throughout the history of Hungary.*

CROSSROADS IN SPACE-TIME

It is a fact of history that the great figures of human culture are not distributed evenly in space and time. They concentrated, for example, in democratic Athens (Aristotle and Sophocles), while the city was fighting against Persian invasions; in renaissance Florence (Michelangelo and

¹¹Teller, Budapest 1991

Galileo), in a city struggling with the supremacy of the Pope; at the beginning of the English industrial revolution (Shakespeare and Newton), while fighting the Spanish Armada. Quiet periods require only *social adjustment*. Under a changing climate, however, old schemes no longer work, such conditions encourage creative individuals. If a very different *final truth* is offered each month, young people learn critical thinking, and become more interested in facts than in axioms. During the recent political turmoil a joke circulated: – *What is the most unpredictable thing today in Hungary? The past!* – Psychology teaches us that an impact-rich environment cultivates talent. To support this view, let's quote one of the strangest Martians, ARTHUR KOESTLER:¹²

– *When Tom Corbett, Space Cadett, behaves on the Planet of Orion exactly in the same way as he does in a drugstore in Minnesota, one is tempted to ask him: "Was your journey really necessary?"*

There may be *historical reasons* for this alien coherence of the Hungarians: – *Hungary was usually in turmoil; a situation attributable mainly to an accident of geography.*¹³ – As Kati Marton (Mrs Holbrook),¹⁴ who left Hungary as a child in 1957, said, – *My parents had too much history.* – My thesis is that Hungary (together with her Central-European neighbors) has been at the crossroads of history, where the routes from Rome (Catholicism), Germany (Reformation), Russia (Eastern Orthodox Christianity), Osman Empire (Islam) met each other, presenting alternatives and igniting conflicts. Armies from East and West were marching on the roads through centuries. We have learned agriculture from the Slavs, the Renaissance arrived from Italy, and industry came from Germany. Through one and a half centuries the armies of the Osman Empire took everything what they could from the Hungarian peasants – but pigs; this is why pork is the favorite meat of the Hungarians even today. Grapes were introduced by the veterans of the Roman legions, in order to make wine. Beer-brewing came from Germany. The Russians have shown how to distill vodka. And the Turks introduced the strong black coffee, a present national drink of the Hungarians. So much about the first Hungarian millennium.

A hundred years ago (when the Martian heroes of this book were born), a German-speaking Emperor–King ruled Hungary, supported by

¹²Arthur Koestler: *The Boredom of Phantasy*, 1955

¹³Stanley A. Blumberg – Gwin Owens: *Energy and Conflict*, 1976

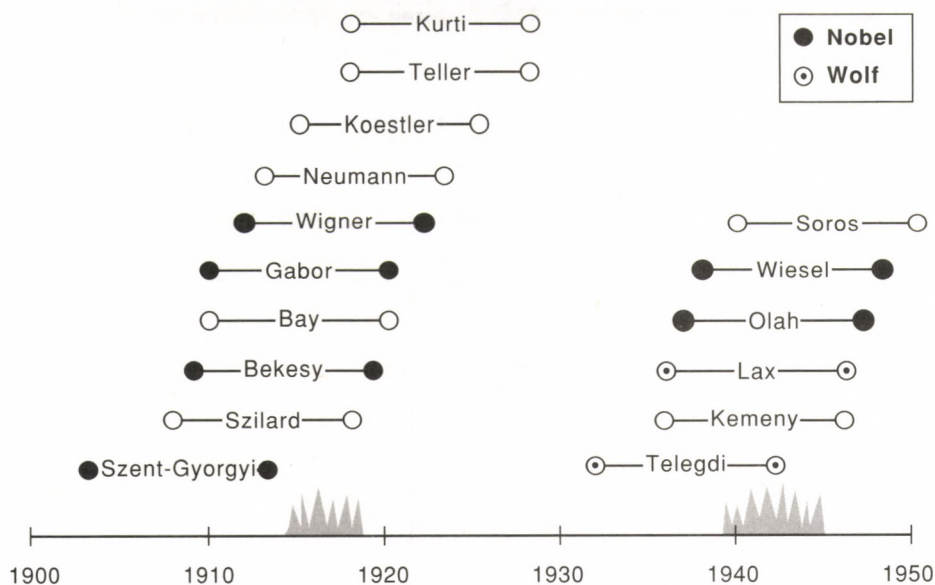
¹⁴*Newsweek*, 17 February 1997

feudal landlords. But the industrial revolution was already in full swing, having brought the parliamentary system, compulsory education (1868) – and unsolved social contradictions. In 1896 politicians in Parliament spoke of the glory of the past thousand years of Hungarian history, but the world exposition, organized in Budapest to honor the millennium, presented new physical inventions (like EÖTVÖS' gravimeter), and the first underground metro system on the continent was already operational in Budapest (second only to London).

As the 20th century arrived, the Austro–Hungarian Empire started playing the superpower: Turkey was expelled from most of the Balkan Peninsula. Austria–Hungary occupied Bosnia (1908), pushing Serbia toward an alliance with Russia. After a Serbian nationalist murdered the Habsburg crown-prince in Sarajevo (1914), war was declared against Serbia. Russia rushed to help the Serbs, Germany responded by attacking Russia, France and England declared war against Germany. Thus World War I was started, and was lost. After the military collapse Michael Károlyi, the liberal Count rose against the Austrian emperor and created a pro-Western democratic *Hungarian Republic* (31 October 1918). But with the encouragement of the Western Powers the neighboring countries attacked Hungary. Károlyi resigned, and a communist government organized resistance – looking for help from Moscow (21 March 1919). Their defense efforts could not last for long: Budapest was invaded by foreign troops (July 1919). Finally a group of Hungarian army officers assembled and took power (November 1919), made the country formally a kingdom again (but the military rulers expelled the Habsburg king trying to return). The rightist military rule took revenge. A wave of emigration began.

Almost all the Martians attended university and began their careers in Germany, where and when quantum mechanics had been born. This does not contradict but confirms our thesis that *conflicts cultivate creativity*. The 1920s were the decade of the Weimar Republic, which was full of psychological conflicts: the democracy was overshadowed by the lost World War (“Dolchstoss von hinten”), the dream of a new German Empire (das Dritte Reich), the trilemma of liberalism–communism–nazism. This fruitful period of the coexistence of contradicting ideologies lasted there over ten years, before terminating in the tragedies of the economic crisis, dictatorship, and war. A similar critical but creative period of *accelerating history* was experienced in Petrograd in the early 1920s, after the fall of the Czar and before the rise of Stalin, resulting in an explosion of creativity. In Hungary, however, all these revolutions and counter-revolutions happened in a mere twelve months!

When were the Martians teenagers?



The most sensitive period in human life is being a *teenager*, when one's personal system of values is built up. The diagram indicates that the Martians – so successful in later years across the Ocean – attended high schools in Hungary just at the time of the great World Wars. What a privileged time to live in!



The Jews were expelled from Western Europe 500 years ago, but were welcome in Eastern Europe for bringing trade and industry, especially by the king of Poland. In the 19th century Poland was divided among Germany, Austria, and Russia. Escaping from the pogroms encouraged by Russian orthodox priests, the Jews moved southward, towards Hungary, adding to her former Jewish population. According to ancient law, Jews were forbidden to own land, so they turned toward trade and industry. Their wealth was increased by the industrial revolution. At the proposal of the Minister of Culture, the enlightened *Baron József Eötvös* (the father of the physicist Roland Eötvös) the Hungarian Parliament emancipated the Jews (1867). Some of them were made noblemen for their services in the economy (e.g. the father of GEORGE HEVESY in 1895, the father of THEODORE KÁRMÁN in 1907, the father of JOHN NEUMANN in 1913). One hundred years ago (1895) BARON ROLAND EÖTVÖS, a physicist served as Minister of Culture just for a few months. Because he was an aristocrat, he was able to convince the conservative Parliament to widen

Sor- szám	A tanuló neve és születésének kelte	Hazája, születéshe- lye.	Atyjának vagy any- jának neve, állapota és lakhelye	Országdijaz-e, tandi- mentes vagy fizető?	Vallása
37	S. Korol Tiwadar 1860 májji 2	Magyarország Pozsony Thoncel-félsziget	Atyja: Sakab Lantigargó Thoncelházi	fizető	kápos
Tantárgyak	Időszakok				Észrevételek
	I.	II.	III.	IV.	
	Tanulmányi előmenetel				
Hittan	1.	1.	1.	1.	I.
Magyar nyelv	2.	2.	2.	2.	
Német nyelv	2.	2.	1.	1.	
Földrajz és történelem	1.	1.	1.	1.	
Menyiségtan	1.	2.	2.	2.	
Mértan és rajz	3. 4.	2. 4.	2. 4.	1. 4.	
Természettan	3.	2.	3.	3.	II.
Természetrajz	1.	1.	—	—	
Vegytan	—	—	—	—	
Építészettan és rajz	—	—	—	—	
Géptan és rajz	—	—	—	—	
Szobrászképrajz vagy min- tázás	4.	4.	4.	4.	III.
Szépirodalom	4	3	3	2	
Ének	—	—	—	—	
Szabad tantervek	—	—	—	—	
Francia nyelv	—	—	—	—	
Olasz v. angol ny.	—	—	—	—	
Torlasztás	—	—	—	—	
Gyorsírás	—	—	—	—	
Írásbeli dolgozatainak kötéseljárása	1.	1.	1.	1.	IV. H. n. 371
Az igazolatlan elmulasztott tanórák száma	—	—	—	—	
Az igazolt elmulasztott tanórák száma	14.	16	3	5.	
Szorgalma	3.	3.	3.	3.	
Magyarságtudása	1.	1.	1.	1.	
Az általános sorozat	Előrendű				

civil rights, including complete religious freedom and civilian marriage. Around 1900, in the tolerant social climate of Hungary, over 50% of all the lawyers and medical doctors had Jewish roots. In the eyes of conservative nationalists, however, the Jews remained menacingly aliens. When the opportunity arose during the right-wing restoration (1920), the first anti-Jewish law, the *numerus clausus* was enacted in Hungary; according to it, the percentage of Jewish university students was restricted to the percentage of the Jewish population in the country as a whole (1920). Thus history was even more compressed in time for the Jews. The place of origin for the *wandering Jew*, the fictional *Leopold Bloom* (alias Virág Lipót) was placed in Hungary by James Joyce, describing the contemplative day of 16 June 1904 on the streets of Dublin in the novel appropriately entitled *Ulysses*.

Theodore Herzl (1860–1904), the founder of the movement for an independent Jewish state¹⁵ was born and attended school in Budapest [facsimile] where he organized a pupils' literary circle. After graduation he left Hungary to study law in Vienna (1878), and he died in Austria. (Now a grand boulevard in Tel-Aviv is named Herzl Street and a hill in Jerusalem is named Mount Herzl.) – The word “Holocaust” (burning completely to dust) was first used by ELIE WIESEL.

On this spot of the globe, within distances less than 1000 km, we find Albanians, Austrians, Bosnians, Croatians, Czechs, Gypsies, Hungarians, Jews, Slovaks, Slovenians, each possessing their own language, their own culture, most of them their own country with a population of a few million or even less. (This may remind us of the city-states of Greece in Antiquity or the city-states of Italy in the Renaissance, but here the linguistic-cultural heritages differ even more.) The tolerated coexistence and sparking conflict of cultures were present not only in foreign affairs or in the sectors of the Parliament but within the heads of young individuals. For example, it could happen in the family that the father spoke Hungarian, the mother spoke German, grandma's family originated somewhere in Poland, grandpa kept the Jewish feasts, the school teacher taught Christianity. Around 1900 for Jews especially, no career was open in politics, or in the army, they had to choose business. If a successful businessman wished to provide higher education for his son, he had to send him to study science or engineering. When later the political climate turned stormy for them, with the wind blowing from the east these young scientists sailed west-

¹⁵the uncle of the bestselling Hungarian writer of Jenő Heltai

ward. They landed on the coast of the New World at a time of great challenges and opportunities. Their rich political experiences, their open minds, and their critical thinking were their strengths. NICHOLAS KURTI told the author:¹⁶

– *I don't think we were much more talented than the other students in the West, but we knew that we could not go back. Our talents would have to be used. There was no chance for us to waste our talents.* – JOHN VON NEUMANN confirmed: – *In this part of Central Europe there was an external pressure on society, a feeling of extreme insecurity for individuals, and the necessity to produce the unusual or else face extinction.*¹⁷ – Not everyone appreciated this originality. TELEGDI recalled Enrico Fermi saying: – *All the Hungarians I met were intelligent or terribly intelligent. Mostly too intelligent. Well, there are times when it pays to be conventional.* – ARTHUR KOESTLER expressed the opinion:¹⁸

– *In contrast to Austria and other small countries, Hungary did not have linguistic contact with her neighbors; Hungarians form an isolated ethnic enclave in Europe. Hungarian writers could find a wider readership only by emigrating, by writing in a foreign tongue. But giving up the mother tongue usually means the end of the career for a poet, or turns him into an insignificant journalist. Since World War I the main export of Hungary has consisted of best-selling journalists, producers, movie stars. They were scattered worldwide by a centrifugal force, which arises when a small country has plenty of talents without the chance for their unfolding at home. But later I recognized that this opinion is only one side of the truth. This demi-monde of the cafes and "goulash-bars" of Vienna, New York, and Tokyo does not represent the most valuable part of the Hungarian contribution to culture. The really valuable elements of the Hungarian "export" were absorbed by the physics, mathematics, and biology departments of universities, furthermore by hospitals, research laboratories, state committees, and orchestras.*¹⁹ *I don't think that a comparable exodus of scientists and artists ever existed since the fall of Byzantium.*

To Koestler's words let us add one remark. It may be that the language of pictures was easier for immigrant Hungarians in America than

¹⁶Budapest 1990

¹⁷as Rhodes quoted Ulam

¹⁸Arthur Koestler: *Ubiquitous Presence*

¹⁹e.g. in 1996 a Wolf Prize was given to György Ligeti "for his musical achievements"

speaking and writing in the foreign tongue.²⁰ The French film review *Positif* recently wrote: – *Hollywood gained much from the immigrant Hungarian artists' creative capacities, dedication to imagery, their tendency of daydreaming.*²¹

CROSSING BORDERS

Tourist brochures advertise Hungary as the country of Tokaji wine, red-hot paprika, gypsy music, csardas dancing. It is less acknowledged that the coach (1400) and the match (1836), ball-point pen (1938) and Rubik's cube (1978), alternating current technology (1885) and streamlined airplanes (1928), tungsten filaments (1905) and krypton-filled light bulbs (1930), radioactive tracing (1913) and the nuclear reactor (1942), electronically programmable computers (1946) and time-sharing computer networks (1960), the BASIC language (1964) and the WORD processor (1981), among others, emerged from brains born and schooled in Hungary, and changed the way we live in the 20th century. Wigner's student, Alvin Weinberg designed the safe water-moderated nuclear reactors; Wigner's other student, John Bardeen invented the transistor, opening new roads for human progress.

José Biro (Biró László József, 1899–1985) was born in Budapest and invented the ball-point pen here (1938). He later emigrated to Argentina, where his birthday, 29 September, is celebrated now as the Day of Inventors. (The "biro" played a role during World War II: the U.K. Royal Air Force used 30000 of them because the air pressure differences made fountain-pens useless.) They arrived in British shops on the Christmas of 1945, and now 15 million disposable ball-point pens are sold every day.

The precondition for the coexistence of different cultures in such a tiny domain of space-time is *tolerance*, a merit of Hungarian society, especially in the early 20th century. Being different enhances critical spirits and creative associations. There is no better expert on this than ARTHUR KOESTLER. He compared his youth to riding a roller-coaster; in his late years he devoted most of his attention to understanding the in-

²⁰Vilma Banky was an admired actor until sound film swept her off the screen for her Hungarian accent. Tony Curtis was born in the U.S. but he had to take long phonetics lessons to get rid of his inherited Hungarian accent.

²¹*Hungarians in Film*, p. 53.

terplay between conflict and creativity.²² According to him the genius in science or the arts notices that two concepts – considered beforehand to belong to completely different dimensions – are deeply interrelated, even identical. (There are historical examples of such insights initiating scientific revolutions: Light/electricity. Heat/disorder. Mass/energy. DNA/heredity. Struggle/evolution.) If the student is instructed to memorize only traditional skills, rules, laws, and boundaries, then he may not recognize further interrelations presented by reality. But if someone is exposed to contradictions, he will not be afraid of wild associations. As Koestler has put it,²³

– *The manner in which some of the most important individual discoveries were arrived at remind one more of a sleepwalker's performance than an electronic brain's.*



– *Chemistry and physics could only become united after physics had renounced the dogma of the indivisibility and impermeability of the atom, and chemistry had renounced its doctrine of ultimate immutable elements. A new evolutionary departure is only possible after a certain amount of de-differentiation, a cracking and thawing of the frozen structures resulting from isolated, over-specialized development. Perhaps our age of specialists is again in need of creative trespassers.*

Well, Martians don't respect political and disciplinary boundaries; this might be how these refugees from the Wild East of Europe came to deserve the adjective: *Mad Hungarians*. It is impossible to classify them according to well-established disciplines; they show *an inherent interdisciplinary spirit*. It is hard to tell whether *George von Békésy, Andrew Grove, George de Hevesy, John von Neumann, George Olah, Michael Polanyi, Edward Teller, Valentine Telegdi, Eugene P. Wigner, Richard A. Zsigmondy* were chemical engineers (as their university diplomas indicate) or biologists, mathematicians, physicists, philosophers.

Geophysics was introduced by ROLAND EÖTVÖS who, after having studied the accurate proportionality of inertia and gravity, applied his gravimeter to peep below the Earth's surface, to find oil. GEORGE DE HEVESY applied radioactivity to geochronology as first. EGON OROWAN used his pioneering results on plastic dislocations not only for explaining why the Liberty ships – bringing war supplies from America to England during World War II – cracked in the heavy seas of the North At-

²²Arthur Koestler: *The Act of Creation*, 1964

²³Arthur Koestler: *The Sleepwalkers*, 1959

lantic, but also to explain the motion of glaciers, drifts of continents, and the formation of mid-oceanic rifts.

Biophysics is a favorite hunting place for Martians: ROBERT BÁRÁNY, ERWIN BAUER, ALBERT SZENT-GYÖRGYI started from medicine, GEORGE VON BÉKÉSY, LEO SZILARD and EUGENE P. WIGNER from engineering, to cross the *physics/biology* borderline. Wigner estimated the mathematical probability for the spontaneous emergence of life in the framework of quantum mechanics. Szilard experimented with evolution and speculated about the biochemistry of aging. JOHN VON NEUMANN, the mathematician, distinguished the role of software and hardware in the living cell before biologists clarified the distinct roles of DNA and enzymes; he constructed cellular automata on the computer screen to explain self-reproducing molecules, and wrote a book about the computer and the brain. Martian mathematicians, physicists, and chemists cannot resist biological temptations.

Information theory is an emerging new development on the border of traditional disciplines. It originated with LEO SZILARD's paper on the conflict between information-creating intelligence and disorder-creating thermodynamics. JOHN VON NEUMANN recognized first the revolutionary importance of electronically programmable computers; after artillery trajectories he applied them to meteorology, economics, and strategy. DENNIS GABOR received the Nobel Prize for extracting the complete information carried by a light ray with the technique of holography. JOHN G. KEMENY recognized that computers were for every (educated) person, therefore he invented the Beginner's All-purpose Symbolic Instruction Code (BASIC). There are Hungarians among the architects of INTEL and MICROSOFT. The Central Research Institute of Physics in Budapest (*Károly Szegő*) prepared the on-board computers for the Russian long-distance space missions, which reached Mars and Comet Halley. The RECOGNITA – software made in Hungary – is able to read hand-written texts, the MODULAR PROLOG can guide robots, the ARCHICAD can design buildings. – But let me add a further very outstanding interdisciplinary Hungarian achievement not yet known outside of Hungary:

– *Ivan Gorchev, a Hungarian sailor from the freighter Rangoon, was not yet 21 when he won the Nobel Prize. To win such a high scientific prize is an outstanding achievement at such a young age, even if someone may find a fly in the ointment: Ivan Gorchev won the Prize by gambling in the card game called "macao." A few days before the King of Sweden handed this prestigious prize originally to Professor Noah Bertinus in Stockholm. Then Bertinus boarded the ship in Göteborg. Later Ivan Gorchev boarded the same ship in Southampton. Before arriving in Bordeaux, Gorchev won away the total amount of the prize*

money in card game. If the professor had traveled as far as Nice, Gorchev might even have won the gold medal as well, which the professor had received acknowledging his successful research in the destruction of atoms. But such minor details are less important; the essential fact is that Ivan Gorchev was indeed 21 when he won the Prize.²⁴

TELLING THE FUTURE

– We live in an age in which the pace of technological change is pulsating ever faster, causing waves that spread outward everywhere. This increased rate of change will have an impact on you, no matter what you do for a living – it will bring new competition from new ways of doing things, from corners that you don't expect. It doesn't matter where you live. Long distances used to be a moat that both insulated and isolated people from workers on the other side of the globe. But every day, technology narrows that moat inch by inch. Every person in the world is on the verge of becoming both coworker and competitor to every one of us. We can't stop changes. We can't hide from them. Instead, we must focus on getting ready for them. – This was written by ANDREW GROVE in his book *Only the Paranoid Survive*, published just a few months ago.

In a stable world sensing the *state* of the environment, the so-called “social adjustment” has survival value. In a variable climate, however, noticing the *trends* of change (the time derivative), sensing *coming storms* helps one survive. This explains another Martian characteristic: *the capability to predict the future.*

– Leo Szilard proved to be the best prognosticator: he was able to foresee events better than anybody else I know – Ben Liebowitz said. When World War I erupted, LEO SZILARD, then 16, told his classmates: – *I am not afraid to be called to the army; Austria, Germany, and Russia will collapse.* – This prediction sounded strange because Russia was on the side opposite to that of Austria–Hungary and Germany, but Szilard turned out to be right! After World War I, in the 1920s he tried to organize a *Bund* in Berlin, which “*might stand ready to exercise the functions of government if and when the parliamentary system in Germany collapses, one or two generations hence.*”²⁵ Hitler took power in 1933.

²⁴P. Howard, alias Rejtő Jenő wrote this in the novel *The Auto of 14 Carats*. (Rejtő, a best selling Hungarian writer, died in the Holocaust in 1944)

²⁵Leo Szilard: *His Version of the Facts*, 1978

Szilard left Berlin one day *before* Hitler ordered that Jews must not leave Germany. He did not stay in Austria either because in 1936 he anticipated, – *Nazi Germany will invade Austria in two years.* – So it happened in 1938. In London he told Michael Polanyi: – *I shall go to America one year before war breaks out in Europe.* – He sailed in 1938, World War II started in 1939. After the war (1945), there was a disagreement concerning the Russian capability to construct an atomic bomb. Vannevar Bush, director at the U.S. Office of Scientific Research and Development guessed a decade; Szilard predicted five years. The first Soviet atomic bomb actually exploded in September 1949. Szilard wrote in his letter to Stalin (1947): – *It will only be a question of time, a few short years perhaps, until peace will be at the mercy of some Yugoslav general in the Balkans or some American admiral in the Mediterranean who may willfully or through bungling create an incident that will inevitably result in a new war.*²⁶ – In Yugoslavia we witness today the Catholic [Croatian]–Eastern Orthodox [Serbian]–Islam [Bosnian] conflict, and the superpower play behind it, having turned again to war.

– *My father taught me that one gains very little knowledge of how to behave as a nation from looking at year-to-year changes. To find the true worth of historical experience, one must examine generations* – KÁRMÁN recalled. It is Central Europe where history happens. World War I erupted in Sarajevo (Bosnia). World War II started in Danzig (Gdansk, Poland). The focus of the present greatest European conflict was again Sarajevo. These condensed historical experiences enable the scientists living here to notice the trends more acutely than those living in quieter regions. DENNIS GABOR had already written in 1938:²⁷

– *President Wilson's 1919 doctrine about national self-determination was so self-evidently right that people did not see what nonsense it was.* – The problem is that people in Bosnia, Chechnya, Kurdistan, and elsewhere still believe in it.

JOHN VON NEUMANN wrote in June 1938: – *I think that there will be war, although it may be at a distance of a half year or perhaps even one or two years.* – (The exact time of grace left was 15 months.) About the Western surrender in the case of Czechoslovakia in Munich (30 September 1938) he said: – *I can only say that Mr. Chamberlain obviously wanted to do me a great personal favor. I needed a postponement of the*

²⁶Sending this letter was not permitted. Printed in the *Bulletin of Atomic Scientists*.

²⁷Dennis Gabor: *What a Price of Peace*, 1938

next world war very badly – because Neumann traveled to Budapest to marry in November. In 1940 the German army *cut through France* as Neumann predicted, but he also expressed the unbelievable views that *Britain would deter a German invasion, and whichever president was going to be elected in 1940, would probably bring America into the war in 1941.* (So it happened.) He thought that free mankind's two enemies (Hitler and Stalin, that time allies) might by then *be doing the nice thing of fighting each other.* – Stanislaw Ulam, a fellow mathematician at the Manhattan Project, said: – *I can testify that in his forecasts of political events leading to World War II and of military events during the war, most of von Neumann's guesses were amazingly correct.*²⁸

EGON OROWAN – a physicist turned mechanical engineer – picked up writings of Ibn-Khaldun, the 14th century Tunisian Arab historian, about the rise, maturation, and senescence of Arabic tribes from dynamic beginnings to rich and decadent ends, when they are replaced by a new wave of dynamic invaders. Orowan has found many parallels to these in modern Western societies where economics becomes to be of central importance. Beginning at Adam Smith and Malthus, Orowan concluded that the present problems of industrialized Western societies result from ever increasing productivity which replaces the old crafts of many skilled craftsmen with automated industries. The outcome is chronic unemployment followed by government's "charity" in the form of armament industry, in government contracts for work and research centers not necessarily needed by society. Orowan liked to call his approach to *socionomy*, coined from *sociology* + *economy*.

– *Till now man has been up against Nature, from now on he will be up against his own nature* – said a most unprobable predictor, an electronic engineer and inventor, DENNIS GABOR.²⁹ – *Our civilization faces three great dangers. The first is destruction by nuclear war, the second is overpopulation, and the third is the Age of Leisure. For the first time in history we are now faced with the possibility of a world in which only a minority needs work to keep the great majority in idle luxury. Soon the minority which has to work for the rest may be so small that it could be entirely recruited from the most gifted part of the population. Almost every important invention unbalances the front of progress, and a new invention is needed to redress the balance. Disinfectants have strongly reduced child mortality, and we need the "pill" to keep the*

²⁸Neumann Memorial Volume

²⁹Dennis Gabor: *Inventing the Future*, 1964

population in bounds. The steam engine, the internal combustion engine are threatening our stock of fossil fuel with exhaustion; we must have nuclear power and later on thermonuclear power. We cannot stop inventing, because we are riding a tiger.



– It's like sailing a boat when the wind shifts on you but for some reason, maybe because you are down below, you don't even sense that the wind has changed until the boat suddenly keels over. What worked before doesn't work anymore; you need to steer the boat in a different direction quickly before you are in trouble, yet you have to get a feel of the new direction and the strength of the wind before you can hope to right the boat and set a new course. And the tough part is that it is exactly at times like this that hard and definite actions are required. So the ability to recognize that the winds have shifted and to take appropriate action before you wreck your boat is crucial to the future of an enterprise. – This is what ANDREW GROVE, a skilled navigator says about his experiences, failures, and successes.³⁰

Perhaps the storms experienced by Martian sailors beforehand in Europe enabled Szilard to sense the approach of the Atomic Era and Neumann to feel the coming of the Computer Era. What do common terrestrials do when the storm arrives?

– When the environment changes in such a way as to render the old skills and strengths less relevant, we instinctively cling to our past. We refuse to acknowledge changes around us, almost like a child who doesn't like what he's seeing so he closes his eyes and counts to 100 and figures that what bothered him will go away. The phrase you're likely to hear from grownups at such times is "Just give us a bit more time."



Correct forecasting of the future may make money. – Countervailing forces usually prevail, but occasionally they fail. That is when we have a change of regime or revolution. I am particularly interested in this occasion. I can do better in the financial markets than dealing with history in general, because financial markets provide a more clearly defined space and the data are quantified and publicly available – GEORGE SOROS said.³¹ – My basic idea is that our understanding of the world in which we live is inherently imperfect. There is always a discrepancy between the participant's views and expectations and the

³⁰Andrew S. Grove: *Only the Paranoid Survive*, 1996

³¹Soros on Soros, 1995

actual state of affairs. Sometimes the discrepancy is so small that it can be disregarded but, at other times, the gap is so large that it becomes an important factor in determining the course of events. History is made by the participants' errors, biases, and misconceptions. – Citizens of quiet regions may afford to believe in a fixed set of values, but Hungarians cannot afford it. This is how Soros explains his successful intuitions:

– Rationality has its uses, but it also has its limitations. If we insist on staying within the limits of reason, we cannot cope with the world in which we live. By contrast, a belief in our fallibility can take us much farther. It can guide us through life.

Andrew Grove gives his diagnosis on the state of the world:

– When most companies of a previously regulated economy are suddenly thrust into a competitive environment, the changes multiply. Management now has to excel in the midst of a global cacophony of competing products, and every person on the labor force suddenly must compete for his or her job with employees of similar companies on the other side of the globe. When such fundamental changes hit a whole economy simultaneously, their impact is cataclysmic. They affect an entire country's political system, its social norms and its way of life. This is what we see in the former Soviet Union and, in a more controlled fashion, in China.³²

George Soros warns that the West is now missing a special opportunity to lead the former communist world from the closed societies of the past into the open community of nations: *– We do not have much time to come to our senses. The collapse of the Soviet Empire meant the end of a stable world order that prevailed during the Cold War, only we did not realize it. We carry on with business as usual while all our institutions of collective security are disappearing. The collapse of communism was a revolutionary event, and a revolution creates opportunities! – Later he added: – We have missed the opportunity, and now it will be forty years in the wilderness.³³*

– We were – and still are – trying to shape the future at a time when this idea doesn't have broad currency. We were – and are – to be early movers – as ANDREW GROVE wrote.³⁴

³²Andrew S. Grove: *Only the Paranoid Survive*, 1996

³³*Time*, 10 July 1995

³⁴Andrew S. Grove: *Only the Paranoid Survive*, 1996

SAVING THE WORLD

A trait related to this peculiar property of the Martians was that they even tried *to save the world*. Some of them were considered to be hawks, others were doves, but each of them felt convinced that he was right.³⁵ It may be due to their rich historical heritage that they all liked to offer advice, even to Presidents. LEO SZILARD urged President Roosevelt to develop nuclear power. President Kennedy answered his letters about the importance of superpower dialogue, resulting in the Washington–Moscow hot line of communication. Szilard also contacted Khrushchev, Nehru, and the Pope. THEODORE VON KÁRMÁN advised President Kennedy on supersonic flight and ballistic missiles; he met Stalin and Gandhi as well. EUGENE P. WIGNER pressed President Johnson on civil defense. JOHN VON NEUMANN advised President Eisenhower on nuclear and rocket armaments. His daughter, MARINA VON NEUMANN advised President Nixon on economic affairs. ALBERT SZENT-GYÖRGYI travelled to Moscow to inform Stalin about the misbehavior of the Red Army in Hungary; invited President Kennedy to his home; criticized President Johnson bitterly for his war in Vietnam; even wrote a Presidential Speech – never told. JOHN G. KEMENY advised President Carter on the safety of nuclear plants. EDWARD TELLER advised President Reagan on Star Wars; he is in contact with Israeli prime ministers and the Hungarian prime minister, Gyula Horn as well, concerning national modernization programs. ELIE WIESEL has received the Medal of the Congress and President Reagan made him the chairman of “The Presidential Commission of the Holocaust.” GEORGE SOROS asked President Clinton to devote more attention to Central-Eastern Europe. As journalists claim, Soros used to have breakfast with one head of state, and dinner with another one on the very same day. – *I am not ashamed of my messianic fantasies; the world would be a grim place without such fantasies.*³⁶

In the middle of the night ARTHUR KOESTLER called and woke up Gaitskell, the leader of the British Labour Party, before Gaitskell’s visit to Moscow, asking for his intervention at Krushchev in order to save the life of the Hungarian writer *Tibor Déry* after 1956 – and he succeeded. In conclusion, let us quote DENNIS GABOR, one of the most ardent prophets, who took a long view ahead in his evangelium entitled *Inventing the Future*.

³⁵This aspect has been emphasized by Gábor Palló.

³⁶*Soros on Soros*, 1995

– *Technological development is much too fast to be matched by biological adaptation of man. Moses showed the Promised Land to his people, but then he led them around for forty years in the wilderness until a new generation worthy of it had grown up. Now forty years is not an unreasonable estimate for educating a new generation which can live in leisure, but we must find a better equivalent of the wilderness. At the present stage of technology the time ought to be shorter – merely the time to train teachers and for the teachers to train the first generation of modern workers. It is not so much the education of the people which is slow but the education of the leaders.*

Some Americans of Martian descent work in more democratic ways: *Ralph Gomory* supports research as president of the Sloan Foundation, *Peter Goldmark* does so as president of the Rockefeller Foundation. *George Soros* created the Central-European University in Budapest. *Charles Simonyi* created the *Charles Simonyi Chair for Public Understanding of Science* at Oxford University.

The prophecies of Hungarians were not always appreciated by their fellow scientists. Still, eventually, some of their forecasts and advice were acknowledged in America – because they worked. This has made the liberation of nuclear power also a Hungarian success story. The first six recipients of the *Atoms for Peace Award* were Niels Bohr (1957) for the theory of the atom and its nucleus, GEORGE DE HEVESY (1958) for radioactive tracing and its application in medicine, LEO SZILARD and EUGENE WIGNER (1959), as well as Alvin Martin Weinberg and Walter Henry Zinn (1960), “to honor the four men, who, of all men living, have done most to originate and perfect the nuclear fission chain reactor. It alone, of all devices thus far conceived, provides practical means for utilizing the energy of the atomic nucleus and producing radio-isotopes in abundance. These gifts of the atom, if used wisely, will be of inestimable benefit to mankind.” – (A Dane, a Canadian, an American and three Martians make up this list.)



The author thanks the discussions and interviews for the Martians whom he met – failing to meet only Hevesy, Neumann, and Szilard in space-time, consulting only with their friends and relatives. And I have not seen Grove yet. Just to check the suggested clues, let us have a closer look at the profiles of Hungarian scientists who landed in the United States in the 20th century. Let’s listen to the voice of the Martians.³⁷

³⁷The biographical data of Hungarians printed in SMALL CAPS characters can be found at the end of the book, on pages 395–405.

Martian Profiles

Kármán Tódor – Theodore von Kármán 1881–1963

*There is nothing more practical than
a good theory.* (T.v.K.)

– *How close it now seems to me the lovely royal city of Budapest, where I was born, in the time of Emperor Franz Josef. I can still see the stately old government buildings along the Danube, the neat parks and their many statues of military heroes. I have no trouble at all in recalling the horse-drawn droschkies (still my favorite form of transportation) carrying silk-gowned women and their counts in red Huszar uniforms. If one had the gift to foresee, one could already detect unmistakable signs that the aristocracy was beginning to fade and give way to a new ruling class and culture. Hungary, like much of Central Europe, was emerging from the Middle Ages and dipping a jeweled slipper into the 20th century. Yet for all these growing pains the era of Emperor Franz Joseph was on the whole an enlightened and gay era, a wonderful time in which to be born. My parents had the wit to recognize this, and to welcome me into the world on 11 May 1881 – Theodore von Karman remembers at the age of 82.*¹

His mother was a descendant of Rabbi Loew Ben Bezalel (1525–1609), the famous mathematician in Prague. According to a myth, Rabbi Loew created the *Golem*, the legendary robot (a body without a soul) in Prague. This has become a symbol for the Era of Information: the first big computer of the Weizmann Institute in Israel was named the Golem. (According to family traditions, the family of ARTHUR KOESTLER's mother originated from the same Rabbi Loew, as that of CORNELIUS LANCZOS/Löwy did.)

Tódor's father, *Maurice Kármán* (Kármán Mór), professor at Budapest University, was authorized by József Eötvös, Minister of Education (father of Roland Eötvös), to organize Hungarian secondary school education in the spirit of enlightenment (1869).

– *My father loved his family but he was really more comfortable in class than at home, or anywhere else. He enjoyed young students, par-*

¹Theodore von Kármán: *The Wind and Beyond*, 1967

*ticularly when he could be close to them and guide their work. I remember once he told me that his great reason for devoting himself to secondary education was that he preferred high school to the university because of the direct contact he was able to establish with his students.*² – Beforehand excellent schools were run by the Catholic, Calvinist, and Lutheran Churches in Hungary, and each church taught the subjects in a way it wanted to teach. Maurice Kármán inspected and studied the German *gymnasium*, the French *lycée*. As State Secretary of Education, he organized the secular gymnasium with a modern curriculum. The pearl of his work was the Minta (Model) Gymnasium, associated with the Budapest University, where contact with social and technological realities were stressed instead of tradition and ideology. This was the school which educated his son and several other young Martians. The impact of the father on Theodore Kármán was decisive: the son considered his father to be a lifelong example. He remembered the warning of his father:³

– *Not only new problem deserves deeper consideration, but the renewed rethinking of the connections among earlier truths may shed new light on science as a whole. There is no greater enemy of teaching than the boring following of a once accepted pattern.*⁴

Maurice Kármán impressed even the Emperor-King: he was requested to take care of the education of the young Arch-Duke Albrecht von Habsburg. It could have been a compensation that Maurice Kármán was made a nobleman (1907). This is how his son inherited the name Theodore *von* Kármán. The young Tódor (or Tivadar, to become Theodore in America) was a peculiar child even in primary school. At family conventions he produced his ability to multiply six-digit numbers in his head, and he did it faster than the grownups checking him with pencil and paper. (As Theodore later recalled, he was able to speak English, French, German, Italian, and Yiddish and was able to add in these languages, but he could multiply only in Hungarian.) His father was shocked because he did not want to have a *superboy*; therefore he pressed Tódor to turn away from calculations towards social studies. The father told his son that the scientific, artistic, and religious aspects of a sunrise should be considered on equal levels.

²Theodore von Kármán: *The Wind and Beyond*, 1967

³in a letter written from Budapest on 27 January 1914

⁴In his testament, at the age of 82 in California, he donated 30 000 dollars to the Foundation for American–Hungarian Studies to translate his father's work.

The Minta Gymnasium liberated the deep talent of the young man: Tódor won the Eötvös Competition in mathematics (1897). As a compromise between science and society, he was enrolled at the Budapest Institute of Technology to study machine engineering. To his dissatisfaction, most of the technical subjects *“were taught like baking or carpentry, with little regard for the understanding of nature’s laws.”* After graduation, his professor gave him the topics of valve clatter. Kármán recognized that this noisy phenomenon is a sort of resonance of the valve caused by the periodic motion of the piston, and he solved the very practical machine problem by using mathematics. This approach was characteristic throughout his whole life.

The industrial revolution was exploding in these years. Kármán worked as a consultant at the Ganz Machine Works and as an assistant professor at the Budapest Institute of Technology. He became interested in another practical problem: the buckling of columns under weight, or mathematically reformulated: the instability of elastic equilibrium. Kármán published about half a dozen scientific papers in Hungarian engineering and physics journals. He loved his work and enjoyed the booming city. When his ambitious father suggested that he continue his studies abroad, Tódor resisted. Finally, under parental pressure he applied to the Hungarian Academy of Sciences for a two-year scholarship in Germany, which he obtained.



In the autumn of 1906 Kármán arrived at Göttingen, which was then perhaps the most respected university of the world. Professor Ludwig Prandtl turned the attention of the young man toward hydrodynamics. The serious Prandtl and the bon-vivant Kármán were completely different characters. The noisy beerhall hardly substituted for the light brilliance of Budapest. After two years he joined his Hungarian friend Julius Vészi for a visit to Paris. Here Vészi’s attractive sister Margit, who had just divorced her husband, the famous Hungarian playwright Ferenc Molnár,⁵ lived.

– One evening, as I remember it, I was sipping coffee in a café on the Boulevard St. Michel, when Margit bounced in. Seeing me, she rushed up to say that at 5 a.m. the following morning she was going to witness a historical event, the first two-kilometer airplane flight in Europe. Would I drive her to the airfield? Next morning I found myself watching with great interest a biplane, a fragile box kite made of sticks, paper,

⁵author of the Broadway hit *Carousel*

and wire. The bearded pilot, Henry Farman flew to a one-thousand-meter marker, turned, and flew back. I was quite impressed.⁶

This sight made Theodore more interested in Prandtl's mathematical theory of flowing fluids. From the new interest in air resistance on moving bodies, his main scientific result emerged: *the Kármán vortex trail*. The energy consumption of trailing vortices which can build up behind airplanes was an essential phenomenon in aeronautics. The elimination of these vortices led to the *streamlining* of airplanes, cars and ships (1911). Later, streamlining became the aesthetic symbol of the 20th century.

In the meantime a great revolution was underway in physics: solids, fluids, and air were not considered as continuums any more, but as assemblies of atoms. Albert Einstein explained (1907) why the specific heat of solids disappeared at very low temperatures: he considered the internal energy of a solid as vibration of its atoms in the crystal lattice. In the case of radiation Max Planck had discovered that the minimum energy of an oscillator is $h\nu$. (h is Planck's constant, ν is the frequency of vibration. If this is valid for the vibration of solid bodies as well, the atom cannot receive vibration energy from the thermal motion of the environment, if $kT \ll h\nu$ (where kT is the average molecular kinetic energy, T being the absolute temperature), thus the crystal does not possess specific heat at low temperature. Einstein's explanation worked qualitatively but failed quantitatively. Seeing this, Theodore von Kármán and Max Born (his roommate in Göttingen) noticed that the vibration frequency ν of atoms was not a fixed constant but depended on the vibration of their neighbors. Instead of considering the crystal as a set of independent oscillators (as Einstein did), but as a collectively vibrating lattice of atoms, by ingenious use of mathematics, Born and Kármán arrived at the correct result (1912).⁷ This was one of the first papers of modern solid state physics, published before Bohr's model (1913). At that time, few people believed in the lattice structure of crystals, therefore it was a great satisfaction for Born and Kármán when Max von Laue and Sir William Bragg verified it with X-ray diffraction (1913).

In some way, Theodore von Kármán was treated a bit as an alien in Göttingen. When at a party the wife of a professor talked of white slav-

⁶Theodore von Kármán: *The Wind and Beyond*, 1967

⁷With a slightly different approach, Peter Debye arrived at a similar result in Zürich in the same year, just a tiny bit earlier. Later on it turned out that – contrary to Debye's treatment – the Born–Kármán theory can be applied to anisotropic crystals as well.

ery in South America, Kármán raised the question: – *Wer kauft Göttingen Mädchen?* (But where is there a market for Göttingen girls?)⁸ – This might contribute to the fact that Kármán did not obtain any permanent job there. This is why he accepted a professorship in applied mechanics in Hungary (1912), at an old mine-engineering college in Selmezbánya, founded in the 18th century. But this town in Northern Hungary was neither the center of the world, nor the center of science and technology. When Kármán obtained an invitation to become a professor in Aachen, he accepted it (1913). Aachen was a cosmopolitan place, the ancient capital of Charlemagne, “*a city noted for its healthy waters and for its beautiful women.*” Here the 31-year old professor began to organize an institute for aviation, and building a wind tunnel.



When Archduke Franz Ferdinand was murdered in the annexed Sarajevo (Bosnia), World War I broke out (1914); lieutenant Kármán – as a citizen of Hungary – was called to the army. After some flirting with ballistics, he was put in charge of supplies in Budapest. When the airplanes turned out to be important from the military point of view, Kármán was called to help in creating an Austrian–Hungarian Air Force, independent of Germany. One of his innovations was how to fire machine guns through revolving propellers. Thus after reconnaissance and bombing planes, a new actor appeared in the skies: the fighter plane.

The war resulted in the defeat of the German and Austrian–Hungarian imperial armies, and in a republican revolution in Budapest (1918). In these days a representative of the Ministry for Education visited Theodore von Kármán. As a former co-worker of Maurice Kármán, the messenger recalled the father’s pedagogical merits, and asked Theodore to rebuild the Hungarian university education system along progressive lines. This is how Theodore von Kármán became under-secretary of university education in the Hungarian Republic:

– *My father believed fervently that in a good university research should be given equal standing with teaching, opposed by the old fellows who didn’t do research, and thought they would end up as second-class citizens of the academic community. With the new progressive regime in power, I knew I would be in a strong position to make my father’s hope a reality. As under-secretary for universities, I was in charge of the program of natural sciences and medicine, which I enjoyed because I could introduce modern biology and psychoanalysis, as*

⁸Teller to the author 1994

well as atomic physics, into the curriculum. Such subjects were hardly considered in Hungarian colleges prior to World War I.⁹

The Western powers were eager to prevent the emergence of any great power in Eastern Europe. Count Károlyi, the president of the Republic resigned, the communists took power to organize the resistance against the partition of Hungary. Theodore von Kármán was asked to keep his responsibility for university education. When ROLAND EÖTVÖS died, the Faculty of Philosophy at Budapest University unanimously decided, "to invite Theodore von Kármán, professor of the University in Aachen, as the most excellent scientist among Eötvös' students and other physicists, for taking over Eötvös' cathedra, and to send this proposal to the People's Commissariat of Education, asking for an urgent decision" (13 May 1919). After 100 days, however, when the invasion of foreign armies caused the collapse of the communist regime, a rightist military rule was established. Theodore von Kármán – understandably – returned to the University of Aachen (1919).



– It was the classroom that gave me my most rewarding experiences and my deepest satisfaction. I loved to teach. I think this is a direct inheritance from my father.

– When teaching in Aachen, in the class I often scanned the sea of brown, blue and green eyes, seeking the occasional spark of understanding that flashed here and there. I made it a point to remember the student who had caught my eye, talk with him, and then eventually invite him to my house.¹⁰ – (In the last year of his long life he obtained the title of *International Teacher of the Year 1963*.)

The 1920s were a promising period in Germany. From his students in Aachen, Kármán began to build up his circle for aviation research. His interest focused on turbulence, one of the main reasons of air drag. – Arnold Sommerfeld, one of the pioneers of quantum theory in the 1920s, once told me that before he died he would like to understand two phenomena: quantum mechanics and turbulence. When Sommerfeld died in 1951, I believe he was somewhat nearer to an understanding of the quantum, the discovery that led to modern physics, but not closer to the meaning of turbulence.¹¹ – Kármán initiated a series of international

⁹Theodore von Kármán: *The Wind and Beyond*, 1967

¹⁰Theodore von Kármán: *The Wind and Beyond*, 1967

¹¹Theodore von Kármán: *The Wind and Beyond*, 1967

conferences on applied mechanics, and with his paper on "*Mechanical Similarity of Turbulence*" he had overcome his teacher and rival, Professor Prandtl. His style connecting practical problems to mathematical models brought him fame and friendship of the leaders of the emerging German industry: Fokker, Junkers, Opel, Zeppelin.

In the meantime young industrial giants were rising elsewhere. Kármán received invitations to visit America and Japan (1926). From the United States the invitation came from Robert Millikan (Nobel laureate), who was eager to strengthen the California Institute of Technology with an Aeronautical Laboratory, relying on the financial support of Daniel Guggenheim. From Japan the invitation came from the emerging aviation industry, supported by the Japanese Navy. Both sides were asking for Kármán's advice in building wind tunnels. Kármán toured both countries, trying to overcome the difficulties coming from his English with "a thick Hungarian accent." (Upon arrival in San Francisco, a journalist asked him why he had come to California. Kármán answered: – "*To see laboratories.*" – The journalist understood: "to see lavatories". – On another occasion Kármán said *chaos*, but the students heard *cows*, therefore did not understand completely the message of the lecture. – There were other misunderstandings as well, e.g. a few years later a Hungarian newspaper reported: "*Dr. Theodòre von Kármán, the great mathematician from Budapest, is now in California working for the Japanese Navy.*" Kármán remarked: fortunately nobody from the American embassy took notice of this news.¹²

Soon after his return to Germany (1927), signs of Nazism started to show at the university as well. When the leaders of the California Institute of Technology decided to invite Theodore von Kármán to be the director of the Guggenheim Aviation Laboratory in Pasadena, that Kármán accepted. He left for Pasadena in December 1929. Kármán revisited Aachen in 1931 and 1932, but he stopped doing so after the Nazi takeover. (Görling, the Nazi minister of aviation tried to get Kármán as a consultant by remarking: – *Who is or is not a Jew is up to me to decide.* – This provoked a good laugh at Kármán.)

The Spanish style villa at 1501 South Marengo Avenue in Pasadena became his home for four decades; he regularly gave Hungarian style parties with students, pretty ladies, Hollywood actresses, Pentagon generals, laughter, science, charm, Hungarian cooking, food with the scent of garlic and paprika, Jack Daniel's whisky abounding. At Christmas time the Gug-

¹²Theodore von Kármán: *The Wind and Beyond*, 1967

genheim Laboratory was regularly visited by Santa Claus, arriving from the sky in a red gown – speaking with a thick Hungarian accent.

In the 1930s America was a land of opportunities, open even for unconventional Martian ideas like supersonic flight, jet assisted take-off, jet propulsion, and racketeering. Kármán developed solid fuel rockets. In World War II the importance of aviation increased. In 1944, out of the *Guggenheim Aeronautical Laboratory* Kármán created the *Jet Propulsion Laboratory* in Pasadena, which pioneered later on many of the American space ventures. Kármán, the director, was called the *Boss*. With his direct access to the Pentagon, Kármán dared to contradict even generals because “*the eccentric Hungarian genius*” was highly respected.

When World War II was over, Kármán was charged to find out what other nations knew about airplanes and rockets. The Pentagon organized military missions called “Operation Lusty.” The missions collected available scientific information in England, France, Germany and the Soviet Union (later in Japan). In Moscow Kármán attended the victory parade in Red Square and the banquet given by Stalin in the Kremlin.

– *At departure, at Moscow Airport I had a sudden urge to fly to Budapest, but how to do it without a visa? Suddenly there appeared a man I knew from Hungary. He was ALBERT SZENT-GYÖRGYI, who had won the Nobel Prize for his work with vitamins. He discovered vitamin C in paprika, and since paprika is the Hungarian national spice, Szent-Györgyi has often been looked upon as a national hero in Hungary. He was in Moscow representing Hungary at the 220th anniversary of the Russian Academy. As he hurried through the air terminal, I stopped him: – “Where are you going to?” – “Back to Budapest.” – “On a commercial plane?” – “No, on a military plane.” – “O.K. I will go with you.” – Without a visa it was a dangerous decision, but Szent-Györgyi said he would be delighted to have me join him. In Budapest we landed at the old airfield where I had made helicopter tests in World War I. The field was in Russian hands. Szent-Györgyi persuaded a Russian captain who drove a mail truck to take him to the city. Szent-Györgyi asked whether he could include me. – “Are you Hungarian?” – “Yes, of course.” – “Do you live in Budapest?” – “For years.” – “All right, where do you want to go to?” – As we drove through the city, I saw that the once beautiful bridges across the Danube were a mass of twisted metal. The buildings were in various states of damage. But soon I warmly embraced my brother. A few days later I found the American Military Mission. I learned that General Arnold and his staff in Washington were worried about me: they had heard that I had disappeared and their first thought was that I might have been kidnapped or shot. A few days later a colonel and a*

reporter of Time magazine drove me to Budapest airport. As we approached the American airplane, a Russian counted the passengers: – “How come you arrived with six people and are leaving with seven?” – Miss Foster, the Time reporter looked at the Russian: “Why, you must mean our doctor.” – “Oh, your doctor, of course,” – the Russian nodded sympathetically, and waved the party on.¹³

Soon the Cold War followed. Theodore von Kármán visited Hungary once more, in a more legal way, as the high guest of the Hungarian Academy of Sciences (1962). He received the Award of the Hungarian Astronautical Society. But before the visit, he sent a message asking for a specific interpreter, giving her name. Kármán surely did not need any interpretation, but he had romantic memories concerning the lady from a distance of fifty years.



After World War II, General Dwight Eisenhower publicly stated: – *The armed forces could not have won the war alone. Scientists contributed technique and weapons which enabled us to outwit and overwhelm the enemy.* – As EDWARD TELLER said in Budapest: – *According to historians, the technological superiority of the U.S. Air Force shortened World War II considerably, saving millions of lives – Hungarian lives as well – thanks to Theodore von Kármán.*¹⁴ – Dan Kimball, Aerojet Board chairman said: – *Since Pearl Harbor our security has been based on the works of Albert Einstein and Theodore von Kármán.*¹⁵ – *For the U.S. Air Force Kármán was a god, what he said was done.*¹⁶ – Kármán received the highest American peacetime civilian award, the Freedom Award in 1956.

The conclusions of Operation Lusty were published in a series of classified volumes, the first volume was written by Kármán: “*Science, the Key to Air Supremacy.*” He emphasized the dramatic change in warfare: the scientific–technological superiority (e.g. dominance of the air) had become more important than the heroism and endurance of soldiers (as it was the case beforehand in World War I and at the Russian front of World War II). In his recommendations, priorities were given to supersonic flight, target-seeking missiles, ground-to-air communication network, weather-independent navigation, and jet propulsion. An *Advisory*

¹³Theodore von Kármán: *The Wind and Beyond*, 1967

¹⁴to the author 1992

¹⁵Gorn

¹⁶Lax to the author 1994

Board of the Air Force had been created, headed by Kármán. In 1953, following the Russian hydrogen bomb test, the Board set up the Nuclear Weapons Panel to examine the question of missiles tipped with nuclear warheads. JOHN VON NEUMANN was made the chairman of the Panel, which included Edward Teller as well.

– *The Air Force liked to think that we, the scientists, could read the future, and they had come to like the idea of grandiose speculation* – he noted when he was asked to organize a brain-storming session under the umbrella of the National Academy of Sciences in Woods Hole, Cape Cod on the topics “*Toward New Horizons.*” It was sponsored by the Air Force by about 1 million dollars in 1956–1957. The brain storming was made suddenly more exciting when the Soviet Union launched Sputnik (1957). PETER LAX, the Hungarian–American applied mathematician (later Wolf Prize laureate) worked also in the commission on ballistic missiles (1958):

– *There was a German from Peenemünde in the Commission, who enthusiastically claimed that his rockets would hit a waste-basket in Moscow from a distance of 2000 miles. Kármán made an impressed face and said that this claim reminded him of the story of the rabbi of Lemberg who was alleged to have miraculous power. A skeptic asked the believers of the rabbi for a proof. – “For example not long ago our rabbi had a vision that Cracow was burning in flames. Having heard this, a group of Jews in Lemberg started to carry help, food, and clothing to the Jews in Cracow. When they arrived, they found Cracow completely intact.” – But if so, what is the miracle? – “It’s true that the rabbi erred in some details, but was it not a miracle itself that he could see from Lemberg to Cracow?” – Well, Kármán erred as well. He was at home in aerodynamics, relied on airplanes, greatly helped the American airplane industry. But he erred on this occasion: ballistic missiles turned out to be very important.*¹⁷ – Missiles were taking over from airplanes as mean tools of aggression and deterrence. This is already the beginning of another story.



Kármán’s father wrote a paper about the cycles of history (1908), leading from family and tribal interests to the formation of nations; he predicted the emergence of international organizations for about 1950. His son, Theodore saw the international community of scientists as a prelude for international cooperation, and – perhaps two generations later – a world government. The cosmopolitan scientist moved around the world, be-

¹⁷Lax to the author 1994

came a fellow of the Royal Society and the Pontifical Academy, honorary doctor of several universities (his Alma Mater in Budapest included). He created the *International Academy of Astronautics* (Paris). When NATO was developed, at his proposal an Advisory Group for Aeronautical Research and Development was created in Paris, under Kármán's chairmanship (1952). Since that, Theodore von Kármán spent most of his time in Paris, accompanied by Lady Barbel Talbot.

Seven hundred people assembled for the birthday banquet in the Washington Sheraton Park Hotel, when Theodore von Kármán became eighty. EDWARD TELLER was the toastmaster. The press declared Theodore von Kármán to be an American hero.

Beyond eighty he once more enjoyed the restaurants in Paris, then went to Aachen to make use of its spa. While floating in the hot water, his heart stopped (3 May 1963). The U.S. Air Force transferred his body to Los Angeles; upon arrival an honor guard saluted. Kármán was buried in the Hollywood Memorial Cemetery on Santa Monica Boulevard, in a low building of crypts behind the Jewish section. His memory is preserved in the Space Hall of Fame in Alamogordo.

This was already the Space Age. With the impact of the Soviet Sputnik, President Kennedy announced the program of the *New Frontier*: to put men on the Moon. The President created a *National Medal of Science*, asking Frederick Seitz, the president of the National Academy of Sciences, to chair a nominating commission. The first choice of the Commission was Theodore von Kármán. A few weeks before the Conclusion, on 18 February 1963, Kármán stood in the Rose Garden of the White House, listening to President Kennedy's words:

– I know no one else who more completely represents all of the areas with which this award is appropriately concerned – science, engineering, and education. It is hard to visualize what the world would be like without aircraft and jet propulsion, or without the vision we have, just entering the realm of reality, of exploring space. I am especially glad to present this first National Medal of Science to one of the pioneers who helped make all of this new and exciting age possible.

It may be appropriate to quote ARTHUR KOESTLER's *Sleepwalkers*:

– The aim of those men who created the Scientific Revolution was not the conquest of Nature, but the understanding of Nature. The revolution in technology was an unexpected by-product. Yet their cosmic quest destroyed the medieval vision of an immutable social order in a walled-in universe together with its fixed hierarchy of moral values, and transformed the Western landscape, society, culture, habits, and general outlook, as thoroughly as if a new species had arisen on this planet.

Hevesy György – George de Hevesy

1886–1966

It has been recognized that food supplied to the body is not only used to supply energy but is also of great importance in the replacement of used parts in the body. However, only recently has interest begun in measuring how long the atoms stay in the body. (G. de H.)

– *The polite smile never left his face, but he never laughed in front of people* – recollected his biographer, Hilde Levi.

Bischitz György was born in Budapest. This region had been in the maelstrom of history many times, especially so at the turn of the century. This is a region where world wars erupt, political systems succeed each other in dizzy rapidity, where borders change fast. Hungary was formally ruled by the rigid aristocracy of landlords, but industrial revolution took over gradually. György's father supplied food for the emperor's army, therefore he was made a nobleman. This was how Bischitz György became George de Hevesy. He enjoyed the advantages of belonging to an enlightened bourgeois family, of becoming a nobleman, and of obtaining an excellent Catholic education. On the other hand, he had to suffer the conflicts of the varying political climates: being a rich noble landowner and a suspected communist Jew at the same time.

In his quest for lasting values in these stormy years, Hevesy started studying chemistry at Budapest University; after two semesters he left for Berlin, obtained a Ph.D. in Freiburg, stayed for a while in Zürich, then began commuting between Manchester, Vienna, and Budapest. Due to the wealth of his father, Hevesy did not have to apply for a salary – he asked only for a laboratory table which his talent certainly deserved. He was welcomed by Lord Rutherford in Manchester, by Stefan Meyer at the Radium Institute in Vienna, and by Gustav Buchböck in Budapest. Hevesy witnessed the discovery of the atomic nucleus in Rutherford's laboratory. He worked on the physical and chemical properties of radioactive elements, mainly on actinium-emanation. He obtained thorium from Paneth (Vienna) and uranium from Hahn (Berlin).

Rutherford obtained 100 kg of pitchblende as a present from the Austrian–Hungarian government, so he asked Hevesy to separate the radio-

active RaD from lead. Hevesy tried all the tricks of analytical chemistry, without success. (As we know today, RaD is just the ^{214}Pb isotope of lead.) This gave him the idea of radioactive tracing, formulated first in a letter to Paneth (Vienna) dated 8 January 1913 (Budapest):

Since RaD cannot be separated from lead we can take RaD as an indicator for lead and, for example, investigate the solubility of PbCrO_4 in water at different temperatures.

The method of radioactive indicator (as we now say: tracer) was presented by F. Paneth and G. de Hevesy in the Imperial Academy (Vienna, 24 April 1913):

*– As we have shown, till today all research for the separation of RaD from lead remained unsuccessful; a shift in their concentration ratio was never observed. We mixed a given quantity of RaD to a known quantity of lead compound, and after their complete mixing their concentration ratio remained the same in every experiment, even in small samples taken from the solution. Since due to its radioactivity RaD can be measured in much smaller quantities than lead, by adding RaD to lead one can trace the lead both qualitatively and quantitatively. RaD is the indicator of lead.*¹ – The Hevesy–Paneth paper was mailed to the *Zeitschrift für anorganische Chemie* on 30 April 1913, and was printed in the same year.² One must not forget that the word “isotope” occurred first in the letter of F. Soddy written to *Nature*, dated 4 December 1913.

Hevesy made his habilitation at Budapest University. During World War I he was assigned to work at a plant which produced copper for the army from old church bells. At the time of suffering, due to the lack of food and fuel, meetings with the chemist friend MICHAEL POLANYI helped him to keep his scientific spirit alive. ROLAND EÖTVÖS proposed Hevesy be made the head of the Institute of Applied Physics (1918), which the Faculty accepted (January 1919). The promotion to professor (3 May 1919) was signed by THEODORE VON KÁRMÁN, who was in charge of university affairs in the government. (At this time – from March 1919 – the communists had been in power.) After the death of Eötvös (8 April 1919), Kármán asked him to take care of all the physics laboratories. Hevesy collected a group of bright assistants like *Imre Bródy* (later inventor of krypton light bulb), MICHEL POLANYI (later member of Royal

¹*Monatshefte für Chemie* 42, 1913, p. 1

²82, 1913, p. 322

Society), and *Paul Selényi* (later pioneer of photocopying). Hevesy's effort to equip a laboratory for studying radioactivity conflicted with the jealousy of smaller talents unhappy because of the fresh winds of atomic physics. Thus, after the fall of the communist republic, Hevesy was attacked by the physicists and defended by the chemists. Hevesy wrote to Paneth on 2 November 1919:

Life at the university is hardly different from death, a re-opening before the spring is not planned. The new regime has learnt much from the communists: at that time one could get rid of one's competitors by denouncing them as counter-revolutionaries. Today they are stamped anonymously or even openly as sympathizers with the previous regime. Incidentally I have asked that an investigation be carried out about me. I gave up the direction of the Physics Institute for numerous reasons: One because of the scandalous removal of deserving assistants for political reasons. Further because I will not be named the permanent director anyhow. Finally because the future is so desolate that I feel no desire to connect my fate with that of Budapest University and Hungary.

Due to the feudalistic–military restoration (1920) he was expelled from the university as a politically unreliable person, being “a protégé of the communist Theodore von Kármán.” Hevesy did not have real financial problems: he owned land in Tura, and a castle built by Miklós Ybl, the architect of the magnificent Opera house in Budapest. So he worked in the lab of the Veterinarian College. A few years ago we succeeded in identifying his lab desk – by tracing leftover radioactivity.

Hevesy befriended Niels Bohr in Manchester. They were complementary characters. Bohr was shy, introverted, slow, and not always understandable. Hevesy moved with an aristocratic charm, he was a great communicator. Bohr was a master of principles, Hevesy knew the facts. Hevesy explained to Bohr the new experiments, and explained to the audience what Bohr intended to say when others found the profound ideas too hard to follow. Hevesy explained Bohr's model to Einstein as well, who became so enthusiastic that he personally recommended Bohr to a membership of the Academy in Berlin. As Bohr said: – *Hevesy understood that I was doing something which would basically change the chemistry of atoms.*

The political turmoils of Hungary made it easy to accept Bohr's invitation to Copenhagen in 1920. At this time chemists were searching for element No. 72, still missing from the Periodic Table. According to the chemists' expectations it were a rare earth metal like its neighbors. This

disturbed Bohr: his model predicted that the element No. 72 should be similar to zircon! When Coster came to Copenhagen in 1922, Hevesy asked Coster to teach him X-ray spectroscopy. Then he went to Hungary for a holiday. At reading geochemical papers in Budapest, he decided to search for element 72. He discussed his plans with Paneth in Vienna. The museum of Copenhagen gave him minerals with zircon content, brought from Norway and Greenland. Hevesy removed the soluble materials. The X-ray spectrum of the leftover sample clearly showed the spectral lines of element 72. Hevesy was jubilant: – *We have caught element 72!* – When this discovery was made (9 December 1922), Bohr was already on his way to receive the Nobel Prize from the King of Sweden for his atomic model. Coster's phone call reached Bohr in Stockholm. Hevesy jumped on a train, and was present at the Nobel lecture when Bohr announced the discovery and chemical nature of element 72:

– *On the expected character of the element with atomic number 72 opinion has been divided. In many representations of the Periodic Table a place is left open for this element in the rare-earth family. In Julius Thomsen's representation of the Periodic Table, however, this hypothetical element was given a position homologous to titanium and zircon in the same way as in our representation. Such a relationship must be considered as a necessary consequence of the theory of atomic structure developed by the fact that the electron configurations for Ti and Zr show the same sort of resemblances and differences as the electron configurations for Zr and the element with atomic number 72. Recently Dauvillier announced the observation of some weak lines in the X-ray spectrum of a sample containing rare-earths; these were ascribed to an element with atomic number 72 assumed to be an element in the rare-earth family. In these circumstances Dr. Coster and Prof. Hevesy took up the problem of testing a preparation of zircon-bearing minerals by X-ray spectroscopic analysis. These investigations have been able to establish the existence in the minerals investigated of appreciable quantities of an element with atomic number 72, the chemical properties of which show a great similarity to those of Zr and a decided difference from those of rare-earths. – The new element was named hafnium (Hafniae = Copenhagen).³*

³Due to reasons of nuclear stability, zircon does not absorb neutrons; therefore the metallic cover of reactor fuel rods is made of zircon. Hafnium, on the other hand, is a neutron absorber; its elimination is important in the fabrication of fuel rods. Hafnium received fame recently because HfTa_3C_5 has the highest melting point among known materials.

In the 1930s Hevesy returned several times to Hungary to enjoy vacations at his estate in Tápiósáp, e.g. in 1933 he spent several months there. But he accepted a full professorship in Freiburg (1926). One consequence of his earlier experiments with Coster was that he developed the X-ray fluorescence method for chemical analysis. His co-worker, Ishibashi, analyzed several meteorites. So Hevesy's interest turned towards geochronology. F.A. Paneth tried to obtain the age of rocks from the amount of accumulated helium in (α -radiating) uranium ores (the α -particles being He nuclei), but this was inaccurate due to the diffusion loss of the helium gas. So was the lead/uranium ratio, due to the diffusion loss of the intermediate radon gas. This is why Hevesy's interest turned to rare earth metals, which did not separate from each other; having almost identical chemical properties. While searching for the missing element No. 61, Hevesy discovered the natural radioactivity of the neighboring samarium: ^{147}Sm , ^{148}Sm and ^{149}Sm (making 40 % of the terrestrial samarium) have half lives of hundred billion years. In 1974, with samarium clock G. Lugmair (La Jolla, California) measured the age of the Earth's crust to be four billion years, reaching an accuracy of three digits.

Argon is a noble gas. The lighter noble gas, ^{20}Ne is much more abundant in the Universe, but is practically missing from Earth, however ^{40}Ar makes up about 1 % of the atmosphere. The explanation of this puzzle is that the early Earth melted due to the originally higher radioactivity, thus the light neon gas escaped. Niels Bohr, being an expert of nuclear structure, told Hevesy: – *This argon is wrong argon!* – He might think that the (1s, 2p, 3s, 3d) energy shells are completely filled up with 20 neutrons, which is why ^{40}Ca with 20 protons and 20 neutrons is the most common metal (in limestones etc.), and this is why one would expect ^{38}Ar with 20 neutrons to be more abundant than ^{40}Ar containing 22 neutrons. Hevesy succeeded in showing that the weak radioactivity of natural potassium is due to the ^{40}K isotope. It decays partly to ^{40}Ca , partly to ^{40}Ar . This second-mentioned decay has built up the present argon content of the atmosphere. (The radioactive potassium isotope was formed in a supernova in $n + ^{40}\text{Ca} \rightarrow ^{40}\text{K} + p$ reaction, and having a half life of 1.28 billion years, it still makes 0.0118 % of terrestrial potassium.) At Cornell University in America, in his *Baker lecture* Hevesy said (1932):

– *From the very recent results of nuclear theory we may conclude that the relative abundances of chemical elements in the Solar System reflects the stabilities of their nuclei. These two properties may be inter-related in a complex way. One may still expect that, by studying the abundances of chemical elements, one may obtain completely new information concerning nuclear structure. This possibility encourages us*

to study the abundances of elements in terrestrial and meteoric materials, furthermore in the atmospheres of the Sun and stars.

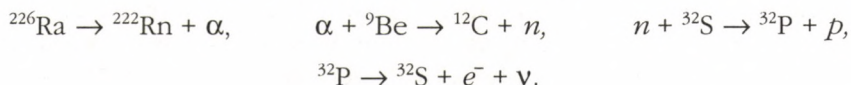
Hevesy liked Freiburg, but when Hitler came to power, to prevent his dismissal, Hevesy had to move again. He wrote to Paneth: – *Recently I have pondered repeatedly whether – out of regard for my children – it would have been better if I had settled in the United States and left Europe and her unfriendly tendencies. But, after all, we cannot foresee the future.* – Taking into account that the children were born in Denmark, Hevesy returned to the friendly Copenhagen (1934).



After the geochemical intermezzo Hevesy noticed the importance of radioactive tracers for biology. In his mature years, he learned life science. As he wrote to *Rudolf Ortway* (in Budapest) from Copenhagen: – *I think this is a unique physical institute where experimental chickens can be kept.* – After Urey's discovery of heavy water, he asked for a sample, and began experimenting upon his own body. By drinking D₂O-enriched water, he measured that the average time a water molecule spends in the human body is 13 ± 1.5 days. He advised his friend Nishina, how to procure heavy water for his research in Japan.

The main problem was that the heaviest elements (possessing natural radioactive isotopes) did not play any biological role, most of them being even poisonous. This explains why Hevesy searched for natural radioactive isotopes in the middle section of the Periodic Table. This was the time when Enrico Fermi irradiated different chemical elements with neutrons and observed the induced radioactivity. Fermi contacted Hevesy as well. In order to understand the chemistry of life, Hevesy invented the fabrication of artificial radioactive isotopes of life-essential elements by neutron activation. (The absorption of neutron turns over the proton-neutron balance of the nucleus, which tries to restore it by β -decay, mostly followed by γ -radiation. This activity makes the localization of the radioisotope easily detectable within the body.)

Bohr's 50th birthday was celebrated in Copenhagen on 7 October 1935. To honor him, the Danes collected 100000 Danish crowns. From this fund Bohr and Hevesy bought 0.6 gram of radium. Hevesy dissolved the radium salt, mixed it with beryllium salt, and let it dry. In this way Hevesy produced several neutron sources. In the basement of the Bohr Institute six sources were immersed in carbon-disulfide. The neutrons slowly transmuted part of the sulphur to radiophosphorus:



Hevesy used the active ^{32}P to trace the metabolism of phosphorus in a living organism. In the September 1935 issue of *Nature* Hevesy and Chievitz reported: – *The results strongly support the view that the formation of the bones is a dynamic process, the bones continuously taking up phosphorus atoms which are partly or wholly lost again and are replaced by other phosphorus atoms.* – This was an idea too new, therefore the editor distanced himself with a note: “*so the authors believe.*” But Hevesy was right.

Phosphorus is an essential constituent of nucleic acid, Hevesy could direct his attention toward nucleic acids, and finally began to study cancer.

Hevesy was always very polite, (almost) always smiling. His favorite assistant, Hilde Levi, however remembers one case, when a ^{35}S sample – prepared with weeks-long effort – was mixed up with an other test tube, and she poured it into the outlet. Then Hevesy became really angry and started shouting – in incomprehensible Hungarian – and ran out of the laboratory. On an other occasion it happened that a cat – injected with ^{32}P – managed to escape. A long search began. Finally the active cat was found in one of the city parks. According to another tale, Hevesy heard rumors that his favorite restaurant made hamburger from the pieces of steak left by the guests. Hevesy injected a mild radioisotope in his steak and left it in his plate. The next day he ordered hamburger in the same restaurant. When the dish was served, the Geiger counter started ticking...

George de Hevesy was awarded the 1943 Nobel Prize in chemistry for the technique of radioactive tracing. Actually he received it in 1944, because World War II was going on. Bohr was asked to safely hide the gold Nobel Prize medals of Max von Laue and James Franck in Copenhagen. But the German occupation of Denmark created danger: exporting gold illegally from Germany was a criminal offense, and the medals carried the engraved names of their proprietors. What to do? Hevesy the chemist found a solution: he dissolved the medals in acid, and the obtained black liquid was placed in innocent looking jars on the laboratory shelf. After the war the gold was regained and the Nobel Committee recast the medals for their owners.

When the German occupation of Denmark became harsher for the Jews, Bohr and Hevesy had to escape: Bohr via Stockholm and England to America, Hevesy to Stockholm. Everyone in need who has received the Nobel Prize has the option to take up Swedish citizenship, which is what Hevesy did. In Stockholm he followed his biological interest.

World War II had created nuclear industry. After the war nuclear reactors were capable of producing cheap radioisotopes of any element with neutron activation. Second only to his friend Niels Bohr (1957), George

de Hevesy received the "Atoms for Peace" Award (1958) in the United States. (The amount of dollars associated with this award is larger than that of coming with the Nobel Prize.)

In his later years he returned to Freiburg, to the university where he graduated, and there he died. At the centenary of his birth, a memorial session was organized at Eötvös University in Budapest, with Nobel laureates attending,⁴ and a memorial plaque was unveiled in the presence of his daughters at Puskin Street 5. His life has taught us lessons of timeless value:

– Science is indivisible. At the university Hevesy studied chemistry, but completed a Ph.D. in physics. He headed a Physics Department in Budapest, and a Chemistry Department in Freiburg, where he studied geological problems. He obtained a Nobel Prize in chemistry. He utilized his experiences in biology in Stockholm, and he is now considered to be the Founding Father of nuclear medicine. The Hungarian Society of Nuclear Medicine honors excellence with the Hevesy Medal. The international Society of Nuclear Medicine gives a Hevesy Prize, associated regularly with a Hevesy Memorial Lecture. (Now nuclear isotope diagnosis and radiotherapy is an everyday procedure in hospitals. As Hevesy proudly mentioned: 500 000 cervical cancers had been treated by radiotherapy by 1961.) But he was not erratic: his path from the basic understanding of the nucleus to high-tech medicine was a straight logical path, cutting through artificial borderlines. And he was able to follow that path. He was worthy of his salt indeed.

– Research requires an open mind, and becomes exciting with an unexpected outcome of experiments. The unsuccessful attempt of separating radium-D chemically from lead yielded more results than any expected success would have. Hevesy might have inherited this serendipity from the cultural environment of his youth where the interplay of complementary ideologies bred tolerance and awareness to deal with conflicts.

– Problems cannot be avoided by complaining, they can be solved by working. Hilde Levi, Hevesy's favorite assistant described an incident when the professor burned his hand with concentrated and hot sulfuric acid. After receiving first aid he went back to the laboratory to continue working. To his protesting colleagues he remarked:

– *Do you think it would hurt less if I went home to rest?*

⁴George Marx, editor: *Hevesy Festschrift*, 1988

Szilárd Leó – Leo Szilard

1898–1964

You don't have to be cleverer, you just have to be one day earlier. (L. Sz.)

– *I was born a scientist. I believe that many children are born with an inquisitive mind and I assume that I became a scientist because in some way I remained a child.* – According to his brother Béla, the young Leo had four guiding principles:

1. Be different!
2. Think and let others tend to the details!
3. Be honest!
4. Focus on the future!

– *Of all Hungarians, Leo Szilard was the most Hungarian. A Hungarian is one who enters a revolving door behind you and comes out ahead. Leo Szilard was a dedicated nonconformist. He did not mind offending anybody, but never committed the sin of being boring. He had one principle which he did not violate on any occasion: never to say what was expected of him* – this is how EDWARD TELLER characterized his compatriot, his coworker in nuclear power development and his antagonist in foreign affairs.¹ His fellow student *Albert Korodi*² commented: – *The German poet Lessing said: "If one tries to be polite, one has to lie," but Szilard always preferred being honest.*³ – EUGENE WIGNER said: – *Throughout my long life I had the chance to meet very talented people, but I never met anybody else more imaginative than Leo Szilard. No one had more independence of thought and opinion.* – And in a low voice he added: – *You may value this statement better if you recall that I knew Albert Einstein as well.*

Once upon a time – when he was already in America – Szilard was called for jury duty. When the murder trial was completed, the jury voted eleven “guilty”, one “innocent.” (This one was Szilard.) Since a unani-

¹Budapest 1993

²uncle of Peter Lax

³to the author 1994

mous vote was required, the verdict was delayed. Szilard went around and argued to the others that the evidence against the defendant were not completely convincing. On the next day the opinion of the jury became eleven “innocent”, one “guilty.” This one was certainly Szilard because, while arguing with the other members of the jury, he discovered a hole in the alibi of the suspect.⁴



Spitz Leó was born in Budapest on 11 February 1898. (The family changed the German name Spitz – meaning *sharp* – to the Hungarian Szilárd – meaning *solid* – in 1900.) At the age of six he read Andersen’s tale in which the Snow Queen gave Kay half of the world and a pair of skates. – “*This is absurd. Since half of the world must already contain at least a million pair of skates, it is ridiculous to add one more pair.*”⁵

He attended one of the new Realgymnasiums (i.e. a science oriented high schools) in Budapest [facsimile].⁶ In around 1910 the electric lighting was the great news in Budapest which fascinated Leo. At the age of 12 he bought Victor Zemplén’s university textbook on *Theory and Application of Electricity*, based already on Maxwellian field theory, and repeated all the experiment described, including wireless telegraph communication between remote parts of their house. Szilard excelled in the Eötvös Student Competition (1916): he became second best in mathematics (*Albert Korodi* was the best), and was the best in physics (together with *András Jendrasik*, future director-general of the Ganz Company; *Albert Korodi* obtained the second prize). Then all three enrolled in the Budapest Institute of Technology to study mechanical engineering. Szilard was critical, as always,

– *This was a good time to study physics in Hungary because the university courses were so bad that the student was forced to develop independent thinking and originality.*⁷ – A biographer noted: – *It’s interesting that several countries tried to use the same method, but it worked only in Hungary.*

During World War I Szilard attended the College of the Engineering Corps of the Austrian–Hungarian Army in Kufstein (Austria). Sensing the approaching collapse, he declared himself ill, and – by adding some

⁴Joseph Rotblat to the author 1995

⁵William Lanouette: *Genius in the Shadows*, 1992

⁶Szilard’s graduation from the realgymnasium in Budapest. (From the Szilard Archive of the University of California, San Diego. The author thanks Tibor Frank for this copy of the document.)

⁷Leo Szilard: *His Version of the Facts*, 1978

family related excuse – travelled back to Budapest. A story told by his friend impressed him very much: – *There was a rumor that an armistice had been concluded, but being cut off from communications in the Carpathian Mountains, a Hungarian troop rode out on patrol duty as usual, and as they emerged from the forest, they found themselves standing face to face with a Russian patrol in charge of an officer. The two officers grabbed their guns and, frozen in this position, the two patrols remained for unnoticed seconds. Suddenly the Russian officer smiled and his hand went to his cap in salute. My friend returned the salute, and both patrols turned back their horses.* – “To this day” – my friend said to me, – “I regret that it was not I who saluted first.” – The message of this story will surface in Szilard’s advices to the leaders of the superpowers during the crises of the Cold War.⁸

After the collapse of the Habsburg Empire a democratic parliamentary republic, later a communist council republic was established. In order to propagate his economic reform ideas about taxes and monetary system, Leo created the Hungarian Association of Socialist Students with his brother Béla (1918). But Budapest was soon occupied by a foreign army, which was followed by a military rule not favoring those who played any political role in the preceding leftist era. Szilard was put on the list of suspected communist students. Thus he rushed to leave Hungary by boat to Vienna in December 1919.

Szilard was heading for the Berlin Institute of Technology to continue his studies in engineering. In the 1920s Berlin was the capital of modern physics. Szilard was unable to resist the temptation of Einstein, Laue, Nernst, and Planck. This is how he came to graduate as a physicist at the University of Berlin. He was more interested in laboratories and seminars than in attending regular lectures. When Planck recommended to take courses on theoretical physics, Szilard answered: – *I only want to know the facts. I will make up the theories myself.* – About the use of mathematical studies he noted to DENNIS GABOR: – *I don’t need to study mathematics. One can always ask a mathematician!* – He was interested in statistical thermodynamics, a fresh topics in the 1920s, and persuaded Albert Einstein (who had just received the Nobel Prize) to organize a seminar on this subject. This seminar was attended – among others – by *Albert Korodi*, DENNIS GABOR, JOHN VON NEUMANN, EUGENE P. WIGNER, and LEO SZILARD himself – developing there a life-long interest in statistical thermodynamics.

⁸The episode is described in Szilard’s letter to Stalin, 1947.

After graduation, Szilard approached Max von Laue, asking for a topic for his Ph.D. thesis. Laue suggested a problem from the theory of relativity, which Szilard found too difficult and less exciting. When the Christmas holiday arrived, Szilard relaxed:

– I thought: Christmas is not a time to work, it's time to loaf, so I thought I would just think whatever comes to my mind. Pretty soon ideas began to come in a field completely unrelated to the theory of relativity. I went for long walks and I saw something in the middle of the walk; when I came home I wrote it down; the next morning I woke up with a new idea and I went for another walk; this crystallized in my mind and in the evening I wrote it down. There was an onrush of ideas, all more or less connected, which just kept on going until I had the whole theory fully developed. It was a very creative period, in a sense the most creative period in my life. Within three weeks I had produced a manuscript of something which was really quite original. But I did not dare take it to von Laue, because it was not what he asked me to do. After one of the seminars held by Einstein I approached him and said that I would like to tell him about something I had been doing. He said: "Well, what have you been doing?" And I told him what I had done. Einstein said: "That is impossible. This cannot be done." And I said, "Well, yes, but I did it." So he said: "How did you do it?" It didn't take him more than five or ten minutes to understand, and he liked it very much. This gave me the courage to take the manuscript to von Laue, saying that I had not written the paper which he wanted me to write, that I had written something else. He looked somewhat quizzically at me, but he took the manuscript. Early the next morning the telephone rang. In was von Laue. He said: "Your manuscript has been accepted as your thesis for the Ph.D. degree."⁹ – Szilard's paper outlined a thermodynamic theory of fluctuations (1925). The Second Law of Thermodynamics precludes making a perpetuum mobile of the second kind by utilizing temperature fluctuations. From this theorem Szilard succeeded in deducing the necessity of the presence of a fundamental constant in the fluctuation formula, which he correctly identified as Boltzmann's constant k . He managed to prove all this without assuming the existence of atoms! This paper impressed Einstein so much that it resulted in their long-lasting friendship.¹⁰

– Szilard hardly ever went to the lab – he sat out in the garden in a deck chair and thought. His chief activity was talking to friends: he rang them up, he talked with them in cafés. He knew everyone and

⁹Leo Szilard: *His Version of the Facts*, 1978

¹⁰Korodi to the author 1994

gladly gave advice to all physicists and biologists. Leo wanted to discuss everything, and to pass on his ideas by word rather than by writing – DENNIS GABOR recalls. In Berlin he enjoyed social gatherings of smart people, especially those arranged by the Hungarian lady, *Eva Striker*, niece of MICHAEL POLANYI, whom Szilard considered to be a fine collection of the genes of geniality in the Polanyi family.

– *Szilard did not feel fully at home in theoretical physics because his skills in mathematical operations could not compete with that of his colleagues* – as WIGNER noted. The number of Leo Szilard's publications in fundamental physics is not awfully impressive.

Szilard was the “assistant in theoretical physics” at Max von Laue, a position which brought more fame than salary. This is why Szilard tried to make money out of his inventions. Szilard's most famous idea was, that household refrigerators would last longer if their compressor pumps had no rotating solid parts subject to abrasion. He wished to use the Lorentz force, exerted by a static magnetic field on direct current flowing through mercury, to drive the liquid metal around. He asked *Albert Korodi*, his friend since their simultaneous winning of the Eötvös competitions, to materialize this idea. Korodi, who was studying engineering in Berlin, made detailed plans and calculations, with the conclusion that the efficiency of the magnetic compressor would be very low, due to the modest electric conductivity of mercury compared to that of copper. A week later Szilard turned up again, suggesting the use of a eutectic mixture of sodium and potassium, which is liquid at room temperature and makes a good conductor. The practical studies of Korodi had shown that sodium and potassium were too abrasive, attacking the insulations of the wires conducting the electric current into the air-tight container. At a meeting with Albert Einstein, Szilard complained about these difficulties. After a few minutes of thinking, Einstein proposed an arrangement in which the current was closed through an air gap within the container, thus the corrosion of the insulator could not endanger the vacuum-tight separation of the aggressive liquid metal. Einstein agreed to patent the magnetic compressor under the names of Einstein and Szilard, possibly to help improve Szilard's financial position. Szilard convinced the Allgemeine Elektrizitätsgesellschaft to build a prototype of the magnetic refrigerator. (This was the second largest German firm in the electric industry where DENNIS GABOR worked.) The company hired Albert Korodi to construct the machine, and he did it. The practical efficiency of the fridge turned out to be still too low, therefore the system did not spread.¹¹ But

¹¹Albert Korodi to the author

liquid sodium driven by a magnetic pump is used nowadays to cool the present high temperature reactors, esp. the *breeders*. (Even the best-selling fiction "*The Hunt for the Red October*" utilized this idea for a fictitious Russian submarine, driven without noisy rotating motors.)¹²

– *He was not a physicist, he was an inventor* – Pontecorvo said.¹³ (Bruno Pontecorvo knew Szilard from the time of the Manhattan Project.) Szilard's list of patents is remarkable indeed: besides the joint Einstein–Szilard patent for the magnetic pump (1928), there is the idea of the cyclotron (1929) before Lawrence's construction, the idea of the nuclear chain reaction (1934), sterilization by ionizing radiation (1938), the chemostat for breeding bacteria under strictly controlled conditions (1951), a family planning clock for women (1951), and the Fermi–Szilard patent for the nuclear reactor (1955), just to name a few. In Berlin, Szilard discussed with Dennis Gabor the possibility of the electron microscope. He speculated also about a device what we call now a linear accelerator. As Gabor said, – *Had he pushed through to success all his new inventions, we would now talk of him as the Edison of the 20th century.* – Nobel laureate James Franck proposed to *keep Szilard in a freezer and to pull him out when new ideas were needed.* – Einstein asked him, – *Why don't you take a job in the Patent Office? That would be the best for you; it is not a good thing for a scientist to depend on laying golden eggs. When I worked in the Patent Office, that was my best time of all.*¹⁴ – But Szilard did not persist long enough in exploiting these ideas if he was not motivated enough – politically.

– *In my childhood I was interested in two things: physics and politics, but I never imagined that these two fields would ever meet. I can possibly thank my political orientation that I managed to survive* – said Szilard.¹⁵ He left Hungary in time (late 1919) to escape anti-Semitism and the military purge. In the 1920s he lived in the Faculty Club in Berlin, two suitcases stood in his room packed, with the keys in them, and "all he had to do was to turn the key and leave when things got too bad."¹⁶ Hitler gained power in January 1933, the Reichstag (the building of the German Parliament) having been burned on 27 February 1933, to create

¹²Gene Dannen, *Scientific American*, January 1997

¹³to the author 1972

¹⁴Leo Szilard: *His Version of the Facts*, 1978

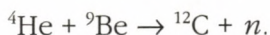
¹⁵Leo Szilard: *His Version of the Facts*, 1978

¹⁶Leo Szilard: *His Version of the Facts*, 1978

an excuse to attack communists and Jews. On 31 March Szilard took a train to Vienna, finally landed in England in the middle of 1933. In London his main public activity was to mobilize institutes and funds in order to help scientists to flee from Germany.



In science Szilard was turning to biology and this is how he became interested in radioactivity. He worked with T.A. Chalmers in St. Bartholomew's Hospital of the Medical School, where they were allowed to use the available radium. They made beryllium an efficient neutron source under the impact of the α -rays of radium:



(This will gain relevance later in our story.) They discovered what is now called the Szilard–Chalmers effect:¹⁷ atoms having captured a neutron emit a γ -quant, and the recoil removes these “hot atoms” from the molecular bond. (This effect can be used to collect radioactive isotopes without a molecular carrier.) Due to his practical results in Bart's, Leo Szilard was already considered to be a nuclear physicist, got a job at Clarendon Laboratory in Oxford. There he made a lasting friendship with NICHOLAS KURTI, who tried to suppress entropy in materials by cooling them to deep temperatures.

– *Szilard was monogamic, had one girlfriend for 30 years. He was not a shy person – I saw him blush only once: when – after the 30-years romance – I congratulated him on his marriage to the Austrian girl, Trudi Weiss (1951).*¹⁸ – Years before the marriage, Trudi and Leo were relaxing with Nicholas Kurti in Oxford. Professor Kurti wanted to do them a favor and offered his kayak for an excursion in two. To his surprise Leo replied with a resounding *No!* Later Kurti understood the reason: Leo could not swim.

It happened in the lobby of the Imperial Hotel one Friday morning (11 September 1933) that he read *The Times*' headlines:

BREAKING DOWN THE ATOM – TRANSFORMATION OF ELEMENTS – THE NEUTRON NOVEL TRANSFORMATIONS – HOPE OF TRANSFORMING ANY ATOM

reporting on the lecture of Lord Rutherford in the British Association. At this point, from science Leo Szilard entered history.

¹⁷published in *Nature* in 1934

¹⁸Teller in Budapest, 1994

Provoked by the Lord's hint of *moonshine*, on one of his creative mornings Szilard got the idea of the neutron chain reaction. To make it a reality, he wanted to check the chemical elements to find out which of them would offer two neutrons at the price of one. Szilard was expert in producing neutrons from the Ra + Be source, and in slowing them by collisions with the protons in paraffin. But he needed about 2000 pounds, to buy or rent radium and beryllium. He approached British physicists – in vain. Thus he mobilized chemists, refugees from Central Europe (Michael Polanyi, Chaim Weizmann, Eugene P. Wigner, and others) for financial connections, but with no success. After Hiroshima, Szilard said: – *Perhaps those of us who missed this discovery in 1934 ought to be considered for the next Nobel Peace Prize.* – The main outcome of Szilard's efforts were British patents 440 023 (applied on 12 March 1934), 630 726 (applied on 28 June 1934) and 814 236 (in 1936). Szilard asked the British War Department to declare these patents secret, but their answer was: – *There appears to be no reason to keep the specification secret so far as the War Department is concerned* (8 October 1935). – Szilard succeeded in convincing the British Admiralty of the importance of secrecy.

In the eyes of the West, Hitler was still the fighter of communism, an appropriate person to keep order in Central Europe. Leo visited Hungary at the end of 1936 – the last time – and urged his relatives: – *Come to America!* – As he said later: – *I prefer roots to wings, but if I cannot have roots I'll use wings.* – On 2 January 1938 he sailed to America.

England, France, Germany, and Italy agreed on the peaceful partition of Czechoslovakia in favor of Germany in Munich in September 1938. Germany attacked Poland and World War II broke out on 1 September 1939.



When Szilard arrived in the United States, he obtained a job at Columbia University, but he went on living in hotels, like the cosmopolitan Hungarian mathematician PAUL ERDŐS used to do, confirming the characterization of Martians. – *I went into the bathroom of the hotel around nine o'clock in the morning. There is no place as good to think as a bathtub. I would just soak there and think, and around twelve o'clock the maid would knock and say, "Are you all right, sir?" Then I usually got out and made a few notes, dictated a few memoranda.* – Szilard's ideas were born in hotel bathrooms that made these hotels historic places:

Harnack House, Faculty Club of the Kaiser Wilhelm Institute, Dahlem,
Hotel Regina, Roosevelt Platz, Vienna,
Imperial Hotel, Russell Square, London (1933),
Strand Palace Hotel, the Strand, near Trafalgar Square, London (1934),
King's Crown Hotel, 420 West 116th Street, New York,

Quadrangle Faculty Club, University of Chicago,
Hotel La Valencia, La Jolla, California,
Del Charro Motel, La Jolla, California

Dupont Plaza Hotel, Dupont Circle, Washington D.C.

In the lobby of the last one, Szilard sat in an elevated chair and people came to listen to his wisdom. Now in front of this hotel a copper plaque says:

LOBBYING FROM THE LOBBY. LEO SZILARD, PHYSICIST, BIOLOGIST, PEACEMAKER LOBBIED CONGRESS AND THE ADMINISTRATION ON SCIENCE AND DISARMAMENT ISSUES FROM HIS "OFFICE" IN THIS LOBBY, SAYING: "I CAN WORK VERY HAPPILY IN THIS LOBBY. I HAVE NEVER OWNED A HOUSE, AND DON'T FEEL THE NEED OF OWNING ONE."

America has more fertile soil for the cultivation of extraordinary ideas. Thus Szilard succeeded in making businessmen like Lewis L. Strauss interested in sponsoring research on neutron chain reactions. He tried to check different chemical elements for double neutron emission. He was already about to give up his efforts, when – in early January 1939 – Niels Bohr landed in New York, bringing the news of uranium fission. On 5 February 1939, *The New York Times* reported on a REMOTELY POSSIBLE ATOMIC POWERHOUSE. The Hungarian conspiracy – Eugene P. Wigner and Edward Teller, mobilized undoubtedly by Leo Szilard – switched to high gear. At Columbia Szilard and Zinn discovered that uranium fission, induced by a single neutron, results in the emission of several neutrons. Anderson, Fermi and Hanstein confirmed the neutron multiplication.

Busy years ensued for Szilard, the physicist–inventor–prognosticator. Hans Bethe (refugee from Germany) said:¹⁹ – *At that time there was much talk about the annihilation and recreation of particles, and Szilard seemed to prove the point. We were convinced that Szilard could be in two places at the same time. He was a person who could be annihilated at one place and appear at another place, being recreated.*

Szilard tried to organize secrecy for the uranium, which had worked in the U.S. and U.K., but had failed in France. He designed the inhomogeneous uranium–graphite reactor and convinced Fermi of its feasibility (3 July 1939). Then he discussed personally with the National Carbon Company the possibility of obtaining graphite of high purity. Fermi started his orienting experiments at Columbia in July 1939. Szilard managed to invite EDWARD TELLER to Columbia University for the summer of 1939,

¹⁹to William Lanouette

and EUGENE P. WIGNER, too, visited them. They persuaded Albert Einstein to write the historic letter to President Roosevelt (2 August 1939). As Einstein noted later, – *really I acted only as a mailbox for Szilard.*²⁰ Szilard's paper on "*Divergent Chain Reaction in Systems Composed of Uranium and Carbon*" was submitted to the *Physical Review* (31 January 1940) with the request to withhold its publication till further instruction. In the meantime he tried to push the administration to move ahead with the Pile Project. After the surprise attack of the Japanese Air Force on the American Navy in Pearl Harbor on 6 December 1941, the Metallurgical Laboratory was established in Chicago with the task of realizing the nuclear chain reaction. Leo Szilard moved to Chicago in early 1942.

In Chicago Fermi organized the work, Zinn built the pile, Wigner did the theoretical evaluation. From time to time Szilard arrived as well to say how to do it – in a different way. Alvin Weinberg said:

– *Szilard was a scientific gadfly. This is an American expression for people who go around and make problems. He was able to ask very smart questions, but his technological skills could not compete with those of Wigner. He stubbornly insisted on using liquid bismuth metal for cooling. Szilard made, however, one important contribution: he emphasized that the fast neutrons from the fission can split ^{238}U in the reactor.*²¹

Besides Wigner, Szilard was also present at the first man-made self-sustaining chain reaction brought into being in Chicago on 2 December 1942. At that time Szilard was officially still a citizen of Hungary. (He did not obtain American citizenship until 29 March 1943.) The pile worked, the people cheered, the Chianti given to Fermi by Wigner was consumed, and the people dispersed. Then Szilard went to Fermi, they shook hands, and Szilard said: – *I think this day will go down as a black day in the history of mankind.*

Based on the application submitted on 19 December 1944, Fermi and Szilard obtained the U.S. patent of the nuclear reactor. The patent was issued on 17 May 1955, and it was bought by the U.S. government from Fermi and Szilard for a nominal price of one dollar. (Beforehand, he obtained \$20000 for his British patent on neutron chain reaction.) Szilard was again unsatisfied: – *They should give the actual value of the invention – or nothing at all.* – Even in the last year of his life he expressed his indignation for the forced transfer of patent rights to the government, and tried to obtain appropriate recompensation.

²⁰William Lanouette: *Genius in the Shadows*, 1992

²¹Weinberg to the author, Budapest 1989

An interesting aspect of this “success story” was that Szilard was not welcome in Los Alamos; even after the war he was excluded. The Army Intelligence Service considered Fermi and Szilard to be highly suspicious persons: – *“Enrico Fermi is undoubtedly a fascist. Employment of this person on secret work is not recommended.”* – *“Mr. Szilard is a Jewish refugee from Hungary. He is an inventor, and is stated to be very pro-German, and to have remarked on many occasions that he thinks the Germans will win the war. Employment of this person on secret work is not recommended.”*²² – Szilard’s employment at Met Lab was rather shaky. General Groves, military commander of the Manhattan Project complained: – *Few enemies were causing us as much trouble as Szilard.* – He officially proposed to intern Szilard. At this time the United States was not on best terms with the Hungarian government, yet American intelligence agencies inquired at the Hungarian police about the suspicious behavior of Szilard back in early 1919.²³

Szilard’s steps were watched by intelligence agents throughout the war in a way described in spy stories. 20 June 1943 was a rather usual day:

Subject observed leaving the Wardman Park Drug Store. Subject appeared to be interested in finding a place to eat but this drug store was very crowded and he did not remain. Upon leaving the drug store Subject walked around on various sidewalks in the grounds. Subject paused momentarily at three eating establishments. These included the White Tower, Peoples’ Drug Store, and Chin’s Chinese restaurant. Subject went into Aurbough’s Restaurant in the same block at 20:55. This Restaurant was very crowded and Subject waited approximately 10 minutes before he was seated. At 21:35 Subject left Aurbough’s Restaurant and returned to the Wardman Park Hotel. He contacted no one at Aurboughs.

On 21 June 1943 more suspicious activities of the observed subject were reported by the agent of the Military Intelligence Service from Washington:

Subject and Wigner were observed coming down the steps from the second floor, walking through the lobby of Wardman Park, then Subject and Wigner went outside the hotel and sat down on a bench by the tennis courts, where both pulled off their coats, rolled up their sleeves and talked in a foreign language.

²²Lt. Col. S. V. Constant’s report, 1940

²³Gábor Palló to the author, 1996

The intelligence reports were occasionally friendly like the Confidential Memo to the Officer in Charge (24 June 1943):

The surveillance reports indicate that the Subject is of Jewish extraction, has a fondness for delicacies and frequently makes purchases in delicatessen stores, usually eats his breakfast in drug-stores and other meals in restaurants, walks a great deal when he cannot secure a taxi, usually gets shaved in a barber shop, occasionally speaks in a foreign tongue, and associates mostly with people of Jewish extraction. He is inclined to be rather absent-minded and eccentric, and will go out a door, turn around and come back, go out on the street without his coat or hat, and frequently looks up and down the street as if he were watching for someone or did not know for sure where he wanted to go.



Szilard did know where humankind was heading. – *He not only accepted the duty of representing the conscience of the world, he was the conscience of the world* – as GEORGE KLEIN wrote. After quoting these intelligence reports, William Lanouette gave the explanation: In 1934 there was peace, but Szilard was thinking ahead of war. In 1944 there was war, but Szilard was thinking ahead of peace. He did not have a direct role in the construction of the bomb; he was interested in nuclear reactors. He proposed transforming the abundant ^{232}Th and ^{238}U to fissionable fuels in reactors (1943); it was he who coined the word *breeder* for it.

The air-cooled Oak Ridge reactor and the water-cooled Hanford reactors were operating, supplying plutonium for the atomic bombs. Not much work was left for the Met Lab in Chicago:²⁴

– *In 1945, as the war drew to its end, one of the younger staff members came into my office at the University of Chicago and said that he felt it was a mistake that so much emphasis was placed on the bomb and that we were not paying sufficient attention to the peacetime applications of atomic energy. – “What particular peacetime applications do you have in mind?” – I asked him, and he said: – “The propulsion of battleships.”*

The politician in Szilard came alive. Until the Chicago Pile his obsession had been to *bring a nuclear chain reaction into being*. After the suicide of Hitler and the defeat of Germany his obsession became to *block the use of the atomic bomb*. He tried to contact President Roose-

²⁴Szilard recalled in his Response at obtaining the Atoms for Peace Award, 1960

velt and President Truman, to prevent dropping atomic bombs on Japanese cities, and he tried again desperately to mobilize his friends, including Albert Einstein, Eugene Wigner, and Edward Teller. In a draft he wrote that – *at some future time, when the war is won or lost, the history of this chapter from "The Tragedy of Man" may perhaps be pieced together.* – We know from history that he did not succeed. In a public lecture at the University of Chicago on 31 July 1946 he concluded:²⁵

– *Transmuting one chemical element into another chemical element was, as you know, the unsolved problem of the alchemists. Madame Curie did not produce radium, she merely separated it chemically. So God remained the first and only successful alchemist. But then uranium was converted to plutonium, and the first use of plutonium, as you know, was in the form of a bomb which destroyed a city. The next use of plutonium might be the same again. While the first successful alchemist was undoubtedly God, I sometimes wonder whether the second successful alchemist may not have been the Devil himself.*

For insiders – Szilard included – it was evident already before the end of the war, that the bombs dropped on Hiroshima and Nagasaki were meant to be warnings for the Soviet Union. Szilard insisted that this policy might result only in a nuclear arms race between the two superpowers. Szilard argued not only with the American presidents, he wrote letters to Stalin and Khrushchev as well. Let us quote from one of the answers of Khrushchev:²⁶

Dear Professor Szilard, I received your letter and read it with interest. Giving credit to your noble efforts aimed at the improvement of the mutual understanding and relations between the United States and the Soviet Union, I welcome your new initiative. In my opinion the more frequently and broadly representatives of science, culture and the public of various countries meet with each other to discuss urgent international problems and the more concern they display for the fate of peace, the greater will be the guarantee that peoples' struggle for complete and universal disarmament, for final removal of war from human life and for peaceful coexistence will be crowned with success. I wish you success in carrying out your important initiative.

With respect, N. Khrushchev

²⁵Leo Szilard: *Collected Works*, Volume 1, 1972

²⁶30 August 1960

Szilard met Khrushchev in Washington (on 26 September 1960); their personal meeting, intended for 15 minutes, lasted two hours. On this occasion Szilard gave Mr. K. the famous Schick razor set as a present, promising a continuing supply of blades *until the outbreak of the war*. – Khrushchev reacted – *In case of war none of us will shave* – and offered to reciprocate with a case of vodka, but – following Szilard's suggestion – sent a case of Borzumi mineral water, supplemented with smoked salmon and caviar. Szilard kept on supplying Mr. K. with blades, and Khrushchev expressed his thanks for them. (The Khrushchev–Szilard meeting had made front page news in *Pravda* on 6 October 1960.) The fact is that the hot phone line between President Kennedy and First Secretary Khrushchev was the positive outcome of this meeting, at the initiative of Leo Szilard, in order to prevent a nuclear holocaust due to misunderstanding.

The best known media events were the CBS and NBC discussions between the two Hungarians, LEO SZILARD and EDWARD TELLER on the topics “*Is Disarmament Possible and Desirable?*” Both considered logic to be the utmost authority. At the beginning Szilard suggested: – *I think, Teller, we should shake hands because maybe later we won't...* – But Teller reacted: – *Szilard, I pledge myself to this. That, to me, it will be always a pleasure to shake your hand. And I will make a prediction that our feelings will remain as before.* – And so they did.

Szilard kept on bringing up wild ideas about how to build trust for a nuclear disarmament on both sides. For example he suggested that an international commission should offer one million dollars to any American citizen who called attention to an American violation of the treaty, and the same money to a Russian citizen who called attention to any Russian violation. He proposed to announce the lists of cities to be destroyed by nuclear missiles one after the other if the enemy made an attempt to use nuclear weapons. Szilard even proposed to place Russian officers armed with atomic warheads in a bunker below Washington, and American officers with atomic warheads in a bunker below Moscow, to ensure Mutual Atomic Deterrence (MAD). Another example of his cruel logic,²⁷ at the time of the Berlin crisis, was:

– *I was asked on television if I thought that there would be an all-out war over Berlin. I answered that I did not see why it would be necessary for America to drop hundreds of hydrogen bombs on Russian cities and for Russia to drop hundreds of hydrogen bombs on American*

²⁷from his letter to Khrushchev, 4 October 1961

Book Review

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Hungarians Think The Darnedest Things



GENIUS IN THE SHADOWS

A Biography of Leo Szilard: *The Man Behind the Bomb*.
By William Lomax with Bela Szilard.
Illustrated 587 pp. New York:
A Robert Stewart Book /
Charles Scribner's Sons. \$35.

By Dick Teresi

FLYING saucer buffs have long cherished the belief that extraterrestrials from an advanced civilization landed in South America centuries ago and left a contingent of scientists behind. Their job was to infiltrate our species and subtly feed us their ideas to bring our earthbound civilization technologically up to par. Physicists scoff at such a notion: no flying saucers ever landed in South America. They landed in Hungary.

cities in order to settle the Berlin issue, when clearly the issue could be settled by dropping just two bombs, both of them on Berlin. They asked me thereupon why one hydrogen bomb would not be enough to demolish Berlin, and I said that this would not work, because if only one bomb were dropped, then Russia and America would not be able to agree on who should drop that one bomb.

As an "alien" with a wider view, during an American–Russian crisis situation regarding the Vietnam War he asked: – *American statesmen think that their sole responsibility is to the American people, for the Russians are, after all, foreigners. Do they really think that God considers them as foreigners?*²⁸ – As Einstein said, – *Szilard was too clever. He tends to overestimate the role of rational thought in human life.* – When Szilard's logic became too sharp for diplomats, Szilard was asked: – *Are the Hungarians really Martians?* – He answered with a smile: – *Perhaps.*

Szilard's most acclaimed writing has been *The Voice of the Dolphins*, a parabolic novel in the style of Jonathan Swift. In order to explain the rationale of nuclear disarmament, he started dictating the novel on 27 June 1960. In this science fiction he described the history of the coming

²⁸Leo Szilard: *Collected Papers*, Volume 3, 1987

25 years. (It predicted a leftist revolution in Iraq in 1970, the unification of Germany in 1980 etc.) In his narrative an International Research Center is created in Vienna to study the intelligence of dolphins. Cooperating Russian and American scientists succeed in understanding the language of dolphins. From humans' experiences and dolphins' intelligence many useful discoveries emerge, e.g. a very cheap food produced from algae, which supplies protein and suppresses human fertility, simultaneously solving two grave problems of the Third World. From the income, a worldwide non-profit television network called THE VOICE OF THE DOLPHINS has been created for transferring the messages of the dolphins to humankind. The dolphins offer a system of controlled nuclear disarmament that is so rational, that neither the public nor the diplomats dare to resist the recommendations of this race of superior intelligence. Finally, in 1987 a conference convenes in Vienna and the recommendations of the dolphins are accepted. In 1988 the Cold War terminates. (It was quite a good prediction 25 years in advance!) Dolphins are praised; the media become interested in interviewing them. But the outbreak of an unexpected epidemic kills the dolphins. At the same time fire destroys all the taped documents. The Russian and American scientists travel home. Later national research teams try to reestablish contact with other dolphins but to no avail. The novel concludes:

– There were, of course, those who questioned whether the Vienna Institute had in fact been able to communicate with dolphins and whether the dolphins were in any way responsible for the conspicuous achievements of the Vienna Institute. In America, a free country, anyone can think and say what he pleases. It is difficult to see, however, how the Vienna Institute could have accomplished as much as it did if it hadn't been able to draw on considerably more than the knowledge and wisdom of the Russian and American scientists who composed the staff. – (The novel was translated into Danish, French, German, Hungarian, Italian, Japanese, Russian, and Spanish.) Szilard confessed later that his book was written not about the intelligence of the dolphins but about the stupidity of humans.²⁹

Szilard gave a copy of the book to Nikita Khrushchev. He did everything to encourage contact among scientists. He co-organized the first Pugwash Conference (1957), being usually the most active participant

²⁹The Physics and Society Forum of the American Physical Society created a Szilard Award for distinguished services in the physics and society aspect. This award is a statue of the shape of a dolphin, for honoring Szilard's ideas.

at these conferences, in cooperation also with JOHN C. POLANYI. They both attended the memorable Pugwash Conference in Moscow (1960) which made also Russian scientists – Andrei Sacharov included – involved in the movement on nuclear disarmament. (John C. Polanyi received later the Nobel Prize in chemistry. He wrote a book on *The Dangers of Nuclear War* in 1979. The Pugwash Movement received the Nobel Peace Prize in 1995.)

On his way back from the Pugwash Conference (1960), Szilard stopped in Vienna and made a phone call to a friend, József Litván in Budapest. Litván asked Leo whether he would be interested in visiting Budapest. Szilard refused, saying he would never return to Hungary because he feared the Hungarian extremists who had hunted him in 1919 and the Jews in 1944. Leo never had the courage to read Orwell's "1984" because his memories of totalitarian regimes were too much alive. (The author remembers having been in a similar psychological state of mind in Budapest after the failure of the 1956 revolt: he was unable to complete reading "1984.")

There was some truth in Szilard's reservations about Hungary. After having obtained the oral encouragement of Trudi Weiss, the author of the present book tried to explore whether a Hungarian publisher – perhaps the Hungarian Academy of Sciences – would be interested in publishing *His Version of the Facts*, containing most post-1945 papers. These were rather political texts: too pink for America, not red enough for the Soviets. In the late 1960s the publishers in Budapest reacted with a polite smile: "Oh yes, we are ready to print a selection politically appropriate for us." Hungary missed an opportunity. Finally, after a decade of hesitation, the Massachusetts Institute of Technology Press published also Volumes 2 and 3 of Szilard's *Collected Works* (1978).



After World War II, after the Hiroshima and Nagasaki blasts, Szilard's interest turned again towards biology, interrupted by the decade long historic intermezzo. He wrote to Niels Bohr (1950): – *Theoretically I am supposed to divide my time between finding out what life is and trying to preserve it by saving the world. At present the world seems to be beyond saving, and that leaves me more time free for biology.*³⁰ – He felt that after having experienced how modern physics had broken away from analysis to turn to principles, there was a good chance to participate in the incoming era of modern biology. A lot of experience had

³⁰Leo Szilard: *Collected Works*, Volume 3, 1987

been accumulated; subtle experimental techniques had been developed, so it was time to discover the deep unifying principles. In his impulsive way, Szilard said: – *Biology does not seem to exist yet.* – As Fred Reines recalled,³¹ when he was interested in directing the attention of university students towards the problems of modern biology, he asked for the advice of Szilard. The answer was: – *What you have to do, have these young people have a Ph.D. in physics first; then they may do biology properly.* – A number of prominent physicists were seduced by biology, like the Nobel laureates George Békésy, Georges Charpak, Leon N. Cooper, Francis Crick, Max Delbrück, D.A. Glaser, Brian D. Josephson, Erwin Schrödinger, Francis Wilkins, and others.

Szilard became a professor of biophysics in Chicago. In order to simplify the situation in microbiological experiments, the external conditions should be kept fixed; therefore with Aaron Novick he developed the *chemostat*, a closed steady environment for bacterial reproduction under complete physical and chemical control. In this milieu hundreds of generations of bacteria can be observed: their mutation, natural selection, evolution can be studied under different prescribed food and mutagenic conditions. The 18 June 1954 issue of the *Newsweek* reported that *here for the first time, as the bouncy, smiling physicist remarked, evolution has been made visible.* – This way Szilard set the example of approaching basic problems of mutation, enzyme response, immune response, selection, aging. Szilard developed the idea of *aging bits*: the number of affordable chromosomic defects determines the natural length of life, which is set at birth. Some people inherit fewer defects or collect new defects less frequently, thus they live longer. The collection of defects might be suppressed by cryogenic preservation of humans, as told in his tale in *The Mark Gable Foundation*.

The conclusions were mostly left to more persistent researchers. Francis Jacob (Nobel laureate in physiology) said: – *Szilard is an intellectual bumblebee, carrying ideas from place to place.* Jacques Monod (who shared the Nobel Prize with Francis Jacob) said: – *Szilard was as generous with his ideas as a Maori chieftain with his wives: offering them to everybody for free.* – In 1954 Monod gave a lecture on feedback regulation of enzyme activity at Columbia. Experience shows that bacteria develop β -galactosidase for digesting lactose if sugar is present. Szilard noted to Monod that *negative feedback used to be more effective*: perhaps there is an inhibitor which prevents the production of the unnecessary digesting

³¹to the author 1994

enzyme while sugar is absent, but when lactose arrives, *inactivates the inhibitor*, and the cell begins to synthesize β -galactosidase. Following Szilard's idea Monod explored the enzyme repressor mechanism in cells and obtained the Nobel Prize for it, and he expressed his thanks to Szilard for the guiding idea in his Nobel lecture (1965):

– *Of course I had learned, like any schoolboy, that two negatives are equivalent to a positive statement, and we debated this logical possibility – without taking it too seriously – what we called “the theory of double bluff,” recalling the subtle analysis of poker by Edgar Allan Poe. I see today, however, more clearly than ever, how blind I was in not taking this hypothesis seriously sooner. This is precisely the thesis that Leo Szilard, while passing through Paris, happened to propose to us during a seminar. We had only recently obtained the first results of our experiments, and we were still not sure about their interpretation. But then I saw that our preliminary observations confirmed Szilard's penetrating intuition, and when he had finished his presentation, my doubts about “the theory of double bluff” was removed and my faith established.*

In his late years Szilard returned to his first research topics: handling information. Szilard asked how a brain can learn, speculating about “*Memory and Recall*.” He explained his theory to his friend, NICHOLAS KURTI with a conspiratorial smile:

– *It may not work, but it is almost impossible to prove it to be wrong!*



There is a Commandment, – *Honor your parents, to have a long life on Earth*. – Leo Szilard proposed another one: – *Honor children. Listen reverently to their words and speak to them with infinite love*. – (Later he noted: – *Nobody at sixty can claim to be as he was at sixteen, even though in most cases it is not intelligence that deteriorates, but character*.)³²

In 1958 the Pugwash Conference was organized in the Austrian Alps. After the conference Szilard revisited Vienna and spoke about his strange ideas not always welcome by physicists. Professor HIGATZBERGER from the University of Vienna suggested that Szilard spend a sabbatical year in Vienna, where good schools of theoretical and experimental physics, radiochemistry, and structural biology were available. While discussing this attractive offer, HIGATZBERGER took Szilard for a ride in Lower Austria. During the trip he noted tears in Szilard's

³²Leo Szilard: *Collected Works*, Volume 3, page 431, 1987

eyes. – *Any problem?* – Szilard answered: – *Oh no. But the villages remind me of Hungary.* – They were only a few miles from the Hungarian border.³³ Next spring Professor Higatzberger made a phone call to the U.S. asking whether the sabbatical year in Vienna could be realized. The sad news was told: the medical diagnosis indicated bladder cancer.

Szilard was organizing one of the Pugwash Conferences, and he visited GEORGE KLEIN, the Hungarian-born professor of medicine, heading cancer research at the Karolinska Institute in Stockholm, and complained to him of pains he felt. There it was discovered that the explanation for his pains was an advanced tumor filling his bladder. The recommended treatment in the medical praxis was extensive surgery to remove the tumor, and prolonged irradiation by γ -rays to suppress the reproduction of the possibly remaining cancer cells. But Szilard did not trust surgeons; instead he asked Klein for more details concerning the biology of immunology and cancer. At Leo's request, Trudi collected the records of patients with similar bladder cancers. It turned out that of forty cases treated surgically only one was found who was saved from cancer. On 7 January 1960 Leo Szilard was carried to Room 812 of the Memorial Hospital in New York. He already knew much about ionizing radiation and cell reproduction and went on studying the literature on the treatment of cancer with the help of Trudi, who was a medical doctor. He made Room 812 an information center, and expressed dissatisfaction: – *I don't mind that the phone is invisible in this hospital room; the problem is that one cannot hear when it rings.*³⁴ – Szilard learned and worked hard there and finally made the decision: endoscopic removal of two tumors and a massive γ -doses totaling 60 sievert onto the bladder.³⁵ (A *whole body dose* of 5 sieverts would kill with 50 % probability! Szilard originally asked for a 90 sievert *local dose*.) During the radiation therapy he occasionally escaped from his hospital room to the nearby Restaurant Budapest, to enjoy the delights of Hungarian cuisine. In the meantime he dictated papers; in one of them he recalled the last act from *The Tragedy of Man*. This epic drama of Imre Madách had been Szilard's favorite reading since the age of ten. From this play the fight of science against the cooling of the Sun was quoted at the beginning of

³³Higatzberger to the author 1993

³⁴Teller in Budapest 1994

³⁵George Klein, Budapest 1991

the chapter on *Chain Reaction*. In the preceding century, when the drama was written, physicists did not yet know about nuclear energy. Thus in the last act of the drama, the Sun is only a faint source of heat, the Earth is frozen, only a few humans fight for survival:

*Now we must roam this endless world of snow
where death looks out at us with empty eyes.
Directly beneath our feet is the Equator.
Science has finally destroyed itself.
Oh yes, whatever you choose to imagine.
The animal in you takes precedence.
New settlers will keep coming, seals are few.
If God you are, I beg you, do it for me,
Let there be less of men and more of seals.*

After having quoted Madách, Szilard stressed anew the need for a small margin of hope to sustain valiant efforts. When the hard radiation therapy ended on 13 February 1960, Szilard's bladder was burned out but his urine did not show any signs of neoplasm. Routine tests continued in the following months, with no indication of cancer. Cancer radiotherapy had been born! Szilard could return to a normal life, to new TV debates and publications, in order to save the world. In May 1960, Szilard and Trudi traveled to Washington to receive the "Atoms for Peace" Award, given to the scientist "*who seems to have been marked by destiny to develop the nuclear reactor.*"

Szilard was one of the originators of the Salk Institute in La Jolla, on the Pacific coast in Southern California, to cultivate biological and social sciences. They convinced Jonas Salk (Nobel laureate for the polio vaccine) to offer his name and fame to the new Institute. Francis Crick (Nobel laureate for the DNA structure) and other celebrities of modern biology were invited to work there. The cosmopolitan Szilard fall in love with the Pacific, moved to the Salk Institute in January 1964, liked his cottage at the del Charro Motel with Trudi, and enjoyed the discussions in the Institute. This was perhaps the most happy time of his life.

At dawn on 30 May 1964 Trudi noticed that Leo was somehow unusually quiet and silent in his bed. Leo Szilard had died of a massive heart attack (coronary thrombosis) in his sleep at the age of 66. Trudi, herself a medical doctor, insisted on an autopsy. No evidence of any abnormality was found in the urinary tract: the cancer had been completely eliminated. In the eulogy his colleague, Edwin Lenow said:

– God would have never gotten Leo if he had been awake!

Leo Szilard was cremated. His original idea was to put his ashes into brightly colored balloons and release them over the ocean. That would at least delight children. Actually, his remains were placed in the Cypress View Mausoleum in San Diego, in the columbarium of the court of Apostles, near the top of the five-meter high ceiling.

– *Leo cared not to carry the torch but to light it*, – as Jonas Salk said. EDWARD TELLER, Szilard's close friend and antagonist, wrote to Trudi:³⁶

– *I cannot but think of the legendary restless figure of Dr. Faust, who – according to Goethe's tragedy – dies at the very moment when he declares he is content.*³⁷

³⁶William Lanouette: *Genius in the Shadows*, 1992

³⁷In the First Part of Goethe's *Faust* the scientist makes a pact with Mephistopheles:

*Werd' ich zum Augenblicke sagen:
Verweile doch! Du bist so schön!
Dann magst du mich in Fesseln schlagen,
dann will ich gern zugrunde gehn!
Dann mag die Totelglocke schallen,
dann bist du deines Dienstes frei,
die Uhr mag stehn, der Zeiger fallen,
es sei die Zeit für mich vorbei!*

At the end of the Second Part of the Tragedy Faust feels happy and satisfied at completing the construction of a dam system for the benefit of society:

*Ja! diesem Sinne bin ich ganz ergeben,
das ist der Weisheit letzter Schluss:
Nur der verdient sich Freiheit wie das Leben,
der täglich sie erobern muss.
Solch ein Gewimmel möcht ich sehn,
auf freiem Grund mit freiem Volke stehn,
Zum Augenblicke dürft' ich sagen:
Verweile noch, du bist so schön!
Es kann die Spur von meinen Erdetagen
nicht in äeonen untergehn. –
Im Vorgefühl von solchen hohen Glück
geniess' ich jetzt den höchsten Augenblick.*

And then the hand of the clock falls, Dr. Faust departs. Edward Teller suggested to the author to quote here Goethe's words, expressing Edward's own thoughts. Budapest, 1996.

Wigner Jenő – Eugene P. Wigner 1902–1995

*It's a joyful thing to know that you are truly
a physicist. What else besides love can com-
pare with it?* (E. P. W.)

– *Like all children, I was born without my permission. What a pity it is that we cannot recall the day of our birth. What a memory that would be! But as soon as I realized that I was alive, I was curious about the world and happy with it. At least internally, I thanked my parents for having given me life* – Wigner told Andrew Szanton who has written the most comprehensive biography about him.

Wiegner means cradle-maker in German and this was shortened to *Wigner* in Hungary. *Eugene* corresponds to the Hungarian given name *Jenő*. It's a bit of a formal grownup name, therefore the small boy was simply called *Jancsi* (Johnny) in the family. (Later on, in America, Eugene signed his letters mailed to friends as *Wigwam*, to be more personal.)

Szanton has described how dearly Wigner loved Hungary. When Szanton mentioned that he wanted to ask about Hungary, Wigner answered: – *Good!* – clapped his hands, and said with his “wonderfully rich, heavily accented voice”:

– *Simple Hungarian poems and songs that I learned before 1910 still come to me unbidden. After 60 years in the United States, I am still more Hungarian than American, much of American culture escapes me. Jokes are apparently universal, but no country could possibly love them more than Hungarians did. I have never known such a taste for jokes in all the years since I left Hungary; certainly not in Germany and not in the United States either. Food and shelter are necessities, but laughter is not. So why do we invent jokes with such skill, and laugh at them with pleasure?*¹ – Wigner especially liked Hungarian poetry, – *perhaps the finest in Europe.* – He liked to recall long texts from his favorite poet, Vörösmarty, even in his late years. – *In Budapest there were many cafés, of a kind that hardly exist in the United States. In such places,*

¹Another Hungarian, ARTHUR KOESTLER wrote a treatise about laughter, discussing the interrelation of humor, discovery, and art [in *The Act of Creation*].

you were not only allowed to linger over coffee, you were supposed to linger, making intelligent conversation about science, art, and literature. – In an interview Eugene said about Budapest that – *you heard a great deal more erudite conversation than you hear in the United States – people talked more about culture.*²

In 1919, after the collapse of the Austrian–Hungarian Empire the communists took over in Budapest. Their leader, Béla Kun was a Jew, indoctrinated in Russia as a prisoner of war. Most of his top commissars were Jews as well: they wished to get rid of the feudalistic–nationalistic supremacy of aristocratic landlords. After the fall of communism this created a further excuse for anti-Semitism. This was the reason why not only THEODORE VON KÁRMÁN, ARTHUR KOESTLER, MICHAEL POLANYI, and LEO SZILARD (that time politically leaning towards the left), GEORGE DE HEVE-SY (accused of cooperation with Theodore von Kármán), but later also JOHN VON NEUMANN, EDWARD TELLER, and EUGENE P. WIGNER (coming from well-to-do capitalist families) – emigrated from Hungary. – *Béla Kun can unwittingly take credit for the American preeminence in the development of nuclear energy* – as Stanley A. Blumberg and Gwinn Owens wrote. (But this was not the reason why Béla Kun was executed by Stalin’s purges in Russia in 1937.)



– *Under the hardening conditions of World War I the communists began gaining strength in Hungary. My father deeply opposed them. Many of the top communist leaders were Jewish. As Jews became more associated with communism, my father arranged the conversion of his family to Christianity. For him Roman Catholicism seemed to be much like communism: a well-run dictatorship. He had been a student in the Lutheran Gymnasium, so it was natural for him to pick the Lutherans.*³

The well-to-do family sent Eugene to the Lutheran Gymnasium, which provided a lasting intellectual provision to him. He especially emphasized the impact of his mathematics teacher, *László Rátz*, who took special care with him, and also of his schoolmate, JOHN VON NEUMANN. When Eugene became 17, he had to decide on his future profession.

– *My father came and asked me: – “My son, when you grow up, what do you want to become?” – After a short silence I answered: – “Father, if I am to be frank with you I have to say that I would like to become a physicist.” – My father seemed to have expected this answer, and asked*

²Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

³Andrew Szanton: *The Recollection of Eugene P. Wigner*, 1992

me: – “Tell me, my son, how many jobs are available in our country for a physicist?” – With some exaggeration I told: – “I think, four.”⁴ – “And do you think, my son, that you will obtain any of these four jobs?” – This is how and why I chose studying chemical engineering. After the high school classes taught by Sándor Mikola, the lectures at the Institutes of Technology in Budapest and Berlin were mere repetitions. Essentially the physics lessons in the Lutheran Gymnasium were the last physics courses which I regularly attended.⁵

He was enrolled at the Budapest Institute of Technology, but the new rightist military regime reduced the rights of Jews to attend university, thus Wigner left for the Institute of Technology in Berlin-Dahlem. There Wigner’s consultant was MICHAEL POLANYI. – *After László Rátz of the Lutheran Gymnasium, Michael Polanyi was my dearest teacher* – remembered Wigner. – *His finest gift was to encourage young men with his very great heart. In all my life, I have never known anyone who used encouragement as skillfully as Polanyi. He was truly an artist of praise.* – In Berlin Wigner considered Polanyi to be as valuable a scientist as the Nobel laureates Laue, Nernst, Pauli.⁶

– *Once I made a remark to Polanyi about the impossibility of an association reaction. He heard my idea without grasping it. Months later Polanyi told me, – “I am quite sorry. This point which you have made on association reactions: I have heard that the same problem had been discussed in a very recent paper of Max Born and James Franck.”⁷ I told them that you had the same idea. I am quite sorry, I failed to understand you.*”

Wigner completed his Ph.D. thesis under the supervision of Michael Polanyi in Berlin. His thesis⁸ treated the formation and decay of molecules. – *As two hydrogen atoms collide, they stick to a single molecule. After a bit of thinking I found it to be a miracle: the molecules have dis-*

⁴in reality there were only three at the three universities

⁵to the author 1987

⁶Polanyi – former Polacsek, due to the Polish origin of the family – studied medicine and chemistry, completed Ph.D. in chemistry in Budapest. He left Hungary in late 1919, became director of the Department for Physical Chemistry in the Kaiser Wilhelm Institute in Berlin. Later, when working in America, Polanyi advocated that not centrally planned research, not a sort of Big Science is what promotes progress, but the Republic of Science, a mutual cooperation and criticism among scientists.

⁷both obtained Nobel Prizes later

⁸published later in 1925 jointly with Polanyi

crete energy levels. How do they know that they have to collide with just such an amount of energy? How do they manage that their angular momentum is an integer multiple of Planck's constant \hbar ? I suggested that the energy of molecular levels is not sharply determined, because the excited molecular state may decay after a while into atoms. Even the conservation of angular momentum is not a completely strict law! At collision the value of the angular momentum jumps to the nearest integer multiple of Planck's constant \hbar . These were written down much before quantum mechanics was invented. This is why several people accused me of having invented Heisenberg's uncertainty relation which is not true. But my conclusions turned out to be right.⁹



Anthony Wigner, himself being a director of a leather factory, worked hard to convince his son Eugene to study chemical engineering, which might become useful in the factory. Dr. Eugene Wigner worked in the tannery in Budapest (1925–1926), where he ordered the *Zeitschrift für Physik*, the avant-garde journal of modern physics. From this journal Wigner learned that quantum mechanics had been invented! After having read the paper of Max Born and Pasqual Jordan, which elaborated Heisenberg's quantum theory, he was in heaven. He could not resist the temptation of becoming an assistant at the Kaiser Wilhelm Institute for a salary of 136 marks per month. (It turned out that Polanyi's helping hand was behind this invitation.) This is when Wigner became seriously interested in symmetry. Let us listen to his recollection:

– When I returned to Berlin, the excellent crystallographer Weissenberg asked me to study: why is it that in a crystal the atoms like to sit in a symmetry plane or symmetry axis. After a short time of thinking I understood: being on the symmetry axis ensures that the derivatives of the potential energy vanish in two directions perpendicular to the symmetry axis. (In case of a symmetry plane the derivative of the potential energy vanishes in one direction.) This is how I became interested in the role of symmetries in quantum mechanics. I spent the holidays – Christmastime and summertime – in Hungary, in Budapest and in Alsóöd, on the shore of the Danube. There I wrote the book on “Group Theory and its Application to the Quantum Mechanics of Atomic Spectra.”¹⁰ – The intrusion of group theory into quantum mechanics was not received with applause. Wolfgang Pauli called the idea *Gruppenpest*.

⁹Wigner to the author in Budapest 1983

¹⁰to the author 1983

Albert Einstein, and Erwin Schrödinger also expressed their uneasiness. Max Born and Max von Laue were more encouraging. JOHN VON NEUMANN and LEO SZILARD enthusiastically encouraged Wigner's efforts. If an experiment is repeated elsewhere in another laboratory under similar conditions, it will give identical result. The experiment today yields the very same result as it yielded yesterday. If we turn the whole equipment by 30° , it will not influence the result. *The outcome depends neither on the location and timing of the experiment, nor on the spacial orientation of the equipment. Even speed (e.g. that of the Earth) does not influence the way the laws of Nature work.* To express this basic experience in a more direct way: the world does not have a privileged center, there is no absolute rest, preferred direction, unique origin of calendar time, even left and right seem to be rather symmetric.

The interference of electrons, photons, neutrons has indicated that the *state* of a particle can be described by a *vector*, possessing a certain number of components. As the *observer* is replaced by another observer (working elsewhere, looking at a different direction, using an other clock, perhaps being lefthanded), the state of the very same particle is described by another vector, obtained from the previous vector by multiplying it with a matrix. This matrix transfers from one observer to another.

The symmetry transformations in Euclidean space and time play such important roles in nature that their generators have deserved specific names: momentum, angular momentum, center of mass coordinate, energy, parity. Actually, the *energy* generates the change of the time coordinate: it transforms *present to the future*.

If a body is rotated by 90° around the *x*-axis, and after that around the *y*-axis, the outcome differs from the outcome of a *y first, x second* rotation. Rotations *don't commute*; their generators, the components of angular momenta *don't commute*. This simple everyday experience of non-commutability of transformations in the three dimensional space and time implies that the corresponding matrices cannot be diagonalized simultaneously, therefore the corresponding quantities cannot be exactly measured at the same time. The *uncertainty relation* of angular momenta (furthermore uncertainty relation between time and energy) was recognized by Wigner before 1925 while working on his Ph.D. thesis, well before Heisenberg's deduction of the uncertainty relation.

The extra power of *left/right* reflection symmetry – resulting in the parity conservation law, leading to specific selection rules in atomic spectra – was recognized by Wigner as first.

In 1930 Wigner showed the utmost power of these experienced symmetry properties of space and time in quantum mechanics. His book has become one of the most important classics of the new science, having been published in German, English, Japanese, and Hungarian. The author is convinced that the long-lasting essence of quantum mechanics has been understood by Eugene Wigner: the basic experiences of superposition and symmetry will serve as a lasting foundation; it will influence how this intellectual achievement of the 20th century with utmost importance will be taught in the schools of the 21st century.

Wigner received the 1963 Nobel Prize *for his contribution to the theory of the atomic nucleus and the elementary particles, particularly through the discovery and application of fundamental symmetry principles.*



History reached again Wigner in Berlin: Nazism was at the corner. Thus he accepted the invitation from Princeton University. CORNELIUS LANZOS, JOHN VON NEUMANN, EDWARD TELLER, and EUGENE WIGNER were called to America to teach the New Physics to the New World. For their advanced understanding of these revolutionary scientific ideas and their special political instinct they were called *the Martians*. Neumann, Szilard, and Teller enjoyed being called Martians, only Wigner did not. He considered himself to be the slowest among the four friends, but he was the one not only sparking with ideas but completing works. This is why it was he who received the Nobel Prize. Wigner enjoyed Teller's wide interest and lightning logics. He acknowledged Szilard's originality, but was puzzled by his pushy character, opposite to Wigner's polite modesty. He admired the superiority of Neumann's brain the most.

The late 1920s and the 1930s were heroic times for quantum mechanics: it was successfully applied to explain the empirical facts collected in spectroscopy, chemistry, atomic physics, molecular physics, solid state physics, nuclear physics. Eugene Wigner and his students like John Bardeen (later a Nobel laureate) and Frederic Seitz (later president of the National Academy of Sciences) played a leading role. Wigner published over 60 fundamental papers in these years, alone and with such celebrities as Michael Polanyi, Pasqual Jordan, John von Neumann, Victor Weisskopf, Frederick Seitz, John Bardeen, George Breit, R. Smoluchowski, and Edward Teller.

From time to time Wigner visited Hungary to spend holidays with his family, and to lecture at the Colloquium organized by *Rudolf Ortway* about quantum mechanics in Budapest. Professor Ortway invited Paul

Adrien Maurice Dirac, the Nobel laureate creator of relativistic quantum mechanics, to lecture at his Colloquium. Dirac was known to be withdrawn, not interested in social activities. Therefore it was a great surprise when in the next year Dirac himself offered a new visit and lecture to Ortvay. Dirac arrived, "by chance" his visit happened in coincidence with that of Wigner, and they both spent a relaxing holiday at Lake Balaton, together with Wigner's sisters. After one of his prominent visits, the deeper reason for Dirac's interest in Hungary became understood: he married Manca Wigner.



The neutron, a new nuclear particle with zero charge, was discovered in 1932. Wigner Jenő published his first paper on nuclear physics in Hungarian, in the periodical of the Hungarian Academy in 1932, about *the theory of neutrons*. He showed how quantum mechanics can be used to understand nuclear properties. Hideki Yukawa began his Nobel lecture by saying:

– *Wigner pointed out that nuclear forces between two nuclear particles must have a very short range, in order to account for the rapid increase of the binding energy from the heavy hydrogen to the helium.*

Wigner recognized a new symmetry in Nature which manifests itself in the *conservation of the total number of protons and neutrons*. (Antiprotons and antineutrons are counted with minus signs.) Proton and antiproton can annihilate each other, but our world¹¹ survived billions of years due to *the conservation theorem of baryonic charge*.

In the meantime history took sharp turns, and Wigner played a decisive role in them. In the 1930s Wigner studied the theory of nuclear reactions (esp. those initiated by neutrons). Thus, as LEO SZILARD brought the news about the discovery of uranium fission in January 1939, they immediately understood its importance in enabling a neutron chain reaction, and elaborated a theory for it. Wigner's close link to the other Princeton professor, Albert Einstein, was essential in sending the historic letter to President Roosevelt. Wigner's role in the Manhattan Project made history: he designed the large reactors in Hanford, which supplied plutonium for the Nagasaki bomb. After the collapse of Nazi Germany, his Central-European historical instinct led him to join Szilard's efforts to prevent the use of atomic weapon against the Japanese. After Nagasaki, after World War II he became director of the Oak Ridge National Laboratory, leading the design of new nuclear reactors. He obtained 37 patents

¹¹consisting of protons, neutrons, and electrons, but no antiparticles

[facsimile]. But the causalities in Hiroshima and Nagasaki haunted his conscience throughout his life: was dropping the bomb on cities really necessary?¹² This made him propose the defense program against nuclear weapons. This made him think about the future.



– Eugene and Heckmann were lying on the lawn near the municipal swimming pool in Göttingen. Heckmann (a German astronomer) observed that a trail of ants was crawling across Eugene's right leg, and he asked Eugene "Don't they bite?" The answer was "They do." Question: "Then why don't you kill them?" Eugene Wigner: "I don't know which one it was." – This story was told by Edward Teller.¹³ According to his other story, while Wigner was driving in Princeton, another car crossed the street unexpectedly. As the blood pressure went up, Wigner shouted at the other driver: – *Go to hell – please!*¹⁴

According to John von Neumann, when Leo Szilard entered a revolving door *following* somebody, he somehow managed to come out *first*. Not so with Wigner. If you are accompanied by Wigner, and let him enter the revolving door first, he manages to leave it last. – *In America every physicist knows Wigner's modesty* – VALENTINE TELEGDİ said.¹⁵ – *This is, however, an "apparent" modesty. Wigner knows his own value very well, the modesty serves only as a defense against provocation.* – Edward Teller characterizes Wigner: – *When he says to a seminar speaker: "What you say is interesting," that is a much harder criticism than my saying to the speaker: "That's damned nonsense."* – (The author of the present book experienced this behavior of Wigner upon himself.)

As a small child, Eugene was taken on an excursion in a carriage. He was supposed to chat politely with grownups, but he would have preferred talking with the horse. Unfortunately, the horse did not speak Hungarian. But he kept this kind of interest through his whole life.

Albert Einstein – and a lot of other giants of physics – had reservations with respect to quantum mechanics because it is not deterministic in the strict Newtonian sense. One can compute the time evolution of the wave function, but at the instant of *measurement* the wave function suddenly shrinks to one of the eigenfunctions of the measured quantity,

¹²Budapest 1987

¹³in the foreword of Francis S. Wagner: *Eugene P. Wigner*, 1981

¹⁴Telegdi to the author

¹⁵in a lecture in Hungary 1989

and we cannot predict exactly to which of them. Quantum mechanics offers only probabilistic prediction about the outcome of a measurement, and about its impact upon the state of the microobject. – *But what is a measurement?* – asked Wigner. He tried to give himself an answer. It is the interaction of the real outside world with the mind of the physicist. This has raised the further question of consciousness. What happens if a human looks at the measuring device but he misses appreciating the position of the dial? And do animals possess consciousness? In his last years, Eugene P. Wigner thought more and more about *consciousness* and its relation to quantum mechanics. In his acceptance lecture for the honorary Ph.D. degree at Eötvös University, Wigner expressed his personal opinion:¹⁶

– *There are phenomena which physics cannot yet describe. For example, it cannot describe life, emotion, or consciousness. This situation is like not taking gravitation into account would be. But gravitation exists and life exists. I am here, I feel joy and desire. It used to be said that man is subdued to the laws of physics, and his emotions are irrelevant. I cannot accept that! I am convinced that the sequence of events is influenced by my consciousness in a similar way as it is influenced by the force of gravity. If this were true, there would be something which physics is not interested in as it was not interested in the existence of atoms 100 years ago.*

– *I can imagine that the human intellect has its own limitations just as the animal brain is limited. Once I tried to teach the multiplication table to a nice and skillful dog. Not to make a difficult calculation like $6 \cdot 8$. Rather, I showed him 2 squares and 3 squares, and I wanted the dog to indicate that the product makes 6 squares. I failed. The dog can learn very different skills, but it seems not to be interested in multiplication. Up to a certain degree we are like animals. It is quite possible that our interest and our knowledge is limited as well. I would like to hope that understanding life does not lie beyond the limits of our intellect. We have learned to describe the behavior of gases and the behavior of atoms. Once perhaps we shall understand life as well. This is why one cannot exclude that a deterministic description of the human mind will not be possible. It may be that present physics will be enough to describe a bacterium. When it succeeds, the bacterium will not be considered to be alive any longer. But in order to describe the whole complexity of*

¹⁶*The Future of Physics*, printed in the *Heavy Ion Physics* Volume 1, a *Wigner Memorial Volume*, Budapest 1996, published by the Hungarian Academy of Sciences

life, including human consciousness, we shall be unable to restrict ourselves to pure wave functions, because the impact of the macroscopic environment disturbs it immediately, e.g. by the cosmic background radiowaves, which are present everywhere with a temperature of 2.7 K. – It is well possible that understanding consciousness remains as far from the human intellect as multiplication from my dog.

According to Wigner, Newton was the greatest physicist because he was able to condense all the available knowledge about the physical Universe in the single volume of the *“Principia.”* The early 20th century Wigner welcomed the arrival of relativity and quantum theory because they promised a compact world picture again at the price of a certain abstraction. As a matter of fact, Wigner’s monography on *Group Theory and its Application to the Quantum Mechanics of Atomic Spectra* is a rather successful attempt to offer a synthesis for the 20th century.

Seeing the expansion of physics, the recent flood of scientific information filled him with anxiety. At the age of 85 he was asked by Hungarian secondary school students about his view of the future:¹⁷

– Well, please, it is a hard question. The realm of physics has been extended tremendously. In the first book I ever read about physics when I was 17,¹⁸ it said: “Atoms and molecules may exist but this is irrelevant from the viewpoint of physics.” Only chemists were interested in atoms. It is marvelous that physics succeeded in explaining atoms. It is not clear whether such a success will be also reached in the future. How far humans can progress in science is not clear.

– Physics has offered me a lot of joy. I loved physics. I still love it. But I cannot grasp a considerable part of recent physics: it is getting too complex and too sophisticated for me. But if a single person is able to catch only smaller and smaller fractions of science, and cannot understand the essence of science, young people may lose their interest in it. Today it is almost impossible to know the whole of physics. I consider this complexity to be a danger for the future of science. If people don’t get an overview, they may lose interest. If they are not interested, they will not learn science. If young people do not study science, that will terminate the development of science.

– I am deeply worried that we have not yet received any message from alien civilizations. It is probable that there are other habitable planets; people or other similar creatures may live on them. It is likely

¹⁷1987

¹⁸written by Sándor Mikola

Eugene Wigner, 92, Quantum Theorist Who Helped Usher In Atomic Age, Dies

By WILLIAM J. BROAD

Eugene P. Wigner, a physicist who made fundamental advances in nuclear physics and quantum theory and helped usher in the atomic age, died on Sunday at the Medical Center in Princeton, N.J. He was 92 and lived in Princeton.

The cause was pneumonia, said Princeton University, where he spent much of his career.

His greatest contribution to science, for which Dr. Wigner won the Nobel Prize in Physics in 1963, was his insight into quantum mechanics, a cornerstone of modern science that looks at the behavior of subatomic particles. He discovered a way to understand the complex actions of electrons, which circle all atomic nuclei in discrete energy bands, jumping from one quantum level to another.

In pioneering this approach, Dr. Wigner became one of the first scientists to peer into the subatomic realm to see the deep symmetry involved in the balance of counterbalancing forces and particles, a perception that subsequently emerged as one of the guiding principles of 20th-century physics. Today the scientific canon includes Wigner crystals, Wigner theorems, Wigner energy and Wigner rules — all tending to be expressions of symmetry and order.

Dr. Wigner was part of a circle of remarkably visionary scientists born and educated in Budapest who eventually came to the West and



Dr. Eugene P. Wigner

transformed the modern world.

In 1920, having glimpsed the possibility of a nuclear chain reaction, Dr. Wigner was one of three prominent scientists who persuaded Albert Einstein to alert President Franklin D. Roosevelt that an atomic bomb was probably feasible and that Hitler might build it first. Their warning led the United States to start the Manhattan Project to build the atomic bomb.

In 1942, he took a leave from Princeton University to work at the University of Chicago, where he made important contributions to the bomb effort. He helped perfect the world's first nuclear reactor, which marked the beginning of the nuclear era.

In the decades after the war, Dr. Wigner became a leader in the development of nuclear energy as well as a staunch anti-communist and political conservative. He sought to minimize the potential effects of nuclear war by urging the construction of bomb shelters, in contrast to colleagues who focused on trying to prevent the bomb's use.

Late in life, he became fascinated by the philosophical implications of quantum mechanics and what he called "the unreasonable effectiveness of mathematics" in describing the natural world. The two, he said, are "disturbingly similar."

Physics, Dr. Wigner once remarked, "has given us the ability for a deeper understanding of nature, this leading to a more carefree life

both materially and also spiritually." But he added that it had also "induced some humility into our thinking by acquainting us with the fact that we are not at the center of the universe — that we inhabit one of the planets of one of billions of stars."

Eugene Paul Wigner was born in Budapest on Nov. 17, 1902, as the second of three children. His father directed a leather factory, and his parents put great emphasis on his education.

Budapest at the turn of the century had celebrated schools that produced no fewer than seven of the 20th-century's leading scientists. In addition to Dr. Wigner, they are Theodor von Karman, George de Hevesy, Michael Polanyi, Leo Szilard, John von Neumann and Edward Teller. While growing up in Budapest, Dr. Wigner befriended Dr. von Neumann as well as others who became prominent scientists.

He developed a lifelong hatred of communism, which revolutionaries took over Hungary after World War I, forcing his family to flee their city temporarily.

Graduating from high school in 1920, he studied chemical engineering under Dr. Polanyi at the Berlin Institute of Technology; he received his Ph.D. in 1925 and got an appointment there soon afterward. In Berlin, he met some compatriots from Hungary, Dr. Teller and Dr. Szilard, and formed close friendships with them.

Dr. Wigner was soon swept into the turmoil of modern physics, which was trying to right itself after being upended by bizarre new theories like quantum mechanics, which seemed akin to magic in some ways. In the ordinary world, an object either exists or does not. But quantum theory provides that something at the subatomic level can both exist and not exist simultaneously. It also postulates that some nebulous, wavelike states of being assume definition form only when they are actually observed.

Dr. Wigner's pioneering ideas on group theory and quantum mechanics appeared in a series of six papers published in 1927 and 1928, when he worked at the Institute of Technology in Berlin. He wrote three of them at Princeton University, where he cooperated with Dr. von Neumann. His book, "Group Theory and Its Application to Atomic Spectra," originally published in German in 1931, remains a scientific classic.

Dr. Wigner came to the United States in 1930 and took a post at Princeton University, where he remained, except for short stints elsewhere, until his retirement in 1971.

In the 1930's, he made major contributions to nuclear physics, eluci-



Dr. Wigner, second from left, posing with Albert Einstein, in long coat, and other physicists at Princeton.

A bold physicist who changed science's perception of subatomic particles.

dating new details of how protons and neutrons are bound together in atomic nuclei and helping to explain how free neutrons can be absorbed in nuclei. Such work eventually played a role in the effort to create a nuclear bomb and a nuclear reactor.

"Under the direction of Enrico Fermi, Dr. Wigner helped develop many of the theoretical methods that formed the basis for the world's first controlled chain reaction, which began on a squash court at the University of Chicago on Dec. 2, 1942, as a neutron counter began clicking wildly."

"Nothing very spectacular had happened," Dr. Wigner once recalled. "Nevertheless, when the rods were pushed back in and the clicking died down, we suddenly experienced a sidown feeling for all of us under the hood of the counter. For some time we had known that we were about to unlock a giant," he continued. "Still, we could not escape an eerie feeling which we

knew we had actually done it. We felt as, I presume, everyone feels who has done something that he knows will have very far-reaching consequences which he cannot foresee."

Fearful that Hitler's scientists were making nuclear progress, Dr. Wigner threw himself into designing reactors for Hanford, Wash., which made plutonium for atomic bombs.

As the war's focus shifted to the Pacific, he came to feel that Japan would surrender without the devastation wrought by an atomic bomb and signed a petition opposing its use.

After the war, Dr. Wigner served briefly as the director of research and development at the Clinton Laboratories in Oak Ridge, Tenn. The site, which pioneered new kinds of reactors, eventually became known as the Oak Ridge National Laboratory.

Back at Princeton, he pursued his theoretical studies, receiving the Nobel Prize. The range of his contributions was reflected in the citation, which honored him for "systematically improving and extending the methods of quantum mechanics and applying them widely."

From 1964 to 1965, he served as director of civil defense research at Oak Ridge National Laboratory. He called such work "one of the most essential endeavors in this country."

Dr. Wigner was often outspoken

and went out of his way to laud Dr. Teller, an old Hungarian compatriot who became vilified in liberal circles for his hawkish views. On the occasion of Dr. Teller's 80th birthday, Dr. Wigner called him a "great man" of vast imagination and "one of the most thoughtful statesmen of science."

Over his long career, Dr. Wigner collected many prizes and honors, including the National Science Medal, the Albert Einstein Award and the Max Planck Medal of the German Physical Society. He held honorary degrees from Princeton and 26 other schools.

In 1990, after the fall of Communism in Hungary, Dr. Wigner accepted a high prize in that country, the Order of the Banner of the Republic of Hungary With Rubies. In 1994, he was given the country's highest accolade, the Order of Merit, "as an acknowledgment of his scientific career and of his outstanding achievements in the enrichment of universal human values."

Dr. Wigner is survived by his wife, Eileen Hamilton Wigner of Princeton; three children, Erika Zimmerman of Berlin, David Wigner of Paris and Martha Upton of Hudson, Ohio; two grandchildren, and two sisters.

A memorial service is to be held at the Princeton University Chapel at 1:30 P.M. on Jan. 28.

that some of these civilizations have developed more knowledge than we have. Therefore it is surprising that they have not established contact with us. I don't think on a direct visit because of the huge distances, but they might use telecommunication. I am surprised that there is only one earth and only one species which is interested. There are two possible explanations for this puzzle. One possibility is that they developed science and technology in the past, they started an arms race, and then they annihilated themselves and their whole planet. If this is a rule of the development of intelligence, it could explain the silence. Another possibility is that they developed science, which raised their standard of living. The luxury made them lazy, they gave up reading books and learning science. It is also possible that physics turned out to be too complicated for them, thus they found it boring, and stopped being interested in science. This is why those beings ahead of us by 50 years or more are not interested in contacting us. I hope I am wrong. I hope my fear of an end of the story is mistaken. I don't know.

In his last two decades WIGNER JENŐ visited his home country several times, lectured to students and professors, published in Hungarian, became an honorary member of the Eötvös Society, and also a member of the Hungarian Academy of Sciences. In 1995 he was buried in the Princeton Cemetery at the side of his former wife Mary. In Hungary, hundreds of people attended the Memorial Session on the 23rd of January 1995. In schools physics teachers spoke about his scientific and historic importance to their students. *The New York Times* printed a six-column obituary about *the bold physicist who changed science's perception of subatomic particles and who helped usher in the Atomic Age* [facsimile]:

– *Wigner was part of a circle of remarkably visionary scientists born and educated in Budapest who eventually came to the West and transformed the modern world.*

Teller Ede – Edward Teller

1908–

What happened in my youth in the first three decades of the 20th century in physics, is as beautiful as Renaissance art or Baroque music. Quantum mechanics is much more beautiful than working on nuclear weapons. To explain superconductivity is much more difficult, much more exciting and much more appealing than thinking about military applications. Our duty is the quest for knowledge. I trust the society I live in that it will use this knowledge in a rather sensible way.

(E. T.)

Ede did not speak at all in the first three years of his life, then suddenly started communicating in complete sentences.¹ During meals, occasionally he declared: – *Please, don't talk to me, I have a problem.* – Koko (this was his nickname) was not a typical child, before sleeping he liked to calculate in his head how many seconds are in a hundred years, or some such problems. – *The most interesting point was that I always obtained a different result.* – He was mercilessly logical. In primary school, during a religion lesson he was instructed: *In the beginning God created Heaven and Earth.* – *But who created God?* – he asked. – *The Serpent in the Garden of Eden had been condemned by God to crawl on its belly.* – His question came, – *How did the serpent get around before that?*² – Older Jews remembered how their parents escaped from the Russian pogroms initiated by the Eastern Orthodox popes. Koko's grandmother used to say: – *If you don't behave, the Russians will come and take you!* – (Behavioral scientists would call this imprinting.) When Ede spoke about his fear of life, his (maternal) grandfather told him: – *Don't be afraid. You have got a head, you have got a heart, don't be afraid of life!* – This made a life-long lasting impression on the young boy. At the age of twelve he thought, – *I know that Shakespeare was somebody, but Jules Verne means unques-*

¹according to his sister (a possible cause could be the bilingual family)

²Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

*tionably much more for me.*³ – For Teller, the future is always more relevant than the past.

Ede attended the Minta Gymnasium, the same school as THEODORE VON KÁRMÁN, NICHOLAS KURTI, MICHAEL POLANYI, and PETER LAX. After the suppression of the 1919 revolts the new regime made Dr. Karl Oberle the director of the school, and he taught mathematics in Ede's class (age 14). The teacher worked out an algebraic proof on the blackboard, but Teller raised his hand. The teacher asked: – *Any problem, Teller?* – *Sir, I think it can be done in a simpler way.* – He did it and was right. Oberle reacted: – *So you are a repeater!?* (one who took the class before but failed).⁴ – This was not the last difficulty Teller was to meet in his life.

At the age of 16, he got acquainted with Maxwell's equations: – *Maxwell's equations were beautiful indeed. Studying them went pretty fast. When I concluded, in the evening I listened to Beethoven's 9th Symphony. I found the symphony a bit more beautiful than Maxwell's equations but considerably more difficult.*⁵ – At 18 he won both the mathematics and the physics competitions. (LÁSZLÓ TISZA was a co-winner in physics.) One of the problems to be answered was: “*Would the water level in a glass of water with ice cubes floating in it rise or fall as the cubes melted?*” Immediately a student song about the law of Archimedes came alive in Ede's mind, and he proudly wrote: – *The water level does not change!*



Max Teller, an educated prosperous lawyer, who was aware of his son's potential, made him to meet John von Neumann, Leo Szilard, Eugene P. Wigner, then recommended Edward that he study *chemical engineering*, to earn money and to create a promising future for himself. Thus the common fate of the Martians reached Ede as well. Ede enrolled at the Budapest Institute of Technology to study chemical engineering. He attended this university in Budapest until Christmas. Then – at the persuasion of his father – Edward boarded a train to Karlsruhe on 2 January 1926.

The University in Karlsruhe had an excellent school of chemistry, relying on the German industrial giant, I.G. Farben. Edward Teller studied chemistry, and mathematics as well, until he met Herman Mark. Let us listen to the impressions of Professor Mark: – *Very frequently, during the*

³to the author 1994

⁴Teller to the author 1994

⁵as he added to the author, quantum theory has turned out even more difficult than Beethoven's opus, 1996

lecture or at the end of the lecture, this young student would say, "Well, I think that was very interesting, but if you don't mind, I presume what you really wanted to tell us was this ..." and he'd explain his idea in a Hungarian accent, and he was always right!⁶ – The young professor lectured about quantum mechanics as the new base of chemistry. This was irresistible for Teller. It was Herman Mark who made Edward Teller a physicist. (It is apparently a Martian syndrome to vacillate between chemistry and mathematics, and then to become a physicist. The author knows this syndrome well because he was trapped in modern physics in the very same way.) When the summer holiday arrived, Ede rushed home, happily sighting János Hill from the window of the train, indicating the arrival in Budapest. Ede made a rhyme:⁷

*Aki Karlsruheban szenved éveken át,
vonatból meglátja Jánosbegy szent ormát...*

("He who suffers in Karlsruhe for years, can now see the holy peak of János Hill from the train.") The young man enjoyed the holidays at home. During the summer of 1927 while walking with three of his friends⁸ in the hills of Budapest, they wrote an epos of their excursion to Dobogókő.

– *My hometown is built around a river. I have lived near the Tiber, the Thames, the Hudson, and the Rio Grande, but no river warms my memory as the Danube does: the river and the beautiful bridges* – Ede remembers even in his 80s. In the summer he worked in the research lab of the Tungsram factory. – *69 years ago – according to the wish of my father – I was a sophomore in chemistry at the University of Karlsruhe, but during the summer holiday I worked as a physicist in the Tungsram Factory in Budapest under Paul Selényi for a few weeks. When he noticed my interest in the new physics, he encouraged me to work in the field I liked. But my father insisted I study chemical engineering to find a secure job. Hearing this, Selényi wrote a letter to my father saying that he would offer me a physicist's job any time at Tungsram if I wished. This made an impact on my father. After this event, Selényi told me a story. "Once an explorer prepared himself for a dangerous expedition. Seeing the anxiety, his friend gave him a small closed box with the instruction: "The box must not be opened any time but in case of mortal*

⁶Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

⁷Paul Erdős to the author 1996

⁸Harkányi Mici's brother, Tibor László, Nándi Keszthelyi

danger!» The explorer experienced dangers but never a mortal one. But at his late age, he became so curious that he opened the box. To his surprise he found the box to be completely empty.” This was also my case with Selényi’s letter sent to my father: “In case of need Tungsram will help.” Sixty nine years passed by but I never made use of the letter, but it encouraged me to follow my own path, to become a physicist. I did not do much for Tungsram but Tungsram helped me.⁹

In the spring of 1928 Edward was already studying at the University of Munich under the Great Old Man of quantum theory, Arnold Sommerfeld. Teller was not enthusiastic about the “Geheimrat” style of the professor because – “I don’t like Geheimrats very much.” – John J. van Vleck was also an assistant there, learning German. One morning, when Arnold Sommerfeld entered the library, Van Vleck greeted the boss: – *Guten Morgen!* (Good morning.) – No reaction. On the next morning he said: – *Guten Morgen, Herr Doktor!* (Good morning, Mr. Doctor.) – No reaction. One day later the greeting was, – *Guten Morgen, Herr Professor!* (Good morning, Mr. Professor.) This was appreciated with a smile. On the subsequent day, Van Vleck tried, – *Guten Morgen, Herr Geheimrat!* (Good morning, Mr. Privy Councilor.) – Sommerfeld answered: – *Ihr Deutsch wird jeden Tag besser!* (Your German improves every day.)¹⁰

The time spent in Munich was interrupted by an accident: On 14 July 1928 Teller was riding in a streetcar, heading for an excursion. Possibly thinking of something more interesting, he missed getting off at the rail station, jumped off the streetcar already in motion. His rucksack might have changed the distribution of his inertia. The streetcar threw him forward and he rolled. As the tram passed by he noticed his boot lying at a distance beside the track. His first thought was: – *How can I go to the hills without a boot?* – A few seconds later Edward noticed another problem: a part of his right foot was in the boot.¹¹

Surgery, amputation in Munich and Budapest followed, and an artificial leg at the age of 20. Edward decided not to give up. He enjoyed thinking, piano, chess; later he learned hiking again, even excelling in ping-pong. In the autumn, he returned to Germany – not to Munich but to Leipzig, where Werner Heisenberg, the creator of quantum mechanics, was a young professor.

⁹Teller recalled at the Tungsram Centenary Festival, Budapest 1996

¹⁰Teller to the author 1994

¹¹to the author 1994

– *It is more difficult to express the idea of an atom with a picture than it is to make a drawing of last night's dream.*¹² – This was the year of Heisenberg's uncertainty relation. Physicists in Germany began to use quantum mechanics, and the sharp turn of philosophy became apparent. – *The opponents will not be convinced, they will die away* – Planck stated in a cruel way. The average age of those working around Heisenberg was below 30. Edward managed (after the accident!) to beat all of them in ping-pong, Heisenberg included. – *But Heisenberg was very ambitious. He made a trip around the world. On the long boat ride he learned to play ping-pong from a Japanese passenger so well that after his trip I never succeeded in beating him.*¹³ – Heisenberg characterized Teller:¹⁴ – *Teller was logical. He usually bested his friends with cold logic, for such a young man he was so precise and so definite both in questions and answers.* – In Leipzig Teller prepared his Ph.D. thesis:

– *Heisenberg gave me a simple problem. Besides the hydrogen atom, the ionized hydrogen molecule is the simplest structure: just two protons and a single electron. Two papers were published on it; a Danish physicist solved the equation numerically for the ground state, and an American proved that no solution exists. Heisenberg asked: – "Find out which of them is right!" – I have learned mathematics, functions interested me. Unfortunately, the American had read a lot about functions but understood only about 50 % of it: he postulated that the wave function must behave in a completely regular way, and the solution of the two center problem did not do so. The Dane, however, used the distances of the electron from the two protons as elliptical coordinates and in this way succeeded in separating the variables in the Schrödinger equation. Evidently, he was interested in the wave function only for real positive elliptical coordinate values. The function at infinite, negative, or imaginary coordinates – where singularities occur – does not have any physical relevance. I told Heisenberg that the Dane was 100 % right. He said: – "All right. Then calculate the excited states as well!" – So I did. There was a mechanical calculator in the institute. It produced some numbers but much more noise. I turned the machine by hand for a year. At that time I slept better than now, mainly in the mornings. In the afternoons I came to the institute to chat and read. I worked on my thesis in the night. I was 21, Heisenberg was 28,*

¹²Edward Teller: *Our Nuclear Future*

¹³to the author 1990

¹⁴Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

he lived in a room just above my office, where I produced numbers and noise. Once, after midnight he walked down and asked, – “When will you be ready?” – “Perhaps one year more.” – “Is what you have produced till now not yet enough?” – He looked at my results and said: – “It will be enough. Write it down for the thesis.” – I don’t know till today whether I have obtained Ph.D. degree (1930) because my work was more than enough or the noise. But I swear: I did not made the noise intentionally to get the Ph.D. degree earlier.¹⁵

Teller’s first field of research was molecular spectroscopy. The unconditional occurrence of degenerate states in linear molecules is called the Jahn–Teller effect. (Clockwise and counter-clockwise rotations around the molecular axis have equal energies.) From Leipzig he went to Göttingen (as Martians used to do) to become an assistant, working with James Franck (to-be-Nobel-laureate and Teller’s partner in the Manhattan Project). He traveled Enrico Fermi in Rome, then worked at Niels Bohr with a Rockefeller fellowship in Copenhagen. Teller visited Hungary every summer, married Mici Harkányi, the sweetheart of his youth (1933), fighting all the objections of the Rockefeller Foundation, which was not enthusiastic “to sponsor a honeymoon.” (When sixty years later Edward was taken around in Hungary, he stopped the car in Mátrafüred to recall the sweet memory of a lovely excursion with Mici taken just a few years before their marriage.)



In Copenhagen Edward Teller met George Gamow, the Russian emigrant. They took rides together on a motorcycle in Denmark. Then Gamow was invited to George Washington University (in Washington D.C.). He posed two conditions: first that he be allowed to organize an annual conference on theoretical physics (similar to the ones held by Bohr in Copenhagen); second, to get a job for a co-worker in the same field. So it happened that the 27-year-old Teller obtained a full professorship: – *There’s this one man who knows everything, just everything* – Gamow said. The invitation reached him in London, and could not be resisted (1935). The U.S. Immigration Office tried to resist but in vain. In the Minta Gymnasium Teller had a schoolmate called Balogh Tamás, who had got the nickname *Sir Balogh* from the other boys for his behavior. Martians are able to tell the future: he became a prominent economist in England and was made Lord by the Queen. Well, LORD BALOGH, the former schoolmate used his influence and the Tellers obtained American visas. He was asked to lec-

¹⁵Teller to the author 1990

ture about quantum mechanics to American students. Even senior people came to listen to his lectures because quantum mechanics was something very new in the United States. Professor Teller was hard with examinations by American standards.¹⁶

Gamow turned Teller's attention toward nuclear physics.¹⁷ Gamow lectured on nuclear physics, among other topics on the theory of α -decay via Gamow-tunneling, and on the nuclear origin of stellar energy, based upon the pioneering paper of Robert Atkinson and Fritz Houtermans. Houtermans – quoted also on the back cover – was a typical Central-European character: he was of Dutch–Jewish descent, did a Ph.D. in Göttingen, as a communist went to the Soviet Union, spent a few years in Stalin's prison, after the Hitler–Stalin pact was given back to Germany, meaning the hands of the Gestapo (1939). Laue managed to free him and Houtermans survived as part of the German nuclear research project; he proposed to use the element 94 for nuclear chain reaction. To the critics of his Jewish origin he reacted: – *Your ancestors were still living in the trees while mine were already forging checks!*¹⁸ – During a walk in Göttingen with the British Atkinson they conceived the first idea of the nuclear origin of solar energy (1927). With Gamow they later coined the name “*thermonuclear reaction*”. Gamow and Teller published a joint paper on the theory of thermonuclear reactions (1938) and organized the 1938 Washington Conference on this topics. Teller vividly remembers:

– *I liked to work with Gamow. He enjoyed laughing at others, not so much at himself but we could laugh at him. I was young and liked sleeping long. At dawn, 10 a.m., he called me almost every day, and told me his idea of the day, which was mostly wrong. His imagination was greater than that of all the science fiction writers combined, Isaac Asimov included. He had a good property: he tolerated my contradicting him. But about once a week his idea turned out to be good, I found no mistake in it. In this way we worked well together. Gamow was interested in the energy source of the Sun and stars. Nuclei have positive charges, repelling each other. At collision, the chance of fusion depends on two factors. One is the Boltzmann factor: at a given temperature only a tiny fraction of atoms possesses large kinetic energy. The other is the Gamow factor: parti-*

¹⁶Ralph Alpher to the author 1991

¹⁷Teller educated Nobel laureate Cheng Ming Yang, and reeducated Maria Mayer to become a nuclear physicist, obtaining the Nobel Prize for the nuclear shell model. (Originally she was a student of Max Born.)

¹⁸Richard Rhodes: *The Making of the Atomic Bomb*, 1986

cles repelling each other may get in touch due to quantum tunnelling, even if classical physics forbids. We multiplied the two factors, to obtain the formula for thermonuclear power (1938), it is in use even today. In Washington our theory of thermonuclear reaction inspired Hans Bethe and he blessed us with a third small factor. Two colliding protons cannot do anything with each other because ${}^2\text{He}$ nucleus does not exist. The only exception is when they suffer β -decay at the instant of the collision, to make ${}^2\text{H}$, but this has a very low probability. Proton-proton fusion is still the most important supply of solar energy. This is how we have come to understand, step by step in 1938, how the Sun shines since billions of years, keeping our Earth pleasantly luke-warm.

In the 1940s George Gamow and Ralph Alpher elaborated the theory of nuclear build-up in the Early Universe, based upon the theory of thermonuclear reactions. (This has got the nickname α - β - γ theory, because it was published under the names of Alpher, Bethe, Gamow, just for fun; Bethe did not know about it.) Alpher remembers that the primordial nucleosynthesis was liked by physicists but rejected by astronomers. (It was one of the first papers, read by the author as a student, and reported in a seminar at Budapest University under strong opposition of his astronomy professor.) Today the agreement between the theoretical isotope ratios of the light elements, deduced from neutron reactions in "the first three minutes," and those obtained from astronomical observations serve as the main proof of the Big Bang theory.

As Maurice Shapiro recalled,¹⁹ he first met Teller when Edward visited Chicago (1939). There were seminars running, one on *astronomy*, another one on *molecular spectroscopy*, a third one on *nuclear physics*, and Teller addressed all the three seminars. *In nuclear physics* he complemented Fermi's theory of the β -decay by introducing the spin-flip Gamow-Teller transitions with George Gamow. He was interested lifelong *in astronomy*, in exotic topics like the collision of a galaxy with an anti-galaxy, the collision of a giant comet with the Earth, the probable intensive interstellar contact of civilizations in dense stellar clusters. *In molecular spectroscopy*, Teller explained the observed lowest-lying excited state of the benzene, and its emission line in the near ultraviolet region.²⁰

¹⁹to the author 1994

²⁰According to Pauling, the ground state of the hexagonal molecule is the positive superposition of two "resonant" states, in which the simple and double bonds are distributed the opposite way. Teller postulated another state of negative superposition; the vibration of deformed hexagonal structure can provide a dipole moment and radiates.

The Washington Conference on Theoretical Physics, which entered history, was the one in January 1939, organized by Gamow and Teller: Niels Bohr announced the discovery of nuclear fission. The following events brought nuclear power from the Sun to the Earth, in which Edward Teller played an active role.

George Gamow would have been predestined to take part in the making of the atomic bomb: he had worked on stellar power and thermonuclear chain reaction before the others. When in the Soviet Union he became an enthusiastic proponent of the quantum theory, he fell out of grace. He was removed from Leningrad University and was sent to instruct meteorology in a military garrison and was given a military rank to do that. Later he escaped from the Soviet Union; therefore he was sentenced to death in absentia in Leningrad. But he did not get a security clearance in Washington either because he had been an officer of the Red Army. Thus he was excluded from the Manhattan Project.

It just so happened in late 1941 (just before the Pearl Harbor attack), that in Chicago, walking back to work in the Met Lab after lunch, Fermi raised the question to Teller: if the chain reaction of nuclear fissions created a temperature exceeding the central temperature of the Sun, could the intensive thermal motion of nuclei not initiate a self-sustaining thermonuclear fusion chain in heavy hydrogen? This was the initiation of Teller's quest for the hydrogen bomb. In the summer of 1942, at a confidential meeting in Berkeley, Teller reported his idea of the "super."

Before the first bomb test in Alamogordo, Oppenheimer asked Teller to check once again whether the Earth would be safe from a runaway thermonuclear reaction. – *This of course did not merely relate to the laws of physics as we knew them, but to the laws of physics that might be unknown to us, to a possible phenomenon that might exist that we had not discovered as yet. This was the kind of job that was really delightful for me: to try to speculate in these wide ranges.*²¹ – His conclusion was negative concerning the doom of Earth, but positive concerning the thermonuclear chain reaction in heavy hydrogen.



The story of the atomic bomb has been told already. Teller contributed to the success of the fission bomb as well with the idea of compressing plutonium to extra high density, meaning less plutonium per bomb, being essential to speed up the fabrication of atomic bombs in the last weeks of World War II. (Now even ²³⁵U bombs work with implosion.) In

²¹Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

Los Alamos, however, Teller behaved,²² “as a rebel on the assembly line”: he was more interested in speculating about the “super” than on daily calculations of the implosion. This increased tension between Bethe and Teller, so Oppenheimer made Teller independent of Bethe’s Theoretical Division. Fermi once told him: – *In my acquaintance you are the only monomaniac with several manias.*

After the victory in World War II, the nuclear industry was developed. In 1947 Edward Teller became the head of the Committee for Reactor Safety. Upon recommending Edward Teller for the Fermi Award, Alvin Weinberg, the designer of water-moderated reactors, acknowledged Teller’s merits as decisive ones in ensuring the safe operation of nuclear reactors in the United States.

After the Geneva conference on Peaceful Uses of Atomic Energy, in 1956 the General Dynamics Corporation (General Atomic) organized a workshop in San Diego (California) on commercial reactors. Teller was asked to lead the discussion on safe reactors. – *He intended to design a reactor so safe that it could be given to a bunch of high school children to play with, without any fear that they would get hurt. Usual reactors are controlled by neutron absorbing control rods. The result of suddenly pulling out the control rods would in most cases be a catastrophic accident. All large reactors are therefore built with automatic control systems which make it impossible to pull the rods out suddenly. For Teller, engineered safety was not good enough. He intended to design a reactor with inherent safety, meaning that its safety must be guaranteed by the laws of nature and not merely by the details of engineering. It must be safe even in the hands of an idiot clever enough to by-pass the entire control system. Teller’s ground rule for the safe reactor was that if it was started from its shut-down condition and all its control rods instantaneously removed, it would settle down to a steady level of operation without melting of its fuel. So we designed the safe reactor TRIGA (reactor for Training, Research and Isotope production from the General Atomic). From Teller’s original proposal it took less than three years for the first TRIGA reactors to be built and licensed. In twenty years 60 Trigas had been sold. It is one of the few reactors that made money for the company that built it.*²³ – Dyson played a decisive role in designing the TRIGA.²⁴ Nowadays Teller is highly inter-

²²Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

²³Freeman Dyson: *Disturbing the Universe*, Harper and Row 1979

²⁴Teller to the author 1994

ested in autonomous nuclear power plants built deep underground with a cooling system controlled by the laws of Nature, responding automatically to changing electric power consumption, untouched by any humans. When the nuclear fuel is exhausted, the reactor stops working and remains safely underground for eternity, avoiding accidents with the transport of highly radioactive waste and the danger of fabrication of nuclear weapons by overambitious political leaders. As James Arnold has put it:

– There may be better scientists than Teller but none more brilliant. You always had him a thousand feet ahead of you.



– In 1919, under the communist rule in Budapest two workers were given one room in our apartment. We were not happy but they were very polite. When I arrived in Germany, I did not have a definite political conviction. It was the time of the great depression; democracy did not work well in the Weimar Republic. The question was whether the world was going to become Nazi or communist. Some of my good friends, like Carl Friedrich von Weizsäcker, inclined to the Nazis, some others were devoted communists like my friends Lev Landau and LÁSZLÓ TISZA, assistant of Ortway in Budapest. When the police found communist leaflets in his desk at the Budapest University, Tisza was imprisoned. When he came out of prison, his career was ruined. I recommended him to Landau, who was then working in Kharkov. But after a few years spent in Stalin's empire, Tisza lost his illusions, emigrated from the Soviet Union to France, then to America, and said to me that Landau was not a communist any more either. Similar change happened to ARTHUR KOESTLER, which is why he wrote the novel, "Darkness at Noon." (John von Neumann took me for visiting Koestler.) Tisza's narrative and Koestler's book – which I read in Los Alamos – made deep political impressions on me. In a way, Koestler's novel is deeper than Orwell's "1984." In Orwell's book there are good guys and bad guys. But Koestler presents the arguments of both sides in convincing ways almost to the end of the novel. We realize the cruelty of the communist system only at the very end. Moreover, Orwell's story is a social science fiction, but Koestler's story happened indeed.²⁵

Teller's parents, his sister Emmi, and Emmi's family remained in Hungary. During World War II, Emmi's husband and Mrs. Teller's brother became victims of the Holocaust. Edward's parents and sister survived in the ghetto established in Budapest and were liberated by the Russian troops. But freedom did not last long. Max Teller, Edward's father died

²⁵Teller to the author, Budapest 1996

in 1950. In June 1951 Edward's mother, sister and her son – as capitalist elements – were moved by the police from Budapest to the small village of Tálya, and they were not permitted to leave the village. János Kirtz, Emmi's son tried desperately to study the secondary school subjects – by mail. After one and a half years they were allowed to return to Budapest, but not to their old home; that had been confiscated. Emmi was taken to a three-day long police interrogation about her knowledge concerning Edward, but she did not know anything. (They did not dare contact Edward Teller directly because the Cold War was on and Edward's role in the nuclear race was known too well. Emmi wrote letters to a former servant of the family who informed Edward.) When the Hungarians revolted in 1956, János Kirtz used the opportunity to escape, crossing the border illegally. Edward's elderly mother was not strong enough for such a dangerous trip. All her requests for a passport were refused. Late in 1958 Edward Teller had to visit Washington and bumped into LEO SZILARD. Teller invited Szilard to dinner. They began to discuss politics. Szilard was just becoming active in organizing Pugwash conferences, and pressed Teller to join him in a visit to Russia. Teller said *no*, explaining that he could be blackmailed in that his mother and sister could be kept as hostages. At a Pugwash Conference Szilard brought up the "absurd story" to the Russian delegate. The Russian reacted: – *Hungary is an independent country. We have nothing to do with what goes on in Hungary.* – But on the next day the Hungarian delegate, *Lajos Jánossy* approached Szilard.²⁶ Jánossy listened to Teller's case, then departed. Three weeks later, Teller's mother and sister were given passports. They left Hungary. On 18 January 1959, Edward met his mother and sister at the San Francisco Airport [facsimile]. This happened after Stalin's death.



Let us turn back to the Stalin era. World War II was over. In America, most physicists rushed back to the university, trying to forget about the atomic bomb. Not so for Edward Teller, who had more direct information of what Nazis had done in Hungary in 1944 and the communists had done in 1949: – *The war is not yet over; Russia is just as dangerous an enemy as Germany has been. The research on nuclear weapons must be continued.*²⁷ – He predicted that the Russians would soon have

²⁶Jánossy was an excellent researcher of cosmic rays, had studied in England and worked later in Ireland at the Institute for Advanced Studies, returning from there to Hungary in 1950.

²⁷Stanley A. Blumberg – Gwinn Owens: *Energy and Conflict*, 1976

THE UNIVERSITY OF CHICAGO
CHICAGO 37 · ILLINOIS
THE ENRICO FERMI INSTITUTE
FOR NUCLEAR STUDIES

January 21, 1959

AKADÉMIAI
LEVÉLTÁR

Professor L. Jánossy
Központi Fizikai Kutató Intézet,
Budapest - XII., Konkoly Thege Út.
Hungary

Dear Professor Jánossy:


Your very kind letter of December 24 has just reached me.

It was forwarded to me with some delay from Chicago while I was traveling about in the country. I am exceedingly grateful to you for advising me that the mother and the sister of Dr. Teller have received permission to leave Hungary.

I was very pleased to get acquainted with you at the Kitzbühel meeting and hope that we will have an occasion to continue our conversation.

With kind regards,

Sincerely yours,



Leo Szilard

LS:er

their own atomic bomb, and advocated work on the “super”: on the hydrogen bomb. The opinion of the bomb-makers diverged: Lawrence, Neumann, Teller, Urey, Wigner were in favor of it; Bethe, Fermi, Oppenheimer, Szilard were against creating a more devastating weapon. Albert Einstein said: – *If it succeeds, radioactive poisoning of the atmosphere and hence annihilation of any life on Earth has been brought within the range of technical possibilities. In the end there beckons more and more clearly general annihilation.* – The start signal for the nuclear arms race was given by the Soviet nuclear explosion “Joe” on 29 August 1949. On 31 January 1950 President Truman decided to go on with the development of the hydrogen bomb. The corresponding decision of the Soviet Politburo had already been made on 12 September 1949.

The construction of the “super” was not a smooth ride. Stanislaw Ulam proved by numerical calculation, that the thermonuclear reaction chain would not work with deuterium (^2H). Ulam’s negative conclusions were confirmed by the ENIAC computer (October 1950). Thus after the President’s decision a complete rethinking of the construction was required.

Alvarez and Lawrence recommended building a heavy-water-moderated uranium reactor, because in heavy water the neutron capture by deuterium makes tritium (the superheavy hydrogen, ^3H): $n + ^2\text{H} \rightarrow ^3\text{H}$, and the fusion reaction $^2\text{H} + ^3\text{H} \rightarrow ^4\text{He} + n$ has a higher probability, due to the deep binding energy of ^4He . The energy liberated may make nuclear fusions to a *thermonuclear chain reaction*.

The first thermonuclear experiments codenamed “Greenhouse” was “wet”: it used liquid heavy hydrogens, was ignited by a fission explosion at about 100 million degrees (six times the central temperature of the Sun). It was performed on the Eniwetok atoll on 8 May 1951. Edward Teller reported: – *Few experiments have been conducted under conditions as exotic or in a place as beautiful as the Pacific setting for the first thermonuclear explosion. In the morning at about 11 we walked through the tropical heat to the beach of Eniwetok’s placid lagoon. Again, we put on dark glasses. Again, we saw the brilliance of another nuclear explosion. Again, we felt the heat of the blast on our faces. Indeed, we had brought down to Earth the innermost power of the Sun and the heavenly bodies. The ancient story of Prometheus has ceased to be a legend. It has become a fact.*²⁸ – Later even the pains of Prometheus were to return.

The “Greenhouse” experiment worked but was still inefficient: the explosion of the fission charge blew most of the heavy hydrogen apart be-

²⁸Teller: *The Legacy of Hiroshima*, 1962

fore the fusion chain reaction fully developed. The next “Mike” thermonuclear test was performed on 31 October 1952, which wiped the islet Elugelab off the face of the Earth. Teller was not be present, but went down to the basement at the University in Berkeley and watched the seismograph. Seismic waves arrived 15 minutes after the time set for the explosion. The vibration of the needle told Teller that the experiment had succeeded. He sent a coded cable to Los Alamos: IT’S A BOY. This was not yet a transportable bomb – it looked more like a laboratory building with 65 tons of equipment in it – cooling heavy hydrogens below their boiling point.

Hans Thirring, a professor in Vienna published a book on the story of the atomic bomb in German in 1946, in which he mentioned lithium deuterid as a possible charge for the “superbomb”: under the impact of neutrons, ${}^6\text{Li}$ produces tritium (${}^3\text{H}$), and tritium plus deuterium may fuse, liberating energy and a neutron:



The neutrons can be fed back to make more tritium. The advantage of this idea is that ${}^6\text{Li}$ can be easily separated from the other stable isotope ${}^7\text{Li}$, due to their large relative mass difference of 15 %. The idea of using dry ${}^6\text{Li}^2\text{H}$ was invented in the United States and independently also in the Soviet Union; it made the fabrication of the “dry” hydrogen bomb possible, a transportable bomb not requiring cooling.

It cannot be the goal of a book, written in Hungary, to tell details. The ignition of the hydrogen bomb was far from being trivial. The breakthrough happened in early 1951: Teller invented a new geometrical arrangement for the “new super” (its official code-name is classified). Let me quote the *Los Alamos Science*:²⁹ “*The first thermonuclear explosives were based on the application of X-rays produced by a primary nuclear device to compress and ignite a physically distinct secondary nuclear assembly. The process by which the time-varying radiation source is coupled to the secondary is referred to as radiation transport.*” The radiation source is a detonating plutonium bomb, its thermal X-rays are focused onto solid ${}^6\text{Li}^2\text{H}$, the heat and the compression of the implosion initiates the thermonuclear fusion. The *Los Alamos Science* indicates that the *work was done by Edward Teller; it was written down by Frederic de Hoffmann*, who participated in the calculations. After 45 years the text of the Teller–Hoffmann report is still classified.

²⁹*Los Alamos Science* 4/7, 1983, p. 112

There was a meeting in Princeton (19 June 1951), where J. Carson Mark, then head of the Theoretical Department at Los Alamos, reported and concluded that the development of thermonuclear weapons in Los Alamos should be terminated. Norris Bradbury, at that time the director of Los Alamos, did not want to let Teller speak but, at the demand of H.D. Smyth, he was given twenty minutes to report. Now even Robert Oppenheimer was unable to resist: – *It's such a sweet idea that we can't disagree.* – (This was a hard-won approval: Teller had already explained the proposal to Oppenheimer the previous day, but during the first part of the meeting Oppenheimer remained silent. The tendency in Los Alamos and Princeton was to fall silent about the development of the “super.”)³⁰

It is a fact of history that the Russians exploded their thermonuclear device “Joe 4” – designed by Andrei Sakharov – on 12 August 1953. This verified Teller’s anticipation of Russian capabilities. Building the hydrogen bomb according to Teller’s scheme took twenty months at Los Alamos. The American hydrogen bomb test “Bravo” took place on 1 March 1954 on Bikini Atoll. (A joint patent of the hydrogen bomb was offered to Edward Teller and Stanislaw Ulam; Teller refused to sign it under this condition: he considered himself to be the inventor. In the media Teller has been called “the father of the hydrogen bomb” – not always with the intention of praise.) Edward Teller received the Fermi Award “*in recognition of his contribution to chemical and nuclear physics, his leadership in thermonuclear research and his efforts to strengthen national security*” from President Kennedy on 2 December 1962.



Los Alamos worked on low flame – even Teller returned to the University of Chicago (1 February 1946). Unsatisfied with the hesitation of Los Alamos Laboratory to work on the “super”, he recommended the creation of another nuclear weapons laboratory. The Livermore Laboratory was created near Berkeley, in California, with the active support of Ernest Lawrence and Luis Alvarez (both would be Nobel laureates for their achievements in high energy physics). Edward Teller moved to California (14 July 1952), and was director of the Laboratory in the period 1958–1960. The Livermore Laboratory made important contributions to the development of lightweight nuclear weapons.

This was the era of the Cold War. The human drama reached its peak on 23 April 1954 when U.S. authorities questioned the security clearance of Robert Oppenheimer, former director of the National Laboratory in Los

³⁰Teller to the author 1994

Alamos. Teller was invited to the hearing to testify. He arrived at Washington with the intention of speaking in favor of Oppenheimer. Oppenheimer's lawyer visited him, saying that Oppenheimer was a good director, which was true. Then Teller was visited by the prosecuting attorney. Edward received him because he had met Oppenheimer's attorney as well. The prosecuting attorney asked Teller to read Oppenheimer's confession. (This would be published in print later on.) It was about the investigation of Oppenheimer's dependability, before nominating him to director at Los Alamos. Oppenheimer confessed: "Yes, I had friends who had Soviet contacts, they might know about security informations, it is advisable to investigate them." One of his friends was Haakon Chevalier, a Norwegian who taught French at U.C. Berkeley. Oppenheimer recommended to investigate him because of his Russian contacts. When the prosecuting attorney asked Oppenheimer whether he had any evidence of the Soviet contacts, Oppenheimer answered "No." – "Then why have you spoken about such contacts?" – Oppenheimer reaction was: – "Because I was a fool." – (This has been recorded as part of the testimony under oath.)³¹ This case changed Teller's mind.³² Teller testified at the Commission with carefully chosen words: – *I thoroughly disagreed with Oppenheimer in numerous issues and his actions frankly appeared to me confused and complicated. To this extent I feel that I would like to see the vital interests of this country in hands which I understand better, and therefore trust more.* – At the end, on 23 December 1954 Oppenheimer was declared to be "a loyal citizen but a security risk." The hearing had been widely publicized in the press and literature, with Teller's role in it. Humanists abhorred the idea of a thermonuclear holocaust, depicting Edward as "Dr. Strangelove". (Teller was aware of other kinds of holocausts in Europe, having endangered his own family members.) Politicians and generals celebrated Edward as a national hero who helped to win the Cold War.

Teller's schoolmates noticed how much he liked teaching, how much he dreamed of becoming a "Professor" and this became his nickname. We experience in Budapest how deeply Professor Teller loves the students. In the 1960s the Berkeley university campus became the center of liberal student demonstrations, fighting for civil rights, condemning Teller as a "war criminal." This was a sad period in Edward's life.



³¹Chevalier later wrote a book *The Man Who Would Be God*, then another one: *Oppenheimer, the Story of a Friendship*.

³²Teller to the author 1996

A fission chain reaction happens if two subcritical masses are brought together, making the mass of the fissionable material supercritical. This puts a practical limit on the explosive power of fission bombs. In principle there is no upper limit for the explosive power of fusion bombs. But the atmosphere is too shallow, and this fact does not let the destructive capability be increased sharply. This is why the race for building more and more powerful bombs terminated. The military quest turned to the transport of bombs by ballistic missiles, introducing the "Space Age." In the guidance and targeting of missiles, miniaturized intelligent computers played an increasing role. After the "sputnik shock" and "missile gap," powerful on-board computers gave the lead back to America. But the number of nuclear warheads increased to thousands on both sides.

– This is why we in Livermore began thinking about defense. I became convinced that it would be possible. When Reagan was elected governor of California, I invited him to visit Livermore. He not only accepted the invitation but listened to us for about two hours, then raised a dozen questions (1967). This might be the origin of Reagan's interest in this new aspect of defense. When he was elected President, I became a member of the White House Science Council, where the case of the defense against missiles was discussed. Our conclusion reached the President. In 1983 he officially accepted the "Strategic Defense Initiative." This was how I convinced Reagan – mostly indirectly – to support this defense program. The opposition, namely Edward Kennedy gave the program the nickname "Star Wars," which is how newspapers liked to write about it. The project is now at low intensity, but its advantage is evident even today in a possible local conflict, like one in Korea.

– It may be that I am biased but the hydrogen bomb was the most important factor in the Cold War. The Americans had it and the Russians had it; this fact made it less menacing. Who had it a few months earlier or later did not count too much. But let us imagine what would have happened if the Soviet Union had a hydrogen bomb ten years before the Americans! Opinions diverge whether the Strategic Defense Initiative was decisive in the Cold War. According to my friend Hans Bethe it did not play a role. According to the Russian scientists I asked, it played a significant role. It may be that in this respect the Russians have been better informed.³³

Edward Teller received the Order of Merit from the President of the Hungarian Republic. In his acceptance speech, he said (26 April 1994):

³³Teller to the author 1994

– I want to tell you, for many years I was a non-person in Hungary. For me personally it was a great event that at about the time of my 80th birthday, when the Berlin Wall was crumbling, I almost was revived in Hungary. And that by and by I succeeded. I want to introduce myself to all of you as a born again Hungarian. For more than fifty years I had to stay away from my native land. When I went back, it was the old place: not only the buildings, the spirit was there indeed. I don't know how big a part I personally had in it, but I know that I felt pride. I did believe that what happened would happen. I expected it to come in the middle of the next century. That it came earlier, that I could see and that I could be a little part of it, is a source of immense pleasure and a little pride. Let me thank you for reinforcing this pride; I want to hold fast to it, even if it is not quite justified.



– The discovery of “Masurium” as element 43 was a mistake. Element 43 as “Technetium” was discovered with the help of neutron bombardment by Segré. It has found its important diagnostic use by which I personally benefitted. In 1984, I had open-heart surgery, and a few years later in Washington, I was dragged by one of the younger men who participated in the operation at Georgetown University in order to check my heart. That was done by injecting a non-negligible amount of technetium into my blood and then placing counters pointing to my heart to find out how many decays of technetium nuclei occurred in my heart as it expanded and contracted. I passed the test (not quite with flying colors).

– After all that was done, I went for lunch with Jay Keyworth, the President's science advisor. No sooner had we sat down, when a guard came running, – “Which one of you carried in some radioactivity?” – I told Jay about my experience, so he raised his eyebrows and said, – “Don't you know, this is the radioactive Dr. Teller!”

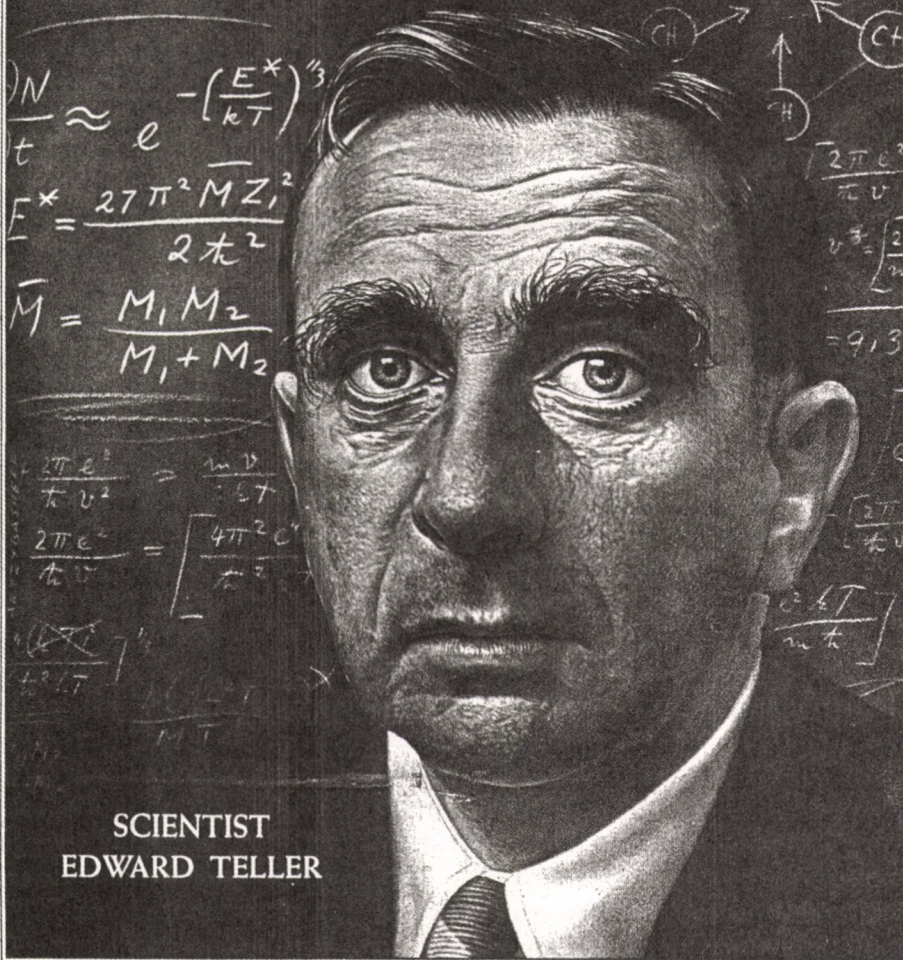
– I am telling you this story because it is one of the instances of the useful medical applications of radioactivity. I want to continue by telling you how similar tests will be carried out in the future. My friend, Lowell Wood suggested that instead of technetium that emits one γ -quant, one should use an appropriate isotope that emits at least two γ -quants in rapid sequence. From the intersection line of the two observations one would get the precise location of the emitter within the body. All one would have to do is to administer the relevant non-radioactive isotope, irradiate it by slow neutrons and look for the double event. This would result in less irradiation and more information.³⁴ – Edward is not afraid of our Nuclear

³⁴lecture in Budapest 1994

TIME

THE WEEKLY NEWSMAGAZINE

U.S. SCIENCE
Where It Stands Today



SCIENTIST
EDWARD TELLER

Future. Teller walks now in the world with the help of a big stick, arguing with people and lecturing about the future. Let us quote GEORGE OLAH.³⁵

– *I see Edward Teller frequently. He is criticized for his past activity but according to my opinion the atomic bomb saved the piece. It seems that to make peace on Earth also a big stick may be needed.*



– *In America all my Hungarian friends were Jewish, but when we gathered together, we were conspicuous not as Jews but as Hungarians* – Teller confesses in his autobiography. Teller's classmates from the Minta Gymnasium planned to come together for the 50th anniversary of their graduation. They called Teller as well: – *If you don't obey, we shall tell Gröger and Martos how you behaved.* – Soon two U.S. security agents paid a visit to Teller, asking him: – *Who are Gröger and Martos?* – Gröger was the teacher of Latin, Martos the teacher of gymnastics in the gymnasium, both rather discipline-oriented teachers, less tolerant of Edward's character.

Teller visited Hungary in 1936, then hot and cold wars erupted. He revisited his native country only in 1990. The author worked hard to arrange a visit, trying to attract Ede with the newest Hungarian political jokes he appreciated, – *If you promise to tell me a good Hungarian joke every day, I may come.* – Teller Ede stressed that he wanted to come not for acting as a politician but working as a physicist. On his first morning in Hungary we were already heading to the Nuclear Power Plant in Paks. Since then, Teller Ede, the “*born again Hungarian*” is back in Budapest almost every year with a Hungarian passport, and lectures at University auditoriums packed with hundreds of students. In the lectures, given in classic Hungarian, he spoke on the applications of quantum theory (e.g. on superconductivity), on the tragedy of dropping the atomic bomb on people, on the safety of nuclear reactors, on the peaceful need for nuclear power. Hungary imports oil and gas in pipelines from Russia (through the Ukraine) or from the Middle East (utilizing a pipeline coming from the Mediterranean Sea through Croatia and Serbia). Neither solution is safe. Hungarian coal is rather contaminated by sulphur (even by uranium), producing dirty smoke. For the economic independence of Hungary the nuclear power plant proved to be essential. Its safety was thoroughly supervised by Teller. And he spoke to physicists, engineers, students, and industrial decision-makers about the future. He told the students at Eötvös University:³⁶

³⁵Hungarian Television 1997

³⁶Budapest 1991

– *When I arrived in the United States, technological progress was glorified. I found it a bit exaggerated at that time. But in America, in the country of progress, everything changed. Now the press says that progress is dehumanizing. I state that humans differ from animals in creating science and in using science. Science and technology alone cannot solve all the problems of mankind. But without science and technology no problem can be solved.*



As Freeman Dyson characterized Teller, – *He is bubbling over with ideas and jokes. Teller has done many interesting things in physics but never the same thing for long. He seems to do physics for fun rather than for glory.* – Let us read further the recollection of Freeman Dyson:³⁷

– *One Sunday I walked back with my family through the trees to our house on the hill overlooking the Berkeley campus. Then we heard a strange sound coming through the open door. The children stopped their chatter and we all stood outside and listened. It was Bach's Prelude No. 8 in E-flat minor, superbly played. Whoever was playing it was putting into it his whole heart and soul. The sound floated up to us like a chorus of mourning from the depths, as if the spirits in the underworld were dancing to a slow pavane. We waited until the music came to an end and then walked in. There, sitting at the piano, was Edward Teller, he excused himself. He said he had come to invite us to a party at his house and happened to see our fine piano begging to be played.*

Teller Ede visited Hungarian secondary schools and met with physics teachers. One of them asked him: what is the beauty of physics?

– *The beauty is that things appearing to be complicated turn out to be simple. If one is ready to face a certain degree of complexity, on a higher level one may gain simplicity. Let me call on an example from the realm of the arts. Among the arts, music has a very special place: it is not bound by any condition but by convention. Architecture has a use, painting has an object. What is beautiful in music depends solely on what we decide to be beautiful. It may be hard to accept this while we are enjoying music, but I think what we like in music is the contrast of simplicity and complexity. If it is too simple, it becomes boring. If it is too complex, we feel it alien. When a sonata presents the same theme in different scales, and connects them in a just recognizable way, we enjoy that we need to pay attention to understand the connections. Music is the play that imitates the process of human knowledge.*

³⁷Freeman Dyson: *Disturbing the Universe*, 1979

Neumann János – John von Neumann

1903 – 1957

Sciences do not try to explain, they hardly even try to interpret, they mainly make models. By model a mathematical construct is meant which, with the addition of certain verbal interpretations, describes observed phenomena. The justification of such a mathematical construct is solely and precisely that it is expected to work. (J. v. N.)

– *The booming Budapest of 1903, into which Johnny was born, was about to produce one of the most glittering single generations of scientists, writers, artists, musicians, and useful expatriate millionaires to come from one small community since the city-states of the Italian Renaissance. In much of 1867–1913, Budapest sped forward economically faster than anywhere else in Europe, and with the delights that a self-reliant plutocracy (rather than self-questioning democracy) temporarily brings – Norman Macrae, the past editor of *The Economist* says enthusiastically.¹ – Budapest surfed into the 20th century on a wave of music and operetta down the blue Danube, as an industrializing city that “still smelt of violets in the spring,” pulsing with mental vigor in its six hundred coffeehouses and its brilliant elitist schools. Nobel laureate Eugene P. Wigner was asked why Hungary in this generation had brought forth so many geniuses. He replied that he did not understand the question. Hungary in that time had produced only one genius, Johnny von Neumann. – GEORGE KLEIN agreed: – John von Neumann was the smartest man of the world at his time.*

Max Neumann was part of this social set. As a banker, he served the industrializing–commercializing country and its ruler possibly well, because the king-emperor made him a nobleman in 1913. This is how his son Jancsi inherited the VON NEUMANN name, with the noble prefix.

Jancsi enjoyed using his brain. He was able to multiply eight digit numbers in his head. Once his mother just stared into nothing, and Jancsi asked: – *What are you calculating, mother?* – At the dinner table Max von Neumann talked with Jancsi occasionally in classical Greek. The father

¹Norman Macrae: *John von Neumann*, 1992

Febr. 9.

Hö Urf,
vinnajättem Suopäköl, és
holnap elutavom innen több
Chicago környékén tartandó
előadásra.

Nagy öröök már annak,
hogy négy, visontlátlak, és
négy elbeszélgethetünk ...
Heil Wigner! Gyancsi.

sent John von Neumann to the same school he himself attended: the Lutheran Gymnasium. His schoolmate and friend was EUGENE P. WIGNER, they exchanged joking Hungarian letters even decades later in America [facsimile].² Wigner used to recall a characteristic story:³

– “Two bicyclists are 40 km apart and each of them drives toward the other at a speed of 20 km per hour. A fly starts from the nose of one of the boys, flies to the nose of the other boy at a speed of 30 km per hour, then back to the first, after landing there it leaves immediately again to the second cyclist, back and forth till the two cyclists meet. What is the total path length the fly has covered?” – This is a popular problem for student competitions, with the physicist’s solution: the cyclists meet after one hour, and in one hour the fly makes 30 km in the air. – When I told this problem to Johnny, he danced a few seconds then answered: 30 km. – “Oh, you have heard the trick before!” – Johnny was surprised: “What trick? I just summed up an infinite series!”

²facsimile, part of a letter to Wigner in 1938

³to the author 1983

The legendary mathematics teacher, *László Rátz* noticed Johnny's talent. He visited Max von Neumann and said it would be a sin not to take special care of Jancsi's mathematical education. Max was not a poor fellow but Mr. Rátz never asked any fee for the extra hours. After having obtained the father's consensus, Rátz turned to the professors of the University. Professor József Kürschák asked Gábor Szegő, a winner of the Eötvös Competition, to pay attention to Jancsi. John von Neumann published his first mathematical work while he was a secondary school student not yet 18.

At that time two brilliant stars were shining on the sky of mathematics in Hungary, born within weeks of each other in 1880. One of them was *Frigyes Riesz* (1880–1956), professor at the University of Szeged (South Hungary), one of the modern architects of functional analysis, his monograph published in Chinese, English, French, German, Japanese, Russian. It offered the mathematical basis for quantum mechanics. His brother, *Marcel Riesz* (1886–1967) became professor of mathematics in Lund (Sweden).

The other star, *Lipót Fejér* (1880–1959) worked in complex analysis and made himself famous with the Summation Theorem of Fourier Series. In 1905 Poincaré came to Budapest to receive the Bolyai Prize of the Hungarian Academy of Sciences (the greatest mathematical prize at that time). When he got off the train, he asked the minister of culture welcoming him: – *Where is Fejér?* – The minister looked at the state secretary: – *Who is Fejér?* – The minister did not know the 25-year-old lad but Poincaré answered: – *One of the world's greatest mathematicians!* – ROLAND EÖTVÖS made Fejér professor at Budapest University, and Fejér soon let such talents fly as PAUL ERDŐS, JOHN VON NEUMANN, *George Pólya*, *Gábor Szegő*. Professor Fejér called the teenager Neumann “the greatest Jancsi in Hungary.” (The author was fortunate enough to enjoy the courses of both giants, Fejér and Riesz.)

Later on, *Gábor Szegő* (1887–1986) and *George Pólya* (1895–1986) became professors at Stanford University. PETER LAX, a relative of Szegő said,⁴ – *You don't have to be Hungarian to be a mathematician, but it helps. In Stanford Szegő showed me the problems he had given to the teenager Johnny, with Johnny's solutions, written on the paper of Max Neumann's bank. Later Szegő sent these sheets to Budapest. In the 1950s Pólya and Szegő organized student competitions also in California, following the pattern of the Eötvös Competition.* – According to Macrae, their educational spirit contributed to the miracle of the Silicon Valley in the

⁴Budapest 1994

1960s and 1970s. THEODORE VON KÁRMÁN recalled:⁵ – *One day during my first year in Aachen a well-known Budapest banker came to see me with his 17-year-old son Johnny. He had an unusual request. He wanted me to dissuade young Johnny from becoming a mathematician. – “Mathematics,” – he said, – “does not make money!” – I talked with the boy. He was spectacular. At seventeen he was already involved in studying on his own the different concepts of infinity, which is one of the deepest problems of abstract mathematics, and he was developing interesting theories. I thought it would be a shame to influence him away from his natural bent. On the other hand, my own father’s role in keeping me away from mathematics in youth came swiftly to my mind. I did not recall suffering from it, nor did it prevent me from eventually learning mathematics. However, in Johnny’s case I finally suggested that the father compromise with his son and let Johnny study chemical engineering.*

Neumann started an interesting life. He was registered at Budapest University as a student of *mathematics*, but spent most of his time in Zürich at the Eidgenössische Technische Hochschule studying *chemistry* (1921–1925). At the end of each semester he returned to Budapest University to pass his course exams. He turned up frequently in Berlin as well, to attend Einstein’s interesting *physics* seminars. He received his diploma in chemical engineering in Zürich and his Ph.D. degree in mathematics in Budapest at about the same time. In his thesis he intended to construct the axiomatic basis of set theory, developed intuitively in the 19th century (1926). Then he went to Göttingen to be an assistant of David Hilbert.

Neumann’s view on mathematical rigor changed when Gödel proved that there are unsolvable problems in any system of axioms. – *I was expelled from the Garden of Eden* – but just for this service he considered Gödel to be one of the greatest thinkers. This was the beginning of the process that made John von Neumann the greatest mathematician of the 20th century in the eyes of non-mathematicians. CORNELIUS LANCZOS said that *John von Neumann was not only one of the most outstanding mathematicians but he was the most outstanding mathematician of the 20th century.*

In the late 1920s interesting developments happened in Göttingen. Next door, in Max Born’s Physics Department Bohr, Fermi, Heisenberg, Oppenheimer, Pauli, Schrödinger, Teller, and Wigner gave each other the door knob: the statistical interpretation of quantum mechanics had

⁵Theodore von Kármán: *The Wind and Beyond*, 1967

been born. Atomic spectra were explained by *Heisenberg* with the help of infinite columns of numbers, indicating the observable dipole moment associated to each spectral line. *Schrödinger* described light emission by the vibration of an elastic electron field. Schrödinger disliked Heisenberg's abstract algebra, Heisenberg considered Schrödinger's electron jelly to be unattractive. But both theories gave identical results! The old Hilbert asked his assistant Neumann to clarify the situation. Soon the 26-year-young Neumann gave Hilbert a note in which he proved: both Heisenberg's columns of numbers and Schrödinger's wave functions represent *vectors in the infinite dimensional Hilbert space*. Later Neumann proved that not only the eigenfunctions of bounded operators, but also the eigenfunctions of unbounded operators make a complete set of base vectors in the Hilbert space. This was important because most physical quantities are represented by unbounded operators.⁶ This means that any quantum mechanical state can be represented as the linear combination of these base vectors. The absolute squares of the coefficients can be interpreted as probabilities for the different outcomes of the measurement to be performed. This has offered a mathematical basis for Born's *probability interpretation of the wave function*, disliked by Einstein and Schrödinger, but accepted now worldwide by physicists and acknowledged with the 1954 Nobel Prize. – *In this way Johann von Neumann had given quantum mechanics a form acceptable to mathematicians as Euclid did for geometry.*⁷ – The era of constructive coexistence of mathematics and quantum mechanics had begun. *The Mathematical Foundation of Quantum Mechanics* by Johann von Neumann became the classical textbook of the new physics.⁸

Another result of Neumann was the exact proof of the quasi-ergodic theorem, laying the firm foundation of statistical physics: a dynamical system can be found “almost everywhere” in phase space during its motion. He looked at this classical mechanical problem not as an analytical exercise in the three dimensional space (or six dimensional phase space) but as a task of dealing with operators on a function space. – Later, in his curriculum vitae he named these two results as his main scientific achievements, which serve as *mathematically* strict foundations of *quantum physics* and *statistical physics* even today. But

⁶Frigyes Riesz contributed as well with several theorems to make this proof possible.

⁷Teller in Budapest lecture 1994

⁸Eugene Wigner followed Neumann as Hilbert's assistant, and there he wrote another basic book on the group theoretical foundation of the new theory.

– *there is no Nobel Prize in mathematics, possibly because Alfred Nobel could not forgive his mistress for running off with a mathematician.*⁹

TELLER has characterized Neumann's talent jokingly:

1. *Johnny can prove any statement.*
2. *Anything Johnny proves is right.*

Teller's other remark may be even more enlightening about the act of creation: – *Johnny was interested in any topics that offered him a chance of seeing a new relationship.*

– *If someone gave a problem and von Neumann did not give an immediate solution, then it was an unsolvable problem.* – Humankind knows and appreciates Neumann's achievements which had benefits outside the realm of mathematics, – *He was a multifaceted genius.*¹⁰ – When the Eötvös Society made Neumann honorary member, his achievements were quoted both in mathematics and in physics (1940). As a matter of fact, in his curriculum vitae he considered himself to be a *mathematician and mathematical physicist*. (Later in America, Neumann was member of both the American Mathematical Society and the American Physical Society.)



Sensing the changing political climate in Germany, Neumann accepted the call from Princeton University, and sailed to America (1930). For him, the direct practicality of the American people was attractive. In contrast to the reservations of Albert Einstein, Eugene Wigner, and Béla Bartók, for Neumann America meant *love at first sight*: Neumann Jancsi, alias Johann von Neumann became Johnny. Before leaving Europe, he came back to Hungary to marry Marietta Köves and – related to the marriage – to be baptized a Catholic.

At Princeton, Johnny was the youngest professor at the newly established Institute for Advanced Studies but soon he became one of its leading personalities. The Neumanns missed the relaxed atmosphere of the European cafés and seminars, thus they organized regular parties, not only as social events but as brainstorming meetings of scientists. Johnny found the Institute without students and laboratories a bit sterile. With his Martian spirit of interdisciplinarity, he said: – *The interest of humanity may change. The present curiosities in science may diminish, and entirely different things may occupy the human mind in the future.*

⁹remark of Theodore von Kármán concerning John von Neumann in *The Wind and Beyond*, 1967

¹⁰Fred Reines to the author 1994

– In 1937, he became a citizen of the United States, and as a good American, he learned to play poker and drive a car. (As a matter of fact, he was a poor player and an equally poor driver because his attention usually scattered to more exciting problems.) The poker parties between Metropolis, Neumann, Teller, and Ulam were famous at Los Alamos.¹¹ Neumann published a paper on the mathematical theory of poker, from which the mathematical theory of games developed. When he became a lieutenant in the reserve of the U.S. Army, he became the foremost expert in ballistics, in shock waves, leading him to computers.

A military test ground was developed at Aberdeen; there THEODORE VON KÁRMÁN constructed the first supersonic wind tunnel (1937). Kármán was interested in aerodynamics, in vortices, which became relevant for supersonic flight. But the equations of aerodynamics were highly nonlinear; to solve them the power of conventional mathematical analysis was insufficient. Kármán asked for the part-time consultancy of Neumann in the same year. Johnny sensed the new challenge of reality and started working enthusiastically for the military establishment. He was made lieutenant of the U.S. Army, elaborated artillery tables, studied explosions and shock wave propagation. This is how Johnny became interested in the first calculators, operated by punch cards, resulting in a longstanding relationship with IBM. – *Neumann made blast calculations also in Los Alamos. My duty was to help Neumann in the dirty work of small calculations. He sat down in his office and started thinking loudly. I scribbled it down, recalculated the details. Later he read what I wrote, made even me co-author, which was very generous.*¹²

– *Later in World War II, I worked with Neumann in underwater explosions. The question was how the “gadget” could be used against an enemy harbor. One idea was to produce huge water waves (a kind of tsunami) by an underwater explosion, to destroy ships. Later the Bikini bomb tests made the experimental study of the created waves possible. Our calculations concerning the relation of the wave height versus distance turned out to be surprisingly good. Another option was to crush submarines by deep underwater nuclear explosions. Neumann and I calculated that a depth of 700 meters might provide the strongest impact. In 1950, such a test was performed indeed in the Pacific, 700 kms off the coast of San Diego, precisely at this recommended depth; this was*

¹¹Koestler as well was a poker addict

¹²Fred Reines to the author 1994

the PROJECT WIGWAM. Metal barrels were placed in the ocean, to be compressed, the nickname for them was "squaws."¹³

Jacob Bronowski – who after the war became a British television personality – worked on bombing patterns during the war. In consulting John von Neumann, Neumann told him: – *Oh no, no, you are not seeing it. Your kind of visualizing in three dimensional space is not right for seeing this. Think of it: what is happening on this explosion photograph is that the first derivative vanishes identically, and that is why what becomes visible is the trace of the second derivative.*¹⁴

EDWARD TELLER said: – *Johnny was able to speak with my three-year-old son in my son's language. Experiencing this several times, I mused: Johnny's contact with us, other people, may go in a somewhat similar way.*

– *I tried to explain the greatness of Neumann to my students –* said PETER LAX.¹⁵ – *When he was expected to come to Los Angeles summertime, even after the war, everybody waited for him, not only the mathematicians but physicists as well. Everyone wished to talk with him, to tell him the newest problems or results. Everyone paid attention to what Neumann said. Today there are no mathematicians of his kind whom the physicists are interested in.*



In peacetime, John von Neumann strongly believed that the technological revolution initiated by the release of nuclear energy would cause more profound change in human society than any discovery made in the previous history of the race.¹⁶ – *In a few decades this new alchemy would bring mankind a new sort of energy that would be as free as the unmetered air.* – He did not claim that nuclear power is *absolutely safe* but the associated risks will be acceptable as the risks associated with automobiles have been generally accepted.

But peace itself was not safe enough: a Cold War started with an armament race. Neumann participated in improving the fission bomb, even attending its testing in the South Pacific in 1946. Neumann did not make calculations on the fusion bomb, his computers did. Neumann's technique turned out to be essential also for the ignition of the hydrogen bomb, developed by Edward Teller and Stanislaw Ulam. To follow a

¹³Maurice Shapiro to the author 1994

¹⁴Norman Macrae: *John von Neumann*, 1992

¹⁵Peter Lax to the author

¹⁶Stanislaw Ulam in the *John von Neumann Memorial Volume*, 1958

thermonuclear explosion required billions of multiplications. – “*In the execution of these calculations we shall probably have to perform more arithmetic steps than the total in all the computations performed by the human race until now*” – guessed von Neumann. We noticed later, however, that the total number of multiplications made by school children of the world sensibly exceeds that of our problem.¹⁷

When General Eisenhower was elected President, John von Neumann – supported by THEODORE VON KÁRMÁN – became the most influential scientist in Washington. The influential Atomic Energy Commission had only five members; Neumann became one of them (1954). The policy of *nuclear deterrence* – as an offspring of his game theory – was designed by Neumann:

– *In the past, when a weapon system was first introduced, it was very potent for awhile until countermeasures were developed. Anyone who had the last move in this game had the advantage for awhile thereafter. The difficulty with atomic weapons will be that they can decide a war in less than a few weeks. This requires weapons systems of high differentiation. Quite unconventional methods of systems analysis and of operations analysis will bear fruit. It brings us back to emphasize the enormous importance of the most powerful weapon of all, namely, the flexible type of human intelligence.*¹⁸

Thanks to Theodore von Kármán, the U.S. Air Force was superior, thus originally the policy of deterrence was simple: none of the enemy leaders were left in doubt that they would be annihilated in person in the first hours of nuclear confrontation, if they dared to provoke one. This is why the Soviet Union decided to develop intercontinental ballistic missiles, and – under Khrushchev – achieved a transient superiority (1957–1959, in the Sputnik Era). Sensing this, Theodore von Kármán and John von Neumann urged the development of missile strategy.



Neumann needed computers to calculate nonlinear shock waves. In Los Alamos only the electro-mechanical punch card calculators of IBM were available, developed originally for the census in 1890. For orientation: the multiplication of two ten-digit numbers takes about five minutes for a human, and took about fifteen seconds for these calculators. E.g. an implosion calculation took weeks, due to the nonlinearity of the partial differential equations. The speed of the calculation was made slow by the inertia of the mechanical relays.

¹⁷Stanislav Ulam in the *John von Neumann Memorial Volume*, 1958

¹⁸John von Neumann: *Defense in Atomic War*

The turning point in the history of computation was 7 August 1944, when John von Neumann visited the ENIAC (Electronic Numerical Integrator and Computer) in Philadelphia. This exploited the frictionless motion of light electrons in vacuum tubes. Neumann was impressed by the ENIAC *imitating the human brain with its 17 000 electron tubes*. ENIAC was moved to the military grounds in Aberdeen (1947), and served the ignition calculations of the hydrogen bomb.

In case of a new differential equation, rewiring of the ENIAC required a quarter of an hour, followed by the computation time of three seconds. This made the machine inefficient for the practical computational point of view. Thinking about this challenge Neumann got the idea in late August 1944 that not only the initial data but even the program can be electronically introduced to the computer and stored in the computer. Then the *central processing unit* executes the operations one after the other, according to the stored program. This has become the *von-Neumann-computer*, now in use worldwide.¹⁹

Still in 1938, just before World War II, Johnny revisited Budapest to marry his second wife, Klara Dan. Later she became one of the first coders of electronic computers. At that time only the characters ABCDE and 1234567890 were available, therefore as error message she used "E2 A B1DE5 10" (the Hungarian phrase EZ A BIDES LO, meaning "this stinking horse").²⁰

Till now linear equations ruled in quantum theory, in telecommunication, in the fields where great progress has been achieved. Johnny taught the world that *from now on we have entirely new criteria of what is mathematically simple or complicated, elegant or clumsy*. – Neumann had the vision that computers will open a new era of (predictive) science, a New Age qualitatively different from the past. After dealing with nonlinear shocks, Neumann's attention turned to improve the reliability of weather forecasts; he set his goal to turn meteorology from a kitchen art into a predictive science. He wished to rely on electronic computation. But the first computers needed two days to make a weather forecast for the very next day. In modern warfare forecasting weather could have strategic importance, thus the Air Force encouraged Neumann's effort. Computerized weather forecasting began in 1955 for military purposes.

– *The formidable mathematical problems by the hydrodynamical equations of the Earth's atmosphere fascinated von Neumann. This problem*

¹⁹A modern *non-von-Neumann-computer* uses several processors working parallel, a possibility, too, first suggested by von Neumann.

²⁰George Gamow to the author

was dear to his mind, both because of its intrinsic scientific interest, and because of the enormous technological consequences which a useful solution could have. Our knowledge of the dynamics of the atmosphere, with the development of computers, may permit not only weather prediction, but perhaps controlling and changing the climate. He speculated²¹ on the approach of time when one could produce, with the now available vast nuclear sources of energy, changes in the global circulation of the atmosphere. In such problems where the physics of phenomena are already understood, it might be that a future mathematical analysis will enable the human race to extend vastly its control over nature.²²

But we are not yet at the end of the road. The *deterministic chaos* in classical nonlinear dynamical systems was discovered in meteorology after Johnny's death, and postponed reliable long-range weather predictions. But Johnny's ideas are alive today more than ever. Global warming, due to the greenhouse effect of enhanced CO₂ emission, was predicted by Neumann, and in our time huge computers try to run climatic models to forecast the next century scenario. Droughts and floods seem to indicate that a global warming started in the 1990s. This may force humankind to rethink our dilemma of using fossil fuels *or* nuclear fuels.

– *Can we survive technology?* – was the topic of one of his essays. Ever accelerating technological progress and changing lifestyles were at the center of Neumann's discussions with Ulam:

– *This gives the appearance of approaching some essential singularity in the history of the human race beyond which human affairs, as we know them, could not continue.*



Neumann's last book was *The Computer and the Brain* (1957). The roots of his ideas on automata can be traced back to 1939. After Neumann's political isolation from his home country, the frequent correspondence with his friend, *Rudolf Ortway*, professor of theoretical physics at Budapest University, served as a supply of Martian ideas. Ortway wrote to Neumann: – *As I see, the operation of the brain is going to be ripe for understanding. The mentality of medical doctors, however, does not make them able to solve this problem. Physicians are not ready intellectually for universal thinking, for understanding the operation of a complex system. Physicists and mathematicians are better trained for such a task. I think only an outsider could give an appropriate push, in cooperation with physicians and physiologists.* – In

²¹1955

²²Stanislav Ulam in the *John von Neumann Memorial Volume*, 1958

his letters Ortvay described his ideas in more details, quoting the success of genetics as an example, where the concept of *genes* – very strange for anatomy- and metabolism-oriented thinking made a spectacular quantitative breakthrough. In a letter dated in 1940 Ortvay went into more details:

The brain is a network with neurons as nodes. Each neuron may receive impulses from several others, and may send impulses to them. The state of the neuron (its sensitivity for incoming signals, and its activity for emitting signals) may depend on previous inputs. The state of the brain may be given by the state of its specified neurons. Each mental situation could be characterized by the set of these data. This reminds me of a telephone central, where the connections will be changed after each phone call. It may be that the appropriate analogies will come from technical networks which are becoming more and more sophisticated. – Neumann reacted to these ideas favorably: – *What you write about biology and quantum theory is very sympathetic for me. Your comments about brain structure are especially interesting. I think one has to take this possibility seriously: the essential biological processes may not be understood in the framework of conventional geometry. If we overemphasize localization, we shall confront the same contradictions and misconceptions as in the case of the simultaneity of distant events in the theory of relativity, or in the attempted simultaneous measurement of coordinate and momentum in quantum theory.*²³

How is it possible to design a reliable machine using unreliable components? Nature has done it in the case of the brain, made of neurons. Democracy is an other good example: a society of fallible citizens. Thus Neumann's interest turned to automata. In a Princeton lecture in 1948, he considered *the computer as a metaphor for the living cell*. He worked by distinguishing two main components of automata: the machine (we call it now *hardware*) and the stored information (we call it *software*). Soon it became evident that these represent two main functions of life: *metabolism* and *reproduction*. In this way, John von Neumann was a forerunner of modern biology. The great discoveries of Francis Crick and James Watson followed five years later to identify protein enzymes with the machine (the hardware performing metabolism), and DNA with the memory (software to be reproduced). In an unfinished paper he discussed the critical size of an universal automata, built of simple cellular modules, which is able to reproduce itself, or may even be capable of evolution, perhaps producing more and more efficient automata in successive generations.

²³Neumann Archive, OMIKK Budapest

Neumann did not live long enough to see all these developments. On 11 August 1955 cancer was diagnosed in his collar bone, already a transfer from a cancer of the prostate. When ZOLTÁN BAY visited him to discuss how to speed up the rate of computers, he told Bay (in Hungarian): – *I don't understand why people are afraid of nuclear energy. They have to be afraid of a diagnosis finding cancer in their body.* – A few months later he received the Freedom Medal from President Eisenhower with the President standing and Neumann sitting in a wheelchair. Early in 1956 he was hospitalized. At his bedside politicians and generals asked for his strategical advice: Johnny was still able to run economical, political and military simulations on computers which were accepted because they *worked*. During the Korean War, when Douglas MacArthur intended to attack China on Chinese territory, Neumann's simulations indicated that the losses would overweigh the advantages and in this way he prevented World War III. As Teller wrote:²⁴ – *Neumann was said to be the only human with a mind working faster than anyone's.*

Einstein characterized Neumann by saying, – *Neumann is kein Säugtier, er ist ein Denktier*, for him not sucking but thinking is a condition of life.²⁵ When cancer attacked *his* brain, he tried himself to plan a radiation therapy, but it was too late. – *Neumann enjoyed using his brain as much as some others enjoy using their genitals. It was depressing for him to experience the decay of his brain. He asked me to visit him frequently, just to have a chance to test and use his logic.*²⁶ – For safety reasons an army colonel was present in his bedroom, to make sure that in a state of delirium Johnny did not blurt out any state secrets. (The security guard, however, was uncomprehending: in his sleep Johnny spoke Hungarian.)

Neumann wrote the book *The Computer and the Brain* in his terminal hospital bed, printed only after his death. When he saw his state of health deteriorating irreversibly, he turned to the Catholic faith, saying: – *It's probable that God exists. Many things can be explained more simply in this way than without Him.* – At his tomb, Bradbury said:²⁷

– *If Johnny is where he thought he was going to, there must be some very interesting conversations going on about now.*

²⁴Edward Teller: *The Legacy of Hiroshima*, 1962

²⁵Telegdi in Hungary 1989

²⁶Teller to the author 1994

²⁷Norman Macrea: *John von Neumann*, 1992

Erdős Pál – Paul Erdős

1913–1996

*Every question that can be asked,
should be asked.* (P. E.)

– *If the Martians had made contact with Earth, Paul Erdős would have made a good choice as our planet's ambassador. The aliens would have appreciated his unearthly intelligence. He spoke the universe's common tongue, the theory of numbers* – as the obituary of *The Economist* wrote.¹ *The Economist* is not a journal for pure science, it is for earthly affairs, but noticed Erdős' bright orbit.

In Budapest he was born. His parents were mathematics teachers who knew *Lipót Fejér* and THEODORE VON KÁRMÁN as well. The father – born as Engländer Lajos – changed his name to Erdős.² The father went to World War I in 1914 and was a prisoner of war in Russia for six years. The mother was teaching, therefore a nurse took care of the child. Thanks to her, Paul learned to speak German by the age of three. At this age Paul also knew numbers and how to count. At age four he could already multiply four digit numbers in his head and discovered negative numbers by saying: – *If something has a temperature of 100° and it cools 250 centigrades, then its temperature will be 150° below zero.* – Paul studied mostly at home, taught by his parents. At age ten the father told Paul that there are arbitrary large gaps between consecutive prime numbers which resulted in an early imprinting by the theory of integer numbers. (Prime is an integer number which can be divided only by 1 and itself.)

In 1919, following World War I, Paul Erdős watched with his mother from the balcony of the apartment the attacks on Jews during the right-wing military terror. When his mother speculated about converting to Christianity, her six years old son replied:

– *You may do as you wish but I will remain the way I was born.*

In 1930 the young man enrolled at the University of Budapest, where Professor Lipót Fejér made the greatest impact on him. In 1932 Paul gave

¹5 October 1996

²The creator of TEX word processor, Donald Knuth, included the option to print \bar{o} as well, and wrote in the TEX manual: *see e.g. Erdős.*

a simple proof for the Chebisev theorem: *if $N > 1$, then there is a prime between N and $2N$* . His thesis was ready at the age of 19 but he had to wait till graduation to obtain the Ph.D. degree at the University of Budapest in the theory of numbers in 1934, at the age of 21. (Martians receive Ph.Ds at an early age.) Paul was hardly 20, when Issai Schur, the famous mathematician from the University of Berlin spoke about "*the magician of Budapest*." The successes resulted in an invitation to Manchester.

– *He was the constantly wandering Jew*.³ – From his twenties he hardly slept in the same bed for seven consecutive nights. A saying circulated among mathematicians:

– *Do you want to meet Erdős? Just stay where you are and wait. He will show up.*

He traveled with a half-empty suitcase, stripping himself from the unnecessary burdens of life: he had no child, no wife, no apartment, no driver's license, no permanent job, no check book, no change of a pair of shoes.⁴ His friends and disciples – scattered all over the globe – helped by feeding and lodging him, lending him money, laundering and buying his clothes, doing his taxes. He payed them back by raising interesting questions and offering \$100 for those who were able to prove his mathematical foresights.

– *Another roof, another proof* – he used to say during his endless journeys. When he turned up at a new place, he called up his friends saying: – *My brain is in town!* – and then raised inspiring questions. Babai wrote⁵ – *Erdős was a virtually inexhaustible fountain of simply stated hard problems*. – He contributed to the accusation of Saunders MacLane:⁶ – *The Hungarian view is that science consists not in good answers but in hard questions*. – When Erdős received the Wolf Prize, the highest award in mathematics, he distributed all the \$50 000 but \$720 among scholarships and mathematical competition prizes. – *He was the prince of problem posers* – the *International Herald Tribune* quoted.⁷ His only addictions were coffee and truth because

³*The Economist*

⁴Contrary to the myth, in Budapest he owned an apartment, that of his mother, but never stayed there. He spent his short Hungarian nights in the guest house of the Hungarian Academy of Sciences. Erdős also had two bank accounts, one in Budapest, one in New Jersey, but the checks were signed mostly by his friends. And he even owned one change of suit.

⁵László Babai: *In and Out of Hungary*, 1996

⁶*Mathematical Intelligencer* 5/4 (1983) 53

⁷25 September 1996

– *The mathematician is a machine for converting coffee to theorems.*

In his life Erdős published almost 1500 papers (one or two publications per month) with about 500 co-authors, and after his final departure about hundred more may be published by his students worldwide, realizing the master's intuitions. The obituary in *Nature* called him the Euler of the 20th century. (Leonard Euler – having lived in the 18th century – surpassed him, his collected works make 20 volumes.) Erdős taught us about the beauty of mathematics: a theorem is beautiful if you can express it succinctly in a simple understandable sentence, but its proof needs a long, sophisticated chain of logic.

– *Prove that each even number is the sum of two prime numbers!* – told students,⁸ or – *Prove that there are infinitely many pairs of primes differing only by 2!*

Already the ancient Greeks knew that there are infinitely many primes. The Great Prime Theorem says that the average density of primes in the region of N is about $1/\ln N$. This was proven by the technique of complex functions already in the late 19th century, but in 1949 Erdős and Selberg proved the theorem by elementary mathematics, which brought him world fame. (The proof was elementary but sophisticated: the professor taught us this proof in a semester-long course.)

Paul Erdős made basic contributions to combinatorics, set theory, number theory, probability theory, the evolution of random graphs and to statistical group theory. Working in *discrete mathematics*, he pursued the utmost purity of logic. But in the hands of his students his theorems became valuable for the whole society. He did not use computers. Computers used him: his methods and theorems. Probabilistic number theory – introduced by Erdős – turned out to be most relevant in order to decide: which problems can be answered by computer, and what is the minimum number of steps in the algorithm (in the computer code)? His theory of random graphs helped others to design random access to telephone networks.

Erdős spent years (mainly 1934–1938) in Manchester, visiting other British universities and relaxing in Hungary during the holidays. In 1936 he recalled the marriage of his Hungarian mathematician friend, György Szekeres, by saying, – *I remember his Wedding Day very well: it was just a day after I learned that Vinogradov had proved the old Goldbach conjecture.*⁹

⁸Goldbach's conjecture

⁹László Babai: *In and Out of Hungary*, 1996

The fateful September 1938 – the occupation of Austria and partition of Czechoslovakia) found him in Budapest. At the time of the Munich Agreement he considered Chamberlain to be a traitor, but soon he modified this mild opinion to a harder one: the Premier was stupid. Erdős could not return to England via Nazi-occupied Austria; therefore he made a long detour through Italy, Switzerland, France, England, landing finally in America, ending up at the Institute for Advanced Studies in Princeton. He spent the following decade in the U.S. It happened in 1941 that Paul Erdős was arrested on Long Island as a spy. (He was out for a walk one evening with an American and a Japanese friend, and they did not notice the NO TRESPASSING sign. The Japanese even took a picture of the American and the Hungarian – by chance with a radar installation in the background. Thus two policemen arrested them, reporting that “three Japanese took a picture of the radar installation.” At the FBI interrogation they were asked how they could miss the warning sign. – *I was thinking* – Erdős explained. – *What about?* – was asked. – *Mathematics*.) The universities of Stanford, Purdue, and Philadelphia were the stations of his American decade. He knew Albert Einstein, Peter Lax, John von Neumann, among others. Erdős had already met Stanislav Ulam in Cambridge in 1935, from which time they worked together on set theory in the U.K. and the U.S. As Ulam recalled: – *Paul was unhappy, homesick and constantly worried about his mother, who has remained in Hungary.* – In 1944 Ulam invited Erdős to work on the Manhattan Project and advised him to write to EDWARD TELLER. In the letter written to Teller, Erdős could not leave without mentioning that after the war he might want to return to Hungary. This desire disqualified him from the Manhattan Project.¹⁰

When Ulam became seriously ill, Erdős rushed to Los Angeles. As Ulam recalled, – *I was already preparing to leave the hospital, fully dressed for the first time, when Erdős appeared at the end of the corridor. He did not expect to see me up, and he exclaimed: – “Stan, I am so glad to see you alive! I thought you are going to die and that I would have to write your obituary and our joint paper. You are going home? Good, then I can go and stay with you.”*

During the Holocaust he lost a number of relatives and friends, but he was most anxious to see his beloved mother. He revisited Hungary in 1948.

In 1951, the president of the American Mathematical Society, JOHN VON NEUMANN gave Paul Erdős the Cole Prize for his results in the theory of numbers. But in 1954 the McCarthy Era arrived in America. The U.S.

¹⁰László Babai: *In and Out of Hungary*, 1996

Government knew about Erdős' correspondence with a renowned number theorist, Lo Ken Hua, living in China. When Erdős applied for a green card, he was interrogated whether he had read the works of Karl Marx. Erdős said that the only thing he had read was the Communist Manifesto, and that although he was not a competent judge, he thought that Marx was a great philosopher.¹¹ To an other question he replied: – *Of course I would visit Hungary because my mother lives there and I have many friends there.* – Thus the U.S. re-entry visa was denied. He still decided to attend the International Mathematical Congress in Amsterdam, visited Hungary as well, and could not return to the U.S. for nine years. He moved around in Australia, Canada, China, Europe, Israel, Russia. As he said,

– *Neither Sam, nor Joe can forbid me where I go.*¹²

In the relaxing political atmosphere, Erdős was elected as a member of the Hungarian Academy of Sciences. Hungarian authorities issued a Hungarian passport to “Paul Erdős, citizen of Hungary, resident of Israel.” – *In the era of the Iron Curtain Erdős single-handedly maintained a powerful channel of communication between the Hungarian mathematical community and its western counterparts.*¹³

In 1963, the U.S. consul claimed that *you are a communist* but finally Erdős (with memberships in about ten academies and honorary Ph.Ds at fifteen universities) still got a special “exchange visitor visa for repeated entries.”

To sum up: Erdős left Hungary in 1934, was away for the decade of war (1938–1948), revisited in 1948, then in 1955. Since then, he returned frequently, spending almost ten percent of his time in his native country. He never gave up his Hungarian citizenship.

On 31 October 1995 Professor Erdős gave a lecture to the students of Eötvös University in Budapest, speaking about his most favorite (and most famous) disciples. He concluded his lecture by saying,

– *I never know whether this will be my last lecture: I was born already in 1913.* – (1913 is a prime number.) But on 1 August 1996 he still talked at the International Mathematical Congress in Hungary. He died of a sudden heart attack at a mathematical conference in Warsaw on 20 September 1996, at the age of 83. (83 is also a prime number.)

¹¹László Babai: *In and Out of Hungary*, 1996

¹²a hint to Uncle Sam (i.e. U.S.) and Joseph Stalin

¹³László Babai: *In and Out of Hungary*, 1996

The obituary in *The New York Times* named him one of the ten greatest mathematicians of the 20th century. JOHN VON NEUMANN was another one among them. They knew each other, but their credo differed considerably both in politics and math.¹⁴ Neumann wished to conform to society and wore a necktie all the time. For Erdős "*private property was a nuisance,*" he walked in sandals. Neumann believed in nuclear deterrence, Erdős believed in peaceful human nature. Neumann emphasized the importance of impacts from external reality on the development on mathematics. Erdős believed in its ultimate purity:

– *Mathematical theorems are not invented but are discovered. In Heaven, God keeps a Book that contains the most elegant proofs of all mathematical problems – whether or not (s)he exists.*¹⁵

¹⁴Erdős to the author 1996

¹⁵In Hungarian there are no contrasting pronouns for *she* and *he*.

Lánczos Kornél – Cornelius Lanczos

1893–1974

It is to the credit of the Greek culture that they deduced the concepts of the Cosmos and cosmetics from the same root: beauty.

(C. L.)

– I was born in a town of about 30000 inhabitants, a town of remarkable vigor and intellectual interest. People lived a life which was rich in many respects. Not materially rich but rich in intellectual values. One may have the wrong impression that such a small country as Hungary was at the end of the world. We enjoyed the privilege of intellectual endeavors, in music, in poetry, in science. We grew up in the late Victorian era as one may characterize this Middle-European scene. Not everybody was able to study; thus we appreciated the fact that we could and it was our duty to work hard. It was very different from the kind of permissive society we have today in America.¹

Löwy Kornél was not born in Budapest, in the present thriving capital of Hungary, but in Székesfehérvár, in the town which was the capital of Hungary 1000 years ago. His father, Karl Löwy was a poor child from an industrial family who studied law on a modest grant in Vienna. From his successful legal practice he founded the wealth of the family: he became the president of the Chamber of Lawyers in Székesfehérvár (1915–1938). He bought an estate in Tekerospusza (near Lake Balaton), and was the leader of the Jewish Community in Székesfehérvár. Sensing the coming turns of history, Karl Löwy changed the name of his children from the German–Jewish sounding Löwy to the Hungarian Lánczos (1906), but for himself he kept the original name.

Lánczos Kornél grew up in this well-to-do family, attended a Catholic Gymnasium, enrolled in the Budapest University of Science where ROLAND EÖTVÖS was one of his professors. Eötvös was a professional *experimentalist* in the modern sense: a researcher of gravity who – with his asymmetric torsion pendulum – proved the proportionality of weight and inertia up to eight decimals. (This is quoted nowadays as the main empirical pillar of the theory of General Relativity.) Eötvös

¹interview taped in Manchester

was educated at great German universities, studying under Helmholtz and others, absorbing the magnificence of the mechanistic world view of the 18th century, based upon *action at a distance*. The new concept of *field* was not accepted by the dominating circle of Eötvös until his death (1919), even less after that, in the 1920s. Those who were more interested in the heretical views of Maxwell, Einstein, and Planck had to cross the Danube and listen to lectures at the Budapest Institute of Technology (where Gábor, Kármán, Neumann, Szilárd, and Teller were enrolled). So after graduation, with his teacher's diploma in mathematics and physics, Kornél Lánzos became an assistant in the Department of Experimental Physics at the Budapest Institute of Technology (1916–1921).

He wrote his Ph.D. thesis on *The Relation of Maxwell's Aether Equations to Functional Theory* rather independently of his professors. He used quaternions to rewrite Maxwell's equations in a compact form. Starting from this relativistic variational principle, he discussed the magnetic electron and its diverging self energy, its relativistic motion in gravitational, electric and magnetic fields (1919). This thesis pointed the way for Lanczos: towards *field theory* and *applied mathematics*. (He confessed that the puzzles of quanta and positive particles remained unsolved.)

But who would understand these ambitions of a young assistant? He sent his thesis to Einstein, Laue, Planck, and Sommerfeld. (Lanczos was also in mail contact with the St. Petersburg mathematician, Alexei Friedman, initiator of the Big Bang cosmology.) He wrote to *Albert Einstein*:²

I have tried to open a new pathway for the theory of electrons. My work is based upon the special theory of relativity. It may be that the birth of general relativity makes the whole work obsolete. But I think that these results are worth some attention, even if they are 10 years late. I have worked on this topic for 2 years. I ask for your permission, to dedicate the printed version of my work to Albert Einstein and Max Planck, the two great heroes of constructive speculation. Respectfully yours Löwy (Lánzos) Kornel.

This was his first letter written to Einstein, followed by 54 further letters in the coming 35 years. Einstein answered on 22 January 1920:³

²3 December 1919, Einstein Archive, Princeton No. 15206

³Einstein Archive No. 15207

I have read your work in as much detail as my present overload of work permits. So I can say that it is a sound and original work of thinking.⁴ It makes you worthy of the Ph.D. degree. I give permission cordially to the honoring dedication to me.

Finally, Lánčzos completed his Ph.D. with *Rudolf Ortway* (1921), who had just returned from Arnold Sommerfeld (Munich) and obtained the chair of theoretical physics in Szeged (in Southern Hungary). Ortway was the person who brought the spirit of quantum theory to Hungary; he became the patron of the Young Turks in physics. As Lánčzos said: – *Ortway encouraged each good idea; he did much indeed to support the young Hungarian scientific generation, and he did it with intense interest and complete unselfishness.*



The fellowship at the Budapest Institute of Technology terminated in 1921. The new rightist regime introduced the *numerus clausus*. This explains why Lanczos moved to Freiburg, then to Frankfurt, in Germany, where he worked in the Maxwellian–Einsteinian classical field theory. As a coronation of his career, at the recommendation of LEO SZILARD he became the assistant of Albert Einstein in Berlin for a year, where Einstein asked Lanczos to study the motion of singularities (i.e. particles) in a gravitational field, prescribed by the nonlinear field equations of General Relativity. When Einstein was asked a tricky question concerning general relativity, he used to answer: – *I don't know. Ask Lanczos!*⁵ – Lanczos maintained the contact and friendship with Einstein for life. In a later letter Einstein wrote to Lanczos:⁶

Dear Mr. Lanczos! I read your paper with great interest. That means more than mere intellectual interest. It may be you are perhaps the only man known to me, who shares my approach to physics: faith in that reality can be captured by its logical simplicity and unity. – It seems to be hard to peep in the cards of the Lord. But I can't imagine for a moment that He casts dice and makes use of telepathic means, as present quantum theory assigns to Him.

Most cordially, yours A.E.

⁴eine tüchtige und originelle Denkarbeit

⁵recollection of NICHOLAS KURTI, from the early years in Berlin

⁶facsimile, Einstein Archive No. 15294

Lieber Herr Lanczos!

Ich habe Ihren Aufsatz mit grossem Interesse gelesen, mit mehr als nur intellektuellem Interesse. Denn Sie sind der einzige und bekannte Mensch, der dieselbe Darstellung zur Physik hat wie ich: Gleiches am Erfassbarsten der Realität durch etwas logisch Einfaches und Einfachstiles.

Es scheint hard, dem Herrgott die seine Karten zu geben. Aber das er wirft und sich, "telepathischer" Mittel bedient (wie es ihm von der gegenwärtigen Gegenwart - Theorie gemindert wird) kann sehr kleine Augenblicke glauben.

Hochachtungsvoll Ihre Ihr

A. G.

Once Einstein asked, – *Could God have created the world to be different from the present one if he wished to do so?* – Let us add Lanczos' confession: – *I offer you two words, please think about them: internal must. On its way trying to move towards final understanding, either in the world of truth or in the world of beauty, human thinking tries to catch reality from inside. We are not interested in what the world is like, but what the world has to be. Shall we reach this goal or not, it is not so important for me. I am satisfied by trying it.*

It deserves one minute to stop at the interplay between Einstein and mathematics. Albert Einstein was not a technically skilled mathematician, did not attend university lectures. His professor, Hermann Minkowski called Einstein "*a lazy dog who never bothered about mathematics at all.*" To prepare for exam, he used the lecture notes taken by his classmate, MARCEL GROSSMANN (having Swiss roots, born in Budapest). Einstein had deep ideas, but he regularly needed some mathematical assistance. At the start this help was offered probably by Mileva Maric (his classmate at the Eidgenössische Technische Hochschule). Mileva was born in Titel (that time in Hungary, now in Serbia). Her parents sent the talented girl to the Royal Gymnasium in Zagreb where she

graduated in a science-oriented all-boys class. Then she went Switzerland, where girls had a better chance for a science career. She became the top student in mathematics at the Eidgenössische Technische Hochschule. According to some authors Einstein owes her mathematical talent a debt of gratitude.⁷ After a long romance with hundreds of love letters flying between Zürich, Bern, Heidelberg, Milan, Kač (Kócs), Budapest, they finally married in Zürich (1903), then visited Mileva's (Serb-speaking) parents in Újvidék (Novi Sad). The divorce happened in 1916, when Einstein was already famous and was called to Berlin. (But he gave half of his Nobel Prize money to her after their divorce.) – Minkowski explained the four dimensional space-time interpretation of Einstein's relativity in 1908. *Marcel Grossmann* explained to Einstein in 1912 the idea of non-Euclidean geometry (curved space), pioneered by the Russian Nicolai Lobatsevski (1829) and the Hungarian *János Bolyai* (1832) a century earlier; Bolyai even wrote: – *The law of gravity seems to be closely related to the nature and quality of the void.*⁸ – Non-Euclidean geometry was more completely developed by Bernard Riemann (1854). By making use of this, Grossmann became Einstein's main co-worker in creating the General Relativity. (The bi-annual international conferences on gravity carry the name *Marcel Grossmann Meeting*.) – In Berlin CORNELIUS LANCZOS filled the vacant place of Einstein's assistant. – In Princeton JOHN G. KEMENY was Einstein's assistant, helping in mathematics for awhile, later on *Nándor Balázs* worked for him.

Martha, Lanczos' wife remained in Hungary with their son Elmar. She was taken care of by the parents of Cornelius, due to her tuberculosis. Cornelius spent his summer holidays with his family in Tekerespuszta, at his father's estate. He kept steady contact with Professor *Rudolf Ortway* (already at Budapest University), gave lectures at the Ortway Colloquium on the *Stark Effect* (1930), and on the *Variational Principle for the Hamiltonian Canonical Equations* (1933).

Central Europe was becoming a more and more dangerous region. Hitler gained power in Germany. Lanczos, Neumann, Teller, and Wigner were invited and welcome in America to teach quantum mechanics. Cornelius wrote from Purdue University to Professor Ortway [facsimile]: – *Here the students learn much less and know much less than in Hungary or in Germany. But it is an advantage that everything is much simpler, the expectations are lower, which makes the life of the teacher more*

⁷Desanka Trbuhovic-Gjuric: *Im Schatten Albert Einsteins*, Paul Haut edition, Bern 1983

⁸unpublished manuscript in the Bolyai archive

A diákok sokkal kevesebbet tudnak és kevesebbet is tanulnak, mint nálunk vagy Németországban. De ezzel szemben áll az az előny, hogy nem olyan borzasztóan komplikált minden, a kivételnek csakélyebbek, ami a tanároknak is előnyös dolgát.

comfortable. – Visits to Hungary and letters to Ortvay were not hindered by the Atlantic in the 1930s. After a long illness, his wife, Martha died in 1938; his father died in 1939. The clouds of Nazism and War were accumulating above Europe. Cornelius obtained his U.S. citizenship in 1938, then took his son Elmar with him to the United States in 1939. The sad 35 years of isolation from his native country began.

Cornelius' mother Adél, his brother Andor, his sister Anna, together with their family died in Auschwitz in 1945. The only survivor of the concentration camp, György Lánzos/Ravid Benjamin, the son of Andor lives today in Israel. Lánzos' daughter-in-law and his grandchildren are Americans.



Heisenberg's matrix mechanics was born from an intention to find a new theory of atoms without introducing traditionally used but practically unobservable concepts like electron orbits within the atom. The outcome was a successful but very novel theory (1925). Physicists had to learn to work with infinite discrete matrices instead of differential equations. In the very same year, on 22 December 1925 another paper arrived to the editors of the *Zeitschrift für Physik*, saying:

– Heisenberg's line of thought is of pioneering importance, giving new meaning to old symbols. Here I will show that each result of quantum mechanics can be expressed by integral equations as well. In this way we obtain a continuum description which is completely equivalent to the discrete matrix description. The formulation given here is more directly related to the field theoretical thinking... – The author was: Cornelius Lanczos, one month before Erwin Schrödinger sent his paper on wave mechanics to the *Annalen der Physik*. Lanczos's paper made it evident principally, that the algebraic and analytical representations of quantum mechanics are mathematically equivalent, a result which Schrödinger accepted only later. Schrödinger's paper made, however, a larger impact as *wave mechanics*, due to his more picturesque and more

explicit (though a bit misleading) use of the wave function and wave equation. Schrödinger used the $\psi(x, t)$ wave function (field – as Lanczos said) to describe the state of the electron. The mathematical equivalence of the different formulations, and Lanczos' priority in offering an analytical form is now generally accepted. Lanczos used Dirac's $\delta(x)$ function as well before Dirac. As P.A.M. Dirac related decades later:

– *My work is just the generalization of Lanczos' formulation.*⁹

This work was completed during Lanczos' years in Germany. Later on, he attempted to work with the Dirac equation in General Relativity. When he moved to America (1931), he immediately gave a two-year course on quantum mechanics at Purdue University. His valuable lecture notes on *Wave Mechanics* – written in the first year – make interesting reading even today because it includes also the mathematical basis of the theory (function space, group theory), because – as Lanczos has emphasized – *modern physics has a much closer connection to mathematics than the previous one.*



The 1930s were years of recession in America; it was a hard fight for jobs and survival in science as well. Lanczos made use of his mathematical talent and skill, and turned towards applied mathematics. During World War II he found work with military projects, then in the laboratory of Boeing (1944) and later at the Institute for Numerical Analysis of the National Bureau of Standards. He was successful in dealing with matrices and spectra. He introduced what we call today the Lanczos algorithm (for solving extended systems of linear equations) and fast Fourier transform (in case of N discrete points reducing the number of operations from N^2 to $N \ln N$) did it at the right time: at the dawn of the computer era. This actuality brought him fame as a mathematician in the New World, which always respects reality, which values a job completed. But in the depth of his brain, Lanczos was still dreaming about the Question: what has to be the ultimate structure of the Universe?

Then the McCarthy era arrived and the most important state laboratories were purged of dubious characters. Lanczos accepted the call from the President of Ireland: he moved to the Dublin Institute for Advanced Studies and worked with Erwin Schrödinger and others on problems what their minds found the most challenging. In 1973 Lánczos Kornél revisited Hungary, where he was elected honorary member of the Eötvös Society. Let us quote from his acceptance speech:

⁹a lecture in Trieste

– *We stand at the shore of a lake, and the surface of the lake seems to be smooth like a mirror. Now a soft breeze starts blowing, and the surface of the water changes to millions of tiny wavelets. The average curvature was zero a minute ago, but now it has taken a high value. If the wavelets are small, looking from a distance we may consider the surface smooth, but in reality the local curvatures are large. Quantum phenomena may result in an agitated metric of geometry. I call this fuzzy view dynamical relativity. We know that a partial differential equation may possess infinitely many different solutions. How about choosing a solution periodic in all the four coordinates? This would give a kind of lattice structure for geometry. How can this be compatible with the apparent isotropy of space and time? It may be that the lattice constant is very, very tiny...* – From Hungary, Lanczos returned to Ireland. From Dublin he wrote to *István Kovács*, to Budapest [facsimile]:

Dear Steve, I go regularly to the Institute, although I find it a bit difficult in case of bad weather because the buses don't commute due to a strike that is completely irrational; the companies have accepted all the workers' demands but the two unions are unable to agree between each other. This is why Dublin has to be without transportation. Besides this, the political situation is unstable, nobody knows what will be the final outcome. How much better everything is organized in Hungary! – But I may not complain because I have got a few constructive ideas. I have succeeded to show that gravity, electricity and quantum phenomena may find their natural place within the framework of a fully rational theory. The only problem is that my colleagues don't show any interest in this direction, because the speculative research is nowadays very suppressed. The physicists are fully satisfied if they succeed to create a modest order locally with pragmatic models in the chaos of observational facts. An embracement from your old friend with love,

Kornél

During the summer of 1974 he revisited Hungary once again. His words showed that the Holocaust, the annihilation of his family could never be forgotten. In spite of deep sadness he felt at home in Hungary and speculated about spending a sabbatical year in Budapest. In the Great Synagogue of Budapest he prayed and spoke to the Jewish Community. His God gave him homecoming. He died in Budapest from a sudden heart attack. He was buried in the Jewish cemetery in Farkasrét, where both the main rabbi and the president of the Eötvös Society spoke about Lanczos' merits.



Kedves Pista!

Jun. 7. 1974

És a magam részéről rendszeresen bejártok
bár csak ismétlésként az ut kinti neheromra
csik, igazán nálunk most már 6 hete a
buzsok egyaránt nem közlekednek egy
szóval kórházban, amely teljesen irracionális,
mert az újságírók belmentek a munkások
minden kivételébe, de hát két szakmavezet
nem tud egymással megegyezésre jönni. Éret
kell egy nap, vérszék transport nélkül
kenni. Problémául is a politikai helyzet
állandóan a kibővítés előtt van és senki
sem tudja, hogy mi lesz annak a vége.
Mennyivel jobban van nálunk minden meg
szervezve!

Mindamellott nem szabad panaszkodnom,
mert volt egy pár konstruktív gondolatom és
sikertelt megmutatnom, hogy egy teljesen
racionális geometria keretén belül tényleg a
gravitáció, elektromosság, és a quantum jelenségeket
igen természetesen megtalálják a helyüket. A
de csak az, hogy a kollégáim ezen
gondolatok irányában semmiféle érdeklődést
nem mutatnak, minthogy jelenleg a spekulatív
irány általában nagyon a háttérbe szorult
és a fizikusok teljesen meg vannak
elégedve, ha felig pragmatikus, felig
elméleti "modell"-ek segítségével sikerül
melik a megfigyelések közzéadásban bizonyos
rendet csinálni.

Szeretettel ölel öreg barátod
Kornél

The destiny of Cornelius Lanczos was to emigrate three times and in the meantime to search for God's order in the Universe. It may be appropriate to quote here ELIE WIESEL, the Jewish-Rumanian-Hungarian-American poet. He was taken to the Buchenwald annihilation camp from Sziget (Máramarossziget, then in Hungary) and lost his parents and sister in the Holocaust as Lanczos had (1945). That memory cannot be eradicated from his memory, feeding his poetry since fifty years. From his youth, Elie Wiesel recalled,¹⁰

– I was born in the depth of the Carpathian Mountains. I loved my parents, admired my teachers, timidly adored God. I was only anxious whether my faith is strong enough.

– In reading old texts something charmed me. Without changing my place, I walked through visible and invisible worlds. I was in two places, thousand places simultaneously, I did a thousand kind of things. At the Creation I was with Adam, who was just awakening in a world bathed in light. I was with Moses on Mount Sinai, below the fire-red sky. I threw myself upon a sentence, a word, and distances did not count any more.

Wiesel received the Nobel Peace Prize (1986), "because of his message is one of piece, atonement, and human dignity. His belief that forces fighting evil in the world can be victorious is a hard-won belief." He began his Nobel lecture saying:

– A legend tells us that the great Rabbi Baal Shem Tov undertook an urgent and perilous mission: to hasten the coming of the Messiah, because all of humanity was suffering too much, beset by too many evils; it had to be saved, and swiftly. For having tried to meddle with history, the Rabbi was punished: banished to a distant island.

In the acceptance speech of the Nobel Prize Wiesel spoke about his personal memory of the Holocaust: *– It happened yesterday or eternities ago. A young Jewish boy discovered the kingdom of night. He asked his father: – "Can this be true?" – This in the 20th century? Could anyone explain the loss of ethical memory of all those lovers of art and poetry, of Bach and Goethe? How could we ever understand the passivity of on-lookers – yes – the silence of the Allies? And the question of questions: Where was God in all these? It seemed impossible to conceive Auschwitz with God as to conceive Auschwitz without God. And that is why we must always take sides. Neutrality helps the oppressor, never the victim. Silence encourages the tormentor, never the tormented. There is so much injustice and suffering crying out for attention: victims of hunger, of*

¹⁰*Tous les Flueves vont á Mer*

racism, and political persecution, writers and poets, prisoners in so many lands governed by the Left and Right. Human rights are violated on every continent. It would be enough to put an end to hatred against anyone who is different – whenever black or white, Jew or Arab, Christian or Moslem, against anyone whose orientation differs politically, philosophically, sexually. A naive undertaking? Of course. But not without a certain logic. Wherever men or women are persecuted because of their race, religion, or political views, that place must – at that moment – become the center of the universe. – Elie Wiesel concluded his Nobel lecture: – I began with the story of the Rabbi. War leaves no victors, only victims. Mankind needs peace more than ever, for our entire planet, threatened by nuclear war. Mankind must remember that peace is not God's gift to his creatures, it is our gift to each other. – Elsewhere he quoted the Talmud:

– It's better to be among the victims than among the murderers.



At the centenary of his birth a Lánzos Memorial Conference was arranged in Székesfehérvár by the Eötvös Society. Documents and lectures on Lánzos Kornél have been edited (in Hungarian language) in a *Lánzos Centenary Volume*. On the other side of the Ocean, at North Carolina State University, a Centenary Conference was held in late 1993. The edition of his Collected Works is in progress. A memorial plaque preserves his memory on the Lánzos house in Székesfehérvár. A small street – branching from *Neumann János utca* was named to *Lánzos Kornél utca*. Local high school students take part in the Lánzos Physics Competition every year.

Kemény János – John G. Kemeny

1926–1992

The main hope of society may be the computer, the harmonic symbiosis of humans and computers. (J. G. K.)

At Princeton, after a successful exam the professor noticed the alien accent of his student, and asked about his origin. When Kemeny answered, the professor raised his hands: – *My God, one more Hungarian!* His father, Kemény Tibor, was active in agricultural trade and in banking as well. Kemény János attended Rácz's Primary School, the same as NEUMANN JÁNOS. Later he was enrolled in the Berzsenyi Gymnasium, SOROS GYÖRGY attended the same school. About this period Kemeny told the author:¹ – *I was very happy in the Berzsenyi Gymnasium. I had a wonderful mathematics teacher.*

In 1938, when Hitler marched into Vienna, John's father said: – *This is the beginning of the end.* – Taking advantage of his import-export connections he travelled to the United States, to build up his business in America. Thereafter, in January 1940 he instructed his family to come to America. Some of his relatives chose to remain in Hungary they disappeared later in the Holocaust.² The family boarded an American ship in Geneva. At that time German submarines were very careful not to sink any American ship, to avoid provoking the United States to declare war. The 14-year-old boy landed in the New World without knowing a word of English. He understood only Hungarian, German, and Latin. In New York he went to George Washington High School. (This might not be a bad school; it was attended also by Henry Kissinger.)

– *There was a great difference between Budapest and New York. I learned good mathematics from Mr. Bölcsbázy in the Berzsenyi Gymnasium in three and a half years of the junior high school. The next occasion to learn more mathematics was offered to me when I enrolled at Princeton University.*



¹Budapest 1988

²John G. Kemeny revisited Hungary only in 1964

RÁCZ-féle
NYILVÁNOS JOGU
MAGÁN ELEMI ISKOLA

BUDAPEST
VI., VILMOS CSÁSZÁR-UT 31. SZÁM

ÉRTESITŐJE

Kemeny János György

TANULÓ RÉSZÉRE



John G. Kemeny graduated from Princeton University in three years. World War II was at its peak. The 19-year old young man fulfilled his military service in Los Alamos. – *When Kemeny obtained American citizenship, he wrote the news happily to his parents, saying that it had gone without any complication and delay: – “Nobody asked me silly questions whether I had been a communist or like that.” – But the letter – like other ones sent from Los Alamos – were censored, even those written in Hungarian. The security officers called Kemeny to a hearing. All his excited friends were waiting for him outside. One hour elapsed, then two hours. Finally, after two and a half hours Kemeny emerged. We asked, – “What happened?” – He answered, – “Well, I let the security officer acknowledge that there are problems in capitalist societies as well.” – Kemeny excelled indeed in debate; as a freshman in Princeton he was the head of the Debate Team. When I discussed something with him, after a while I switched to Hungarian because (due to my later arrival to the United States) I spoke Hungarian more easily than he.*³

³Peter Lax to the author 1994.

On the Hill Kemeny worked in the Computer Laboratory of the Theoretical Department, under Richard Feynman who was not much older than he. This was where Kemeny's interest and sensitivity towards computers originated from. He had a chance to work with JOHN VON NEUMANN, who had made an impact on Kemeny. He noted:

– *Neumann was quite a normal man, and the greatest mathematician alive. He taught me, among other things, that I don't have to look terrible as some professors try to do if I wish to become a successful mathematician.*⁴

When his army service was over, he received his B.A. degree from Princeton University at the top of his class of 1947. In 1949 he obtained a Ph.D.; both degrees in logic related topics. (Later in his life his red car had the license number LOGIC.) In 1948 Robert Oppenheimer, the director of the Institute of Advanced Studies, elected Kemeny as the assistant of Albert Einstein [facsimile].

– *Einstein was the kindest man I ever met. His assistant was always a mathematician. He did not need any assistance in physics, but he could use some help in mathematics. Einstein was educated in mathematics but he did not know up-to-date mathematics. This is why he needed an assistant. To be frank, I was more familiar with modern mathematics. Certainly I had to know a bit of physics as well. As an undergraduate and graduate student I learned physics. I am not a genuine physicist; I have become interested mainly in the theory of relativity, having read a lot about it.* – According to Einstein's interest, they worked on unified field theory.⁵ Between 1949 and 1951 Kemeny worked in Princeton. During that period he had the opportunity for a closer scientific relationship with John von Neumann and with the scientists of the Research Institute of the Navy; he achieved fine results in the theory of Markov chains. In the early 1950s Kemeny became a member of the Department of Philosophy. (His philosophical interest was awakened by the lectures of Bertrand Russell at Columbia University.) He did show a Martian interdisciplinarity, reaching from the purest logic to the application of game theory in economics and social studies.



Thanks to Einstein's recommendation, Dartmouth College invited John G. Kemeny to the chair of mathematics. This college (founded in 1759) was older than the United States itself and had inherited very conservative WASP traditions.

⁴ *Yankee*, March 1980 issue

⁵ to the author

THE INSTITUTE FOR ADVANCED STUDY
PRINCETON, NEW JERSEY

OFFICE OF THE DIRECTOR

August 15, 1948

Dear Mr. Kemeny:

On the recommendation of Professor Einstein, I am pleased to offer you a Membership in the Institute for Advanced Study for the academic year 1948-49. Your position here will be that of assistant to Professor Einstein. We can make available to you a salary in the amount of \$2,500 to cover the expenses of your visit.

We look forward to having you as a member of our group.

Yours sincerely,



Robert Oppenheimer

Mr. John G. Kemeny
57 Princeton Avenue
Princeton, N. J.

Professor Kemeny – feeling the utmost relevance of mathematics in society – considered mathematics teaching to be his profession for life. The obituary of *The Guardian* quoted Kemeny's complaint: – *You can study mathematics for fourteen years without meeting any topics created after 1800.* – Kemeny liked lecturing freshmen. – *Kemeny was the only professor who could give a proof of a theorem verbally, without writing on the blackboard.*⁶ – Kemeny's lectures presented the power of mathematics also to those who were not going to become pure mathematicians. His *Introduction for Finite Mathematics* sold 200 000 copies. – *Each generation has one textbook or two, which changes the character of teaching, Kemeny's book was one of them.*⁷ – About the aim of the book Kemeny wrote:

– *In the usual introductory mathematical curriculum the courses are those leading to the calculus. A few years ago, the Department of Mathematics at Dartmouth College decided to introduce a different kind of freshman course, which students could elect along with the traditional ones. The new course was designed to introduce a student to some concepts of modern mathematics early in his college career. While primarily a mathematics course, it was to include applications to the biological and social sciences and thus provide a point of view, other than that given by physics, concerning the uses of mathematics. Our aim was to choose topics which are initially close to the students' experience, which are important in modern day mathematics, and which have interesting and important applications.* – This is why the book includes mathematical logic, theory of information, mathematical statistics, linear algebra, theory of games – and a lot of exciting problems from behavioral science (business, economics, genetics, even marriage customs). The book, written forty years ago, makes fresh reading now because its concepts have come to be of central interest.

John von Neumann had a vision about the future role of computers in science. John G. Kemeny had a vision about the future role of computers in society.

25 years after the discovery of the electronic computer he wrote a book on *Man and the Computer* (1971). He argued that *a new intelligent species had been born on the Earth: the computers, and humans have to learn to live with them in mutually useful harmonic symbiosis.* In biology symbiosis is the intimate union of two organisms of different

⁶Michael Jerry Antal to the author 1996

⁷Peter Lax to the author 1994

kinds to the benefit of both. The computers are structures operating million times faster than humans. Humans, on the other hand, may have more fantasy. These properties make their symbiosis promising. The high speed of the computer makes it possible that a single computer can contact thousand users, one after the other, but at such a rate that each human user feels: the computer talks directly to her or him.

The grand creation of John G. Kemeny was the *time sharing system*, the connection of a single fast computer to thousands of terminals (1963). This achievement was acknowledged by IBM with the very first Robinsion Prize (1991).

The symbiotic coexistence of humans and computers presupposes that the two partners are easily able to communicate with each other.

The first computers understood only the *machine language*, what humans had to learn. But as the memory and speed of computers increased, the possibility arose that computers learn the *language of humans*, and we talk to them in our way. The strict FORTRAN and ALGOL languages were meant only for scientists. But seeing the promise of computers to the whole society, Kemeny and Kurtz developed the BASIC language (1964), which can be learned step by step, can be used at different levels of sophistication. This has made the computers accessible to each schooled citizen. Nowadays more humans – and more computers – speak Basic than e.g. Hungarian.

In the book, written 25 years ago, Kemeny said, that – *the predictable evolution of the computer species is networking. The computers will turn out to be a telephatic race, possessing a group consciousness.* – In New England Kemeny realized such a net, centered at Dartmouth College; civilian users sent e-mails to each other already in the 1970s.

– *How can man keep up with his symbiotic partner? A rapid social and scientific evolution must take place if man is to maintain the role of a full partner. This, I predict, is one of the most exciting challenges facing humankind.*

Kemeny was a liberal thinker. He foresaw the high efficiency a completely centralized computer library, but foresaw its danger as well, as an efficient tool of thought police, watching the minds of people and prohibiting spreading nonconformist ideas. Therefore he spoke out in favor of a polycentric network. Present developments indicate that the evolution of the computer species and human reactions to it confirm Kemeny's foresights. John G. Kemeny deeply felt the future coming. He appreciated the achievements of the new automata, and did his best to educate the new generations for a peaceful coexistence of people and machines:

– *The trouble with old-fashioned machines was that they never did what you told them to do. The trouble with modern computers is the fact that they do precisely what you told them to do, and not what you meant to tell them to do.*

Kemeny recalls, that when his parents were born, cars were unknown, but for the kids in the second half of the 20th century, cars are facts of everyday life, their nervous system has been able to adapt itself completely to the new dimensions of speed. In a similar way, Professor Kemeny was *absolutely amazed at the ingenuity and creativeness of his exceptional undergraduate students* at living with computers. When he became the head of the Mathematics Department (1955), the most visible sign of his reorganization efforts was that the average age of staff members dropped below thirty. He made computers available (even compulsory) for each student of the College.

In these ways, John G. Kemeny became the architect of the minds of the new generation, not only at Dartmouth College but worldwide. Since he wrote his book, a new generation has been born and grown up in the computer era. Hungarian schools are connected to the world by the Internet and it is an everyday experience that teenagers are much more at home on the Information Superhighway than the professors. As Kemeny emphasized, only those will be in danger of losing their jobs due to automation who did not learn in the school how to learn lifelong. This is why Kemeny became deeply interested in school education as well; he chaired the American Committee on Mathematics Education and wrote about introducing the theory of probability, random walks, games and decisions to high school mathematics. Even in his late years – after having developed heart problems – Professor Kemeny insisted:

– *Teaching is the only cure that helps me.*



The 1960s were the era of student protest movements in the United States. At this time the popular and future sensitive Kemeny was elected to President of the College. On this occasion he revolted against the rule, “The president may not give lectures,” saying: – *If I asked to have two free afternoons a week because I like golf, the College Council would surely grant that request. Well, you have to consider this request on the same line. I have always considered teaching to be my profession, not the presidency.* – While being the President of the College, Professor Kemeny kept all his classes. He only complained that *professors don't know computer programming and don't know teaching either.* – When the Security Service of the College asked him what to do if student demon-

strators were to occupy the President's Office, as had happened elsewhere, Kemeny answered: – *Give them all the unanswered letters, and oblige them to burn the letters!*

The football team of Dartmouth College was called the INDIANS, but it was President Kemeny who, in the 200 year long history of the College, made it first possible for native Indians to be enrolled. In spite of strong opposition, he achieved also the admittance of girls to the old conservative College.

– *For the present problems of humankind modern science and technology were made responsible. It's true that the problems are direct or indirect consequences of modern science. Some of the young people think that all problems will be solved if we forget about technology and return to the earlier primitive way of living. Some of them did so. This is a comfortable solution indeed while the other parts of society cultivate modern science and technology at such a high level that society is able to support those who have left the society. It's true that without the discoveries of Einstein the atomic bomb would not have been invented. But I have a dream that the General Assembly of the United Nations will agree to the elimination of nuclear weapons, and utilize inexpensive nuclear power to raise the standard of living in developing countries.*

– *You have to ask who is guilty if this does not happen. Nobody denies that medicine is the most humane science. On the other hand, overpopulation is one of the gravest problems of the world. But it would be a mistake to make medicine a scapegoat for it. The average citizen trusts the statement of an engineer concerning the safety of a bridge, or in that of a medical doctor concerning sickness. But where are the social scientists whom we could trust in a similar way? When an excellent social scientist predicts something, it is probable that another equally respected social scientist will make the opposite prediction. After the successful breakthroughs achieved in physical sciences and biological sciences, the incoming generation has to make an equally reliable breakthrough in social studies. Those young people have to do it who are now our students, otherwise no time will be left to prevent the catastrophe endangering humankind.*⁸

John G. Kemeny became an honorary doctor at nineteen universities, received the Prize of the New York Academy, and was an honorary member of the Eötvös Society. The peak of his carrier was when he entered the Oval Room of the White House.

⁸Kemeny's lecture at Dartmouth College 1973

– At 4:00 a.m. on the 28th of March 1979, near the town of Harrisburg in the state of Pennsylvania, a very small and completely insignificant technological incident happened in a nuclear power station. Within a week this was made the greatest media sensation of the year. Two weeks after the incident the President of the United States nominated a Commission of twelve members to investigate the case, and he charged me to chair the Commission. On 11 April 1979, as we were driving with my wife toward the White House, we tried to figure out what NRC could mean, which I was supposed to cooperate with; perhaps National Research Council? Because I never had heard about the existence of a Nuclear Regulatory Commission. Then after six months the NRC wished that they had never heard of me.⁹

– The concept of probability is taught almost everywhere. It is my absolute conviction that we must teach the concept of risk and risk analysis as well. The public likes to think in categories 0 or 1. But a risk can never be 0 and this is why the concept of acceptable risk is unavoidable. When I teach probability theory, I start by saying that each of our decisions relies upon probabilities. After that, my whole lecture is nothing else but the explanation of this fact.

– At the Three Mile Island nuclear power station there were a few minor disturbances in the machines, but these were not extraordinary. All the real errors were made by people at different levels: operators, operator trainers, on up to the Nuclear Regulatory Commission. I was shocked by the huge number of human errors. For me the most important message of the Three Mile Island accident was that humans commit all the mistakes which can be committed. The other important conclusion was that in spite of human errors practically no radiation leaked out.

– The main problem in the U.S. is that since the case of Three Mile Island people are afraid of nuclear power. I tried to explain that coal mining and smoke is risky as well but public opinion is completely irrational. While we were writing the Report of our Commission, there was a huge explosion in a chemical factory in Canada, not far from the border of the U.S. The escaped chemical poison killed people. A much larger area was evacuated than in the case of the Three Mile Island accident. But the chemical accident made headlines only for one day, the public reaction was negligible compared to that of the Three Mile Island nuclear accident. It is hard to explain to people that in a nuclear reactor a

⁹Kemeny's lecture at Dartmouth College 1979

John Kemeny, 66, Computer Pioneer and Educator

By SETH FAISON

John G. Kemeny, a distinguished mathematician and computer pioneer who was president of Dartmouth College for more than a decade, died yesterday at the Dartmouth-Hitchcock Medical Center in Lebanon, N.H. He was 66 and lived in the town of Etna, near the Dartmouth campus.

Alex Huppe, a spokesman for the college, said the cause of death was apparently a heart attack.

Dr. Kemeny was a forceful and popular leader who guided a tradition-cherishing Ivy League institution through a series of profound changes, including the admission of women in 1972. The creator of a widely used computer language, he was an advocate both of making computers more accessible and of maintaining a central educational role for liberal arts.

Dr. Kemeny was also appointed by President Jimmy Carter to head the Federal commission that investigated the nuclear accident at the Three Mile Island power plant in Pennsylvania in 1979. The commission issued a report that criticized Federal regulators and the nuclear power industry for lax safety standards.

A Doctorate at 23

John George Kemeny was born in Hungary on May 31, 1926, and immigrated to the United States with his parents in 1940. His spoken English retained a gentle Eastern European accent throughout his life.

Widely praised by his colleagues for both the depth and the breadth of his intellect, Dr. Kemeny was selected a year after his graduation from Princeton University to be a research assistant to Albert Einstein, and he passed the first milestones of his academic career while still remarkably young. He earned a doctorate in mathematics from Princeton at 23, was made a full professor of mathematics at Dartmouth at 27, was appointed chairman of the mathematics department there at 29 and was named president of Dartmouth at 43.



The New York Times, 1980

John G. Kemeny

He served as president for 11 years, until 1981, when he resigned to return to teaching. But his most lasting contribution to the thousands of students who came to know him, and to others who did not, may have been as co-inventor of BASIC computer language, one of the most widely used in the world. BASIC provided the intellectual building blocks for many later forms of software and is still a major tool in teaching computer programming.

Dr. Kemeny saw to it that Dartmouth's computing center was made accessible to students and faculty via telephone hook-up to terminals in their offices and other areas, Mr. Kurtz said, years before other Ivy League schools were doing so.

As president of Dartmouth, Dr. Kemeny became popular by making himself accessible to students, teaching occasional classes and holding regular office hours so that a student could meet him without an appointment.

Dr. Kemeny was critical of the conservative wave that grew at the college at the end of his tenure as president and that was epitomized by *The Dartmouth Review*, whose articles provoked turmoil on campus and attracted attention from some of the nation's leading conservatives, like Patrick J. Buchanan and William F. Buckley, Jr.

Within this movement Dr. Kemeny detected the seeds of intolerance. On his final day as president, in June 1981, he warned his students in a commencement address against "a voice heard in many guises throughout history, which is the most dangerous voice you will ever hear."

"It appeals to the basest of instincts in all of us, it appeals to human prejudice," he said. "It tries to divide us by setting whites against blacks, by setting Christians against Jews, by setting men against women. And if it succeeds in dividing us from our fellow beings, it will impose its evil will upon a fragmented society."

After stepping down, he returned to Dartmouth's mathematics department, where he taught until 1990. He remained active in the college's fund-raising efforts until his death.

When he arrived with his family in New York City in 1940, Dr. Kemeny attended George Washington High School. Three years later he graduated at the top of his class. He became an American citizen in 1945 and served in the Army as an assistant in the theoretical division of the Los Alamos nuclear project in 1945-46.

Dr. Kemeny was the author and co-author of more than a dozen books about mathematics, computers and philosophy. He received more than 20 honorary degrees.

He is survived by his wife, Jean; two children, Jennifer Kemeny of Rowley, Mass., and Robert Kemeny of La Canada, Calif., and two grandchildren.

The New York Times Magazine
illuminates the news.

*slow chain reaction proceeds with slow neutrons; in the atomic bomb a fast chain reaction proceeds with fast neutrons. The anxiety with respect to nuclear power is based on the psychological fear from the atomic bomb.*¹⁰ – He concluded: – *The modern machines are already reliable. The humans are not yet reliable enough.*

In 1979 John G. Kemeny, this boy from Budapest, became the most publicized scientist in the American press. President Carter personally thanked Kemeny for the report of the Commission. In October Professor Kemeny returned to teach at Dartmouth College. His students insisted that he speak about Three Mile Island. Over 1000 students assembled, including environmentalists. (The school color of Dartmouth College is green.) Professor Kemeny began his lecture by saying, – *You can't imagine how good a feeling it is to return to civilization after six months spent in Washington.* – Following the lecture, the environmentalists canceled the intended demonstration.



John G. Kemeny liked crossword puzzles, Sherlock Holmes, and Agatha Christie. He kept a teddy bear from his grandson on his bedside table. Each evening he told the bear “good night.” He died in the night due to a sudden heart attack. The obituary of the *New York Times* quoted his words told to his students when he retired from the College Presidency (1981):

– In the years to come you will hear a voice heard in many guises throughout history, which is the most dangerous voice you will ever hear. It appeals to the most basic instincts in all of us, it appeals to human prejudice. It tries to divide us by setting whites against blacks, by setting Christians against Jews, by setting men against women. And if it succeeds in dividing us from our fellow beings, it will impose its evil will upon a fragmented society. Don't listen to this voice! Listen much more to the internal voice which says that mankind may live in harmony, mankind may respect the right and dignity of each human being. I ask you to use your talent – this great immanent value – for the creation of a better world, for making a liveable world, in which there will be a place for all of us. Sons and daughters of our College: the whole of humankind is your brother and sister, and you are the custodians of your brothers and sisters.

¹⁰to the author 1988

Gróf András – Andrew S. Grove

1938–

Only the paranoid survive.

(A. G.)

In 1995 well over 50 million personal computers were bought by consumers. PC production is close to surpassing TV production rates. Nowadays in California 63 % of the teenagers would rather use a computer than read a book. 50 % would rather use it than watch TV.¹ This is what ANDREW GROVE calls a demographic time bomb in human culture. Who will shape this New World?

GRÓF ANDRÁS was born in Budapest and attended the Madách Gymnasium [facsimile]. Summers he earned money by working as a waiter. The young man began to study chemical engineering (1955), but we shall not be surprised if this “mad Hungarian” will not pay attention to disciplinary boundaries. Then came the Hungarian revolution against Soviet rule (1956) starting at the Budapest Institute of Technology.

*– I was a student and went along with some of the demonstrations, like anybody else. Then I hid in a coal cellar while the Russians were blasting our area. When I got sufficiently scared about sticking around, I took a deep breath and left the country.*² – The young man landed in New York. By making use of the knowledge learned in Hungary, he collected credits even from Russian language, and graduated in chemical engineering in New York (1960). He dreamed of making a career as an opera singer but he actually did a Ph.D. in chemical engineering at the University of California in Los Angeles (1963).

This was the time when Robert N. Noyce, inventor of the integrated circuit – together with Gordon E. Moore – established the Fairchild Semiconductor Company; Mr. ANDREW GROVE worked for them. In the years to come, Grove published dozens of papers about semiconductors and taught the physics of semiconductors at the University of California, Berkeley, for six years. He wrote a textbook on the physics and applications of semiconductors (1967).

¹ *San Jose Mercury News*, 10 April 1995

² *International Herald Tribune*, 19 November 1996

A tanuló									
neve ¹⁾ : <u>Görög András</u>		apja neve: <u>Görög György</u>		jelenleg 1945 előtt: <u>tanítvány (okt. n.)</u>		1945 előtt: <u>magántanuló</u>		ha más iskolából jött, előző bizonyítványát melyik iskolában:	
Sorsz.: <u>8.</u>		anyja leánykori neve: <u>Földes Károl</u>		jelenleg 1945 előtt: <u>tanít.</u>		1945 előtt: <u>h.t.b.</u>		hányadik osztályról:	
Szül.: 1936 évi <u>febr.</u> hó <u>2.</u>		gondviselője ²⁾ neve:		jelenleg 1945 előtt:				ismétlő v. magántan. minőségben:	
község: <u>Guđoyest</u>								mikor kapta:	
város: <u>Pest.</u>									
megye: <u>Pest.</u>									
származása: <u>E. g. é. l.</u>									
A tanuló hol lakik? <u>húcéinél</u>				Szülők (gondviselő) lakása: <u>ny. V. Majakovszky - u. 73</u>					
Szüleinél vagy				(dolgozóknál a munkahely)					
Tantárgyak	FÉLÉVI ÉRTEŚITŐ				BIZONYÍTVÁNY				
	Érdemjegyek		Jegyzet (A tanuló évközi kilépése, csúszás eltávolítása v. kizárása, egyéb észrevétel)	Érdemjegyek		Jegyzet (A tanuló évközi kilépése, csúszás eltávolítása v. kizárása, egyéb észrevétel)			
szám-mal	betűkkel	szám-mal		betűkkel					
Magartartás	5	Példás		5	Példás				
1. Magyar nyelv és irodalom	5	Jeles		5	Jeles				
2. Történelem	5	Jeles		5	Jeles				
3. Alkotmánytan				5	Jeles				
4. Orosz nyelv és irodalom	5	Jeles		5	Jeles				
5. Rom. Német nyelv és irodalom	5	Jeles							
6. Latin nyelv és irodalom									
7. Matematika	5	Jeles		5	Jeles				
8. Ábrázoló geometria	5	Jeles		5	Jeles				
9. Fizika	5	Jeles		5	Jeles				
10. Természetrajz	5	Jeles		5	Jeles				
11. Kémia									
12. Földrajz									
13. Testnevelés	5	Jeles	5	Jeles					
Rendkívüli tárgyak									
Általános tanulmányi eredmény	5	Jeljes	5	Jeljes					
A tanári testület határozata	Érteśítési vizsgát belet.								
Mulasztott órák száma	igazolt	I. félévben: <u>16.</u>	II. félévben:	Egész évben mulasztott órák száma:	igazolt <u>52.</u>	igazolatlan:			
A díjkezdvezmény mértéke	az I. félévben	<u>mentes</u>	a II. félévben						
Észrevétel (osztálydij, segélydíj, felmentés, stb.)	Jegyzet. (Magán-, javító-, felvételi, különbözeti vizsga kelte és egyéb, ezekre vonatkozó adatok)								

¹⁾ Ha a tanuló ismétlő- vagy magántanuló, ezt a név után jelezni kell. — ²⁾ A rovatot csak akkor kell kitölteni, ha név az apa v. anyja a gondviselő. T. U. 901/a. raktári szám. Általános gimnázium. (Bélfv.) — Nyomtatványellátó vállalat. 3198. — Állami Nyomda, Budapest, 1964. — 533/06.

In 1968 Gordon E. Moore left Fairchild, created INTEL and Grove became its first employee. Later he became the President of INTEL (1979), then Chief Executive (1987) and – when Gordon E. Moore retired – Grove was elected the Chairman of the Board (1997), keeping also the position of President. In these short three decades INTEL climbed up to become the fifth-most-admired company in America, and the seventh-most-profitable one with sales over \$20 billion per year, making several billion dollars profit in 1996, a new record. But this climb was a bumpy ride.

Originally INTEL fabricated memory chips. Their 64 bit chip offered such a computer memory on 1 cm², which had been realized by 64 electron tubes in the computers of twenty years before. Not much later the 256 bit memory chip followed. In 1969 this was considered the marvel of technology. The 1024 bit memory chip made INTEL the ruler of the market and Andy Grove the president of INTEL (1979). His book on *High Output Management* has been translated into eleven languages.

At the peak of this boom, however, the Japanese entered the chip market and in the middle of the 1980s they were about to take over with cheaper memory chips of high quality. Now let us listen to Grove.³

– *I remember a time in the middle of 1985. I was in my office with INTEL's chief executive, Gordon Moore, and we were discussing our quandary. Our mood was downbeat. I looked out the window, then I turned back to Gordon and I asked, "If we got kicked out and the board brought in a new Chief Executive, what do you think he would do?" Gordon answered without hesitation, "He would get us out of memories." I stared at him, numb, then said, "Why shouldn't you and I walk out the door, come back and do it ourselves?" Thus we figuratively went out the door, stomped out our cigarettes and returned to the job. As we came back in that door, the main question we faced was this: if we are not doing memories, what should INTEL's future focus be?*

– *Microprocessors were the obvious candidate. In about 1970 or so we had produced microprocessors. The microprocessor is the brain of the computer: they calculate while memory chips merely store. We had now been supplying the key 286 microprocessors for IBM-compatible personal computers. The 386 microprocessor became very, very successful, by far the most successful microprocessor to that point. The slogan INTEL INSIDE (1981) suggested to the computer users that the microprocessor that's inside his or her computer is the computer. Thus they began speaking about their computer in this way: "I have a 386."*

³Andrew S. Grove: *Only the Paranoid Survive*, 1996

The 486 microprocessor followed, then the 586 microprocessor named PENTIUM was developed by INTEL (1994). Fifty years ago Neumann had asked for about \$1 million to support the development of the Princeton Computer. The research and development costs of the PENTIUM were above \$1 billion. But at this moment an accident happened. A math professor encountered a division error while using the floating point capabilities of the PENTIUM chip. The design error was not significant: an average user would run into this problem once every 27000 years of spreadsheet use. But comments were printed in journals under headings like BUG IN THE PENTIUM. The wide use of the new INTEL chip is demonstrated by the fact that due to this minor bug, INTEL lost almost \$500 million in six weeks. The bug was eliminated and now the net profit of the company makes 5 billion dollars a year and it grows at a rate of a spectacular 30 % per year. The newest 686 named PentiumPro performs 400000000 arithmetic operations per second. Within ten years the computer performance increased by a factor of 100 per unit cost.

Professor Grove teaches *strategy and action* at the Stanford University Graduate School (with a Martian accent); he likes physicist rhetoric like reaching an *inflection point*, letting *chaos* reign, watching out for *signals* in the sea of *noise*, waiting for a new *order* to emerge.

– *An inflexion point occurs where the old strategic picture dissolves and gives way to the new, allowing the business to ascend to new heights. However, if you don't navigate your way through an inflexion point properly, you go through a peak and after the peak the business declines. It is around such inflexion points that managers puzzle and observe, "Things are different. Something has changed." A strategic inflexion point can be deadly when unattended to. But it creates opportunities for players who are adept at operating in the new way.*

– *Given the amorphous nature of an inflexion point, how do you know the right moment to take appropriate action, to make the changes that will save your company or your career? Unfortunately, you don't. Getting through a strategic inflexion point requires enduring a period of confusion, experimentation. It requires listening to Cassandras, deliberately fostering debates, loosening up the level of control that your organization normally is accustomed to. The operating phase should be: "Let chaos reign!" Not that chaos is good in general. It's awfully inefficient and wearing on all participants. But the old order won't give way to a new one without a phase of experimentation and chaos in between. The transition requires causalities and personal transformation; it requires accepting the fact that not all would survive and that those who did would not be the same as they had been before. But this should be*

followed by a period of single-minded determination to pursue a new direction toward an initially nebulous goal.

– When I think about what it's like to get through a strategic inflexion point, I'm reminded of a classic scene in old western movies in which a bedraggled group of riders is traveling through a hostile landscape. They don't know exactly where they are going; they only know that they can't turn back and must trust that they will reach a place where things are better. I think of this hostile landscape through which you and your company must struggle – or else perish – as the valley of death. It is very hard to lead a company out of the valley of death without a clear strategic decision. If competition is chasing you (and they always are, this is why only the paranoid survive), you only get out of the valley of death by outrunning the people who are after you. And you can only outrun them if you commit yourself to a particular direction and run as fast as you can. Otherwise you will run out of water and energy before long. But companies don't die because they are wrong; most companies die because they don't commit themselves. The greatest danger is in standing still. The other side of the valley of death represents a new order, that was hard to realize before the transition.

Andy Grove is referred to in professional circles as the *mad Hungarian*. We quoted from his book, entitled *Only the Paranoid Survive* (1996). Peter Drucker commented, – *This terrific book is a dangerous book: it will make people think.* – Steve Jobs, creator of the MACINTOSH computer, said, – *You must learn about Strategic Inflexion Points because, sooner or later, you are going to live through one.*

In 1995 Grove was diagnosed with prostate cancer; the doctors recommended that he undergo surgery. Delving into the information available on INTERNET on-line, Grove found that despite the professional medical preference for cutting out the tumor, radiation therapy offered similar chances for recovery with far less unpleasant side effects. Andy Grove turned out to be right. After his recovery even the doctor who eventually had carried out the radiation therapy confessed that faced with the same choice, he would have taken surgery. (In this respect, remember Szilard's story.)

The INTERNET arrived in the 1990s. Some companies began developing small mobile sets without memory, to be connected to a mainframe computer, saving the user from the duty of programming (and thinking). But Grove works on a smart system which will couple the attraction of the television and the communication capability of the telephone with the interactivity of a videogame and the computational power of the computer in a single set, in order to serve human intelligence:

– In technology, whatever can be done, will be done.

Kösztler Artur – Arthur Koestler

1905–1983

Since the Renaissance the “ultimate reason” has shifted from heaven to the atomic nucleus. (A. K.)

– In 1919 at the age of fourteen I was lying on a hill near Budapest, below the blue sky. My eyes were overwhelmed by the quiet, translucent, limitless, saturated blue above me. I was filled with mystic ecstasy, so often experienced in childhood and so rarely later. In this state of happiness my brain was hit by the paradoxon of infinite space, as if a wasp had bitten me. One may shoot an arrow into infinity, which can leave the attraction of the Earth, bypass the Moon and the Sun; it would fly through interstellar space, beyond the Galaxy; it would go on and on, past the spiral nebulae, and there would be nothing to stop it, no limit and no end – and the worst of it was that all this was not fantasy but literally true. Such an arrow could be made real; in fact the comets which moved in open parabolic orbits were such natural arrows, rising in space to infinity – or falling into infinity; it came to the same thing, and it was a torture to the brain. Nothing would stop it, neither in space, nor in time. The most exciting thing about this idea is that it is not mere imagination, it's true! A comet in a parabolic orbit epitomizes this Arrow in the Blue tormenting my brain. The idea that infinity would remain an unsolved riddle was unbearable. The more so as I had learned that a finite quantity like the Earth – or like myself reclining on it – shrank to zero when divided by an infinite quantity. If space was infinity, the Earth was zero and I was zero and one's life-span was zero. It made no sense, there was a miscalculation somewhere, and the answer to the riddle was obviously to be found by reading more books about gravity, electricity, astronomy, and mathematics. Maybe I had been chosen and elected to solve it.

This is how Koestler remembered the urge of his youth in his autobiography, appropriately entitled *Arrow in the Blue* (1953). He considered himself to be such an arrow, shot out from Hungary. He flew through Palestine, Stalin's Russia, the prison of the Spanish civil war, the French Foreign Legion, over the North Pole, deep into the dreamworlds of drug-induced hallucinations. Along the way he tried several ideologies, and experienced their real outcomes. As a *Drinker of Infinity*, he was

fascinated by the collision of opposites, as shown by the titles of his other books like *Le Zero et l'Infini*, *Arrival and Departure*, *Promise and Fulfillment*, *The Yogi and the Commissar*, *Insight and Outlook*, *White Nights and Red Days*, *Darkness at Noon*. He was as much moved by the prospects of nuclear power as by the grandeur of the Big Bang. In his autobiography Koestler wrote:

– *Almost a century was required to digest the idea of Copernicus, which devaluated man's place in the Universe. After Hiroshima, it's even more difficult to digest that the Human Race has become mortal.* – As a journalist trained in science he interviewed Louis de Broglie, Sigmund Freud, and Albert Einstein. Learning about the possibility of a curved and closed Universe, he dreamt on: – *It may be that the Arrow does not run away forever but after eons it returns to that sunny hillside in Budapest from where it left to fly beyond the Moon and the Galaxy.*



His ancestors – escaping from the menacing pogroms – arrived from Russia to Hungary. Grandfather Lipót settled in Miskolc (1865) and chose the name Kösztler “because it sounds so fine.” Lipót’s son, Kösztler Henrik was a daydreamer, who created – among other ventures – a factory to produce radioactive soap (1916), using the moderately active clay found not far from Budapest, because “*radium was the new miracle, reminding the layman of Madame Curie, X rays, and the miraculous healing effects of radioactivity.*” – This was Arthur’s father. His mother came from Prague, a descendant of the famous Rabi Levy, who built the Golem to protect the Ghetto from attacks.¹

Arthur attended school in Budapest [facsimile]. At the age of ten he decided to become a physicist or engineer, his favorite pastime being repairing household electric installations and playing chess. From Jules Verne he read about flying to the Moon. Instead of Buffalo Bill, his heroes were Kepler and Newton, Darwin and Spencer, Herz and Marconi. So the fateful year 1918/1919 arrived. The young teenager sang “*Let God bless Hungary*” with the crowd of the Chrysanthemum Revolution, when Count Michael Károlyi declared the independence of Hungary from the Habsburg Empire, and tried to create a democratic parliamentary republic. Later he befriended the Count in exile and wrote: – *The West did not understand what it was about in Hungary and let foreign armies in-*

¹The Golem did not work well enough: his mother’s relatives, having remained in Central Europe, were exterminated in the Holocaust of Auschwitz. Arthur’s mother – having survived in Budapest – joined Koestler in London in 1946.

Sorszám	A tanuló neve, vallása, születésének ideje (év, hónap és nap) és helye?	Atyjának vagy gyámjának neve, állása és lakhelye?	Az előbbi osztályt hol végezte a tanuló és mily eredménnyel?*	Ösztöndíjas-e a tanuló? Részvétel-e segélydíjban? (cim, keltezés és szám)	Tandijmentes-e a tanuló? (adományozó, keltezés és szám)
31.	Westler Arthur, isk., 1905. szept. 6., Budapest.	Hootler Klauzál, kereskedő, Budapest.	IV. oszt. II. oszt. 2. kintű 2. jeles - jó - elégséges - ből elégtelen javítóvizsga viseltből <u>jeles</u>		
Értesítő			Bizonyítvány		
Tantárgyak	I. Félév		Érdemjegyek (bétűvel)	Észrevételek	
	Érdemjegyek (számokkal)	Észrevétel			
Vallás	3		jeles	Mulasztásainak oka: Általános gyengeség + idegesség miatt 104 óra.	
Magyar nyelv	2		jeles		
Német nyelv	1		jeles		
Földrajz	2		jeles		
Mennyiségtan	3x		elégséges		
Természetrajz	2	-	elégséges		
Rajzoló geometria	1		jeles		
Szépíráás	2		elégséges		
Tornázás	3		elégséges		
Ének					
Mikor oltalott utoljára?	1915. márc.		1915		
Írásheli dolgozatainak külső alakja	rendes		rendes		
Az elmúlt tanévi igazolt órák száma	igazolt	9	123		
	igazolatlan	—			
Magaviselet	1		jeles		
A tanári testület zárértékzeletli ítélete:			felsőbb osztályba lélephet.		

1905. évi. Budapest.

vade Hungary. The Communist Regime followed as an outcome of the West's blindness. – In the spring of 1919 the communists tried to resist the foreign invasion. The words of the “Internationale,” – *We shall lift the globe from its axis* – reminded the enthusiastic boy of the words of Archimedes: – *Give me a fixed point outside the Earth, and I shall remove the Earth from its corners.* – The communist dream collapsed within 100 days, under the pressure of invading foreign armies. In late 1919 a rightist military rule followed. Arthur converted to the Calvinist religion and emigrated to Austria at the time of the summer school holiday. He concluded the gymnasium in Vienna and enrolled at the Technical University. There he learned to know and admire the emerging modern physics. His scientific training educated him to understand the role of *scientific revolutions* in human history, which helped him later to become a future sensitive science journalist:

– *A peculiar characteristics of our age is that an educated person is ashamed to confess that he does not understand a piece of art. At the same time he proudly declares that he does not know anything about the laws working in a household electrical switch. He uses radio and other technical products without more knowledge than a savage. People live today in an artificial world offered by the cheap technical products; thus they have isolated themselves psychologically from their immediate environment.*

In Vienna, Koestler experienced (and participated) in the fights between nationalist and Zionist Burschenschaften (student organizations). The Arrow shot into the Blue split in two. Koestler enthused over both: scientific and social revolutions, over Einstein and de Broglie, over Freud and Marx (1925). Koestler said, he thought in Hungarian in his youth, even translated the Hungarian poet Endre Ady into German. (As he confessed, even later he dreamt occasionally in Hungarian.²) Koestler possessed a Hungarian passport until 1939.

Koestler's destiny offered him more experiences and adventures than an astronaut may dream about. Just a few weeks *before* obtaining the engineering diploma he traveled to Promised Land, in this way burning the bridge behind himself, in order to escape the temptation of a quiet civilized career loaded with compromises. He joined one of the early Jewish kibbutzes to make the desert flow with milk and honey (1927). After two years of hard manual work he moved to the cities, trying to survive by selling lemon juice on the streets of Haifa, then by reporting as Middle-East correspondent for newspapers in Tel Aviv, Jerusalem,

²Arthur Koestler: *Arrow in the Blue*, 1953

Cairo, and Bagdad, and interviewed even King Faisal. To satisfy his conscience he asked for a Palestinian passport of dubious value. His book *Like Thieves in the Night* influenced the members of the Palestine Commission at the United Nations' Organization in declaring the creation of the State of Israel. But within a year we find Koestler in Paris as the correspondent of leading German newspapers.



These were already the times when the signs of approaching political chaos manifested themselves. When Koestler arrived in Berlin, the liberals had lost in the election, replaced by large communist and fascist blocks in the Parliament (1930). This is why he gave up political journalism and became a *scientific* correspondent of German newspapers. Koestler was not a professional physicist but was blessed with social sensitivity. He noticed the approaching Nuclear Era:

– I argue for avoiding the slavery of coal-mining, the wastage of internal combustion, the purgatory of the oven in steam ships. I am in favor of clean natural energy sources, like collecting and storing solar power, and for using such radioactivity-like transmutations of atoms which direct the rise and decline of stars and spiral galaxies.

Koestler interviewed the physicists who tried to split the atom by milking the power of lightning at Monte Grosso (a peak in the Alps) and immortalized the researcher who lost his life in the daring experiment. He wrote in the *Vossische Zeitung* as early as 1930:

– If we interpret these facts correctly, then we stand before a new era of human history. All the technological developments of the past hundred years – which profoundly reshaped the face of the Earth – will be considered by historians only as a clumsily fumbling prelude to the achievements of the following utopian society. It is remarkable that the signs of the new technological revolution appear at the time of political chaos, when society has become ill.



– East of the Rhine the only alternative left was fascism or communism. I convinced myself that communism was a lesser evil than fascism. For Europe it is the only road left open to Utopia – wrote Koestler. At that time even EDWARD TELLER expressed his doubts: – Until I lived in England some years later, I did not believe that democracies could be stable. In Central Europe at that time, the choice seemed to be between the communist and Nazi parties. – This is how and why Koestler followed his habit of burning bridges behind him, and joined the Communist Party; he even traveled to the Soviet Union, eventually to Samarkand, and stayed one year in the Caucasus region. This period was long enough to become again disillu-

sioned. In 1933 he traveled back to Hungary, remaining Marxist and communist party member for five years more. In Budapest he became the friend of Attila József. This brilliant Hungarian poet was of the same age as Koestler and was original enough to be expelled from the Hungarian Communist Party. Later on, Attila József committed suicide. Hearing this, Koestler wrote an obituary in *Das neue Tagebuch*. Let's quote:

– *This happened at a strange place, in a small country of seven million. The Hungarians are the only people in Europe without racial and linguistic relatives in Europe, therefore they are the loneliest on this continent. This exceptional loneliness perhaps explains the peculiar intensity of their existence. The wild talents explode like fireworks above the tight horizon of Hungary, afterwards their fragments are collected. The hopeless solitude feeds their creativity, their desire for achieving, and their hysteria. To be Hungarian is a collective neurosis. A Hungarian genius like Attila József had been born deaf-mute for the world outside. This is why I hesitate to say, because the reader is unable to check it, that this Attila József, who threw himself below a train at the 47th northern latitude and 18th eastern longitude, was the greatest lyrical poet of Europe.*

These were the times when two Hungarian communists, Sallai and Fürst, having been sent with fake passports from Moscow to Budapest to reorganize the illegal communist party, were sentenced to death and executed. Koestler entered Hungary with a Hungarian passport, but his Soviet visa made the police suspicious. He was called in for interrogation but he found this occasion more friendly than the interrogation experienced at the Soviet political police in Baku. Yet Hungarian newspapers were afraid to print his reports on Turkestan, “the country of origin of the Hungarians.” In September 1933, Koestler was again underway – this time to Paris. His Hungarian friends testify that Koestler remained lifelong thoroughly interested in the Hungarian language. In speaking with them he carefully searched for the most appropriate synonyms even if he had not used that Hungarian word since his childhood.

In 1937, Koestler traveled to Spain as the correspondent of the *British News Chronicle* and the Hungarian *Pester Lloyd*, to report on the Civil War. Koestler was captured by the rightist army, experienced fascist prison there, faced a death sentence, and waited through one hundred days to be executed. Then at British intervention he was exchanged for a prominent fallangist who was in the hands of the leftist army. Arthur survived once again. After seven red years (1931–1938) he left the Communist Party, concluding:

– *To be burned twice during one's life is a very exceptional privilege.*



Laura Polanyi was the sister of MICHAEL POLANYI; she married Sándor Striker, one of their children was *Eva Striker* (1906–). The girl attended the kindergarten run by Laura Polanyi where she met Arthur Koestler, attending the same kindergarten. Eva Striker graduated from the Szilágyi Erzsébet Gymnasium, and began a career in object design. She moved to Berlin in 1926. At her parties the leading intellectuals of this fertile era met, like Arthur Koestler, Lev Landau, Michael Polanyi, Erwin Schrödinger, Leo Szilard, Viki Weisskopf, etc. Weisskopf characterized Eva as “*magnetically attractive, both physically and intellectually.*” (Eva was the girlfriend of Arthur.) Later Eva Striker joined Alex Weissberg, an Austrian physicist; after Hitler’s takeover they married and emigrated to the Soviet Union, which was the dreamland of Western intellectuals in the 1930s. In Kharkov Alex Weissberg, Viki Weisskopf, and Lev Landau organized the Institute for Low Energy Physics. The relationship between Alex and Eva did not last long. (Weissberg, as a suspicious foreigner, was imprisoned in 1936, and in 1939 the Soviet political police gave him – as a communist registered by the Gestapo – into the hands of German political police in Warsaw.)

Eva – after the separation – lived in Moscow, worked there as a leading industrial designer of ceramic objects. Thanks to her talents, she became the director of design in the porcelain factory in Dulevo, near Moscow; her creations were proudly presented at expositions of industrial arts. But on a day in May 1936, at four o’clock in the morning, the Soviet police captured her. At searching her home, a gun was found; it was essentially the property of Gyula Hevesi, a devoted Hungarian communist, who carried the gun under the short-lived communist council republic in Hungary in 1919, then emigrated to the Soviet Union, keeping the gun. (Eva rented a room in Hevesi’s apartment.) By using this gun as evidence, Eva was charged with planning the murder of Comrade Stalin. Eva spent a considerable time in solitary confinement in the Lublianka prison, awaiting possible execution. As a result of police pressure, Eva signed a confession dictated by the police investigator. Fearing the worst, Eva took a piece of wire and cut her artery. The custodian noticed her critical state and suggested her to write a letter directly to Stalin saying that the police investigator forced her to make a false confession. She had nothing to lose; thus she did so, and the surprising outcome was that the investigator was removed from his job. Later it turned out that Stalin ordered the police to fabricate evidence that Trotsky had attempted to organize the murder of Stalin via French communists infiltrating the Soviet Union. (This was meant as an excuse for murdering Trotsky by Soviet agents.) Eva Striker was intended to be made one of the guilty infiltrators.

Thanks to the support of Pjotr Kapiczka and other leading Russian intellectuals, Eva was released in May 1937 and met Michael Polanyi, who also stayed at that time in Moscow. In September 1937 she was transferred to Vienna. Barbara Striker (the wife of Eva's brother) met her in Vienna and Eva told her the whole story throughout a night.³ In 1938 Adolf Hitler occupied Austria. On the very same day Eva, with two suitcases, took a train and traveled to Switzerland, then – with the help of Arthur Koestler – to England. Eva met Arthur there and told him all her adventures at Soviet police and in Soviet prisons. This narrative made Eva the Muse of Arthur: Koestler wrote the novel *Darkness at Noon* based upon Eva's experiences (1940). This novel is a deep and bitter analysis of the communist reality, depicting the psychology of Stalin's purges.

Among the other narratives, Eva told Arthur, how they communicated by knocking on the wall of the prison cell. A simple code transferred the characters of the alphabet one after the others, in this way important messages were exchanged. Arthur described this method in the *Darkness at Noon*. The novel was read and known among intellectuals. So when *Paul Ignotus*, the Hungarian writer became imprisoned, he began to communicate using Eva's method; in this way he learned to know his never seen prisonmate in neighboring cell – and after their release they married each other.⁴

When Hitler was to take most of Europe, Eva Striker moved to the United States and married an Austrian lawyer, Hans Zeisel. To avoid the attention of possible Nazi and Soviet secret agents, she took the name Eva Zeisel and became a respected designer of ceramics. Her pieces of art were exhibited in the Smithsonian Museum, and taken around the world. For the exhibition, she wished to start and close her life's work with pieces made in Hungary, thus Eva Zeisel revisited her native country and worked here for awhile on some beautiful designs for the Hungarian ceramic industry. She received the Order of Star of the Hungarian Republic. On her 90th birthday the Museum of Modern Art organized a banquet of celebration. Eva lives in New York, still working in creative art. It is worthwhile to listen to her for a minute:

– *Sometimes the artist is asked "to make something different." This is not a sufficient motivation for creation. Negation never inspires creation. You have to create something which never existed before, you have to make something out of nothing. You have to imagine, to invent something, possi-*

³Barbara Striker to the author 1997

⁴Eva Striker to the author 1997

bly a beautiful object. Out of empty air, you have to create a vision, a plane, something which has a character and attractive power. It is easy to describe something which is standing in front of view. If someone designs a new object, he or she has to describe something what does not exist yet. You have to find the appropriate words to describe that. While searching for these words, its character becomes clearer and clearer, the words create an elusive image; trying the articulation once again, the image will be filled with content. As the words become more specific, the image of the object of creation takes more and more definite shape. Some of the used words carry definite illustrative meaning. Other words are more elusive. One may try to use words like "growing, hard, dynamic, quiet, solid, merry, soft, slim, crisp, elegant," etc. One may articulate shapes even with the hands. I move my hands as if I were pulling or pushing the air, as if I let the air shrink or blow up like a balloon. While I am pugging the air between my hands, I try to describe with words the changes I am producing in the image. When you have got a feeling of the image, you may begin to draw, finally to make it into a three dimensional reality. – (We may remember her words when we reach the period in Koestler life when he concentrated on *The Act of Creation*.)



Darkness at Noon made Koestler a friend of George Orwell (1941), an other disillusioned former communist, author of "1984" describing the world after the complete victory of a communist revolution. In reviewing *Darkness at Noon*, Orwell wrote: – *Only those Europeans can write true antifascist literature who were in direct contact with fascism and communism.* – During the make-up trial of Slansky in Prague, one of the victims, Otto Katz repeated word for word what Rubasov, Koestler's hero, created in the image of Bukharin, said in *Darkness at Noon* in order to express the value of accusations in the Slansky trial.

Koestler's novel played a role in history: Before the parliamentary election held in France just after World War II, the French Communist Party asked its members, to buy up all copies of the French edition available in bookstores. What was not planned was that the communists would read the book, and the Communist Party – expected to win – lost the elections.

Darkness at Noon was Koestler's last book written in German, his greatest work of fiction. This was the end of the German Period (1925–1939) of his mind.



The outbreak of World War II found Koestler in France; he was interned as a suspicious foreigner for nine months. This was why he volunteered for the French Foreign Legion, from which he soon escaped. (It was the

right decision. It turned out later that he was on the “most wanted” list of the German Gestapo, and after the German invasion Pétain’s new government would have extradited him.) With British officers he escaped from the Foreign Legion to Casablanca. From there, in a fisherman’s boat he sailed to Portugal and applied for a British visa, but in vain, thus he entered England illegally. In Bristol he was put again into prison for six weeks as a citizen of an enemy country (namely Hungary). He found the British prison to be the most humane one compared to his earlier experiences. In his autobiography he indicated this experience to be the main reason for settling in London.

Koestler began writing, thinking, and speaking in English – with a Hungarian accent. He was already readying his mind for other kinds of adventures.



– *The Church tries to convert the faithless but burns heretics.* – Koestler tried repeatedly to be a sincere believer but suffered disillusionments. He had lost most of the friends of his youth in the Spanish Civil War, in Stalin’s purges, and in the hell of the Holocaust. On 12 June 1943 Koestler wrote to MICHAEL POLANYI:

I refuse to regard Russia as a valid test for state-socialism; I still believe that under more favorable conditions the state can be an employer as liberal and more generous than the Nuffield Trust.

But finally Koestler arrived at a bitter conclusion: somehow the human mind is a failure of biological evolution. Superimposing a *new intellectual brain* onto the good *old emotional brain* of reptiles had not succeeded. In his lecture, at the Nobel Symposium (Stockholm, 1969) Koestler emphasized: human history has shown that *homo sapiens* is the only species which allows killing within its own species and that is murder. Throughout human history most murders were committed not for material gains but in the name of ideologies. People, however, don’t choose their belief but mostly inherit it by birth. *Words* are far more dangerous weapons than *atomic bombs*. The words of Jesus and Mohamed have created world religions but were misused to organize crusades and jihads. Words of Hitler and Stalin turned people into mass murderers. Is there any route still left open, or is *homo sapiens* a scrap from the workshop of the Great Constructor? Is there a chance to heal consciously what has gone wrong biologically?⁵

⁵Arthur Koestler: *The Ghost in the Machine*, 1967

Koestler considered Newtonian mechanics (together with the materialism of Marx and his commissars) a dead end: the future is not strictly predetermined as is the orbit of a thrown stone. He turned to quantum mechanics in order to explore the poorly understood role of the human psyche in shaping the course of events.⁶ Most of his friends were scientists (among others DENNIS GABOR, JOHN VON NEUMANN, MICHAEL POLANYI, *George Polya*, LEO SZILARD, EDWARD TELLER). Reading *Darkness at Noon* contributed to Neumann's and Teller's life-long anticommunism. Koestler considered himself to be a writer in 40 % and a scientific thinker in 60 %.⁷ He published scientific papers, among others in *Nature*. He used to spend holidays in Austria where he organized the *Alpbach Symposiums* of intellectuals to discuss the role of science and to save the world. Arthur wrote to Eva:

Mishi and I have become great friends and are going to save the world together.

And he wrote to Mishi (Michael Polanyi):

I invited C.P. Snow, Ludwig von Bertalanffy and others to the planned symposium. I think the title should be something stirring which indicates a post-materialist Renaissance. The founding fathers of the scientific revolution called their movement the New Philosophy as opposed to degenerate scholasticism. Another catchword which comes to my mind is Uomo Universale. Dirac is here – more inhuman than ever.

Koestler desperately explored extreme options: para-science,⁸ hallucinogenic drugs (psychocybine), as possible escape routes from ourselves. Today there is an *Arthur Koestler Chair of Parapsychology* at the University of Edinburgh to perform objective statistical research of this doubtful phenomenon. As he said: – *True life science has to be ready to face infinity.*

– *Scientific research is never materialistic. The quest for understanding the Order in the Universe is a religious task in its essence.* – His studies and literary achievements won him the Sonning Prize of Copenhagen University (1962). When the Marxian determinism of the 19th century no longer worked, he looked for a place for the individual man in high-tech society. On 12 June 1941 he wrote to MICHAEL POLANYI:

⁶as George Soros has also tried to do

⁷Arthur Koestler: *Bricks to Babel*, 1981

⁸Arthur Koestler: *Roots of Coincidence*, 1972

The truth that practical results in applied science are welcome, but rather accidental Abfallsprodukte of "pure research" was obvious to me already in my embryonic days as a reporter for German newspapers. Nevertheless I believe that the scientist has a mission of social usefulness to fulfil; the only point is how "social usefulness" should be defined; certainly not in the vulgar-marxist way of economic utility; that would mean that the Copernican system is less "useful" than the invention of a new lavatory-brush. I vaguely imagine a definition of this sort: "Socially useful is every activity which tends to establish the maximum of harmony between society and nature, and within society itself." The first condition covers Pure Science, because the establishment of "Laws of Nature" is a fundamental contribution towards a harmonic relation between man and his surroundings. As to planning research – I imagine that every scientist – (like every writer, poet, musician) should feel that he does not live in an ivory tower but is acting under the orders of society; like a captain, setting out to sea with a sealed envelope (containing his route) until he is back in harbor again. That is, he has to make his own decisions; he is, in fact, entirely free, but he knows that the envelope is in his pocket. This might sound idiotic yet it corresponds to a psychological reality within many writers, and probably also scientists.⁹

By making use of his rich Martian life experiences, Arthur Koestler traced the role of scientific revolutions in social evolution. *The Sleepwalkers* was perhaps his most brilliant masterpiece (1959). Arthur Koestler also discussed these issues regularly with DENNIS GABOR in England. He managed to convert his pessimism to optimism by studying *The Act of Creation* in art and science (1964). He considered *discovery* as the beneficial fruit of painful *conflicts*, but the verification of the discovery only follows the *act of creation*. Koestler worked on this topic at Stanford University (in the Silicon Valley, Palo Alto, California) where he discussed the problem of creativity with the Hungarian mathematician *George Polya*. There the author listened to Koestler's lecture on creativity:

– *The discoverer perceives relational patterns of functional analogies where no one had seen them before, as a poet perceives the image of a camel in a drifting cloud.*



⁹letter quotations from Bela Hidegkuti: "Arthur Koestler and Michael Polanyi: two Hungarians in Partnership in Britain," in *Polanyiana* vol. 4, No. 4, Budapest 1995

Arthur Koestler began to write a play in Moscow, and completed it on a train traveling from Moscow to Budapest. The *Twilight Bar* (Bar du Soleil) is a story of two “extraterrestrials” who arrive on Earth, in order “to find a fertile planet for their overpopulated alien civilization”. They announce that only happy planets have a cosmic right to survive. Therefore they give a last chance to humankind for organizing a World of Happiness – otherwise extraterrestrials would “liberate” the Earth from its sufferings, in order to use the planet for better purposes. Facing this ultimatum the terrestrial governments resign, the opposition declares itself to be not responsible. Finally a poet named Glowworm has been made the dictator of happiness. The new era miraculously works: authorities, borders, armies, secrecies, taboos, even money have been abolished. But three days later unfortunately it turns out that the two visitors are not real aliens, only swindlers, therefore humans don’t have to be happy. The poet-prophet is expelled and the old political–financial order is quickly restored.¹⁰

Arthur Koestler was a man of final decisions who burnt the bridges of return. On 3 March 1983 he and his wife committed suicide. (Arthur had got leukemia upon a very progressed Parkinson’s disease.) In his autobiography¹¹ he had tried to peep into the future: – *I would give one hundred of today’s readers for ten who read my works a decade from now, and for a single one who reads them in the coming century.* – Well, the novel *Darkness at Noon* has been published in a dozen languages: German (in Germany and also Switzerland), English (in the U.K. and also the U.S.), furthermore in Dutch, French, Hungarian, Icelandic, Japanese, Italian, Portuguese, Spanish, Swedish, and Urdu; this book has been read by millions. His science history, *The Sleepwalkers* also has become a classic textbook (published in Hungary in 1996) used at several universities worldwide. In this book Arthur teaches us with the example of Kepler how to respond to the challenge and call of a New Age.

¹⁰In 1933 in Budapest Koestler’s friend Andor Németh gave the manuscript of *Twilight Bar* to the director of a downtown theater (Belvárosi Színház), Arthur Bárdos, who expressed his interest in staging it as a musical. Attila József was asked to write songs, Béla Reinitz to compose music for the play. But the promise was not fulfilled: ultraleftist tendencies were noticed in the story. *Twilight Bar* was published in London only in 1945.

¹¹Arthur Koestler: *Arrow in the Blue*, 1953

Harsányi János – John C. Harsanyi

1920–

The most important scientific results are born, if the researcher works in several disciplines, and transfers his knowledge and results to an other – perhaps far away – discipline. Arthur Koestler was right when he argued that a real scientific breakthrough might happen at coupling two or three fields of research. (J. C. H.)

Harsányi János entered the Lutheran Gymnasium in Budapest through the same gate Neumann János had entered about two decades before. As teenager, Harsányi enjoyed playing chess. But Harsányi's chess-addict schoolmates began memorizing different opening and end games from books and in this way they overcame Harsányi's intuition; therefore he gave up. The young man turned to classics and to mathematics. He enjoyed finding out what 2^{-3} or $(-5)!$ could mean. Harsányi became third-best in the Greek competition and won the National Student Competition in mathematics (1937). He dreamt about a career in mathematics and philosophy.

Harsányi's father owned a pharmacy and wished his son to inherit it. For his father's sake, János studied pharmacology at Budapest University, but – obeying his real interest – attended Professor Fejér's mathematical lectures as well. But Fejér did not bother to explain what the *use* of complex functions was, was wishing only the beauty of pure mathematics to blossom. For Harsányi, the purity of mathematics had less appeal than its power in applications.

History entered the young man's life: World War II was underway, Hitler having captured the majority of Europe. The Hungarian Jews – considered to be unreliable for the war effort – were called to forced labor service. Harsányi's group had to deliver supplies to Hungarian factories. When Hungary's attempted surrender to the Allied Powers failed, with German military support an extremist government took Hungary over. Harsányi enjoyed the protection of the Vatican's safe-conduct for a while. But later they were ordered to the rail station. Noticing the trains waiting for them, possibly heading to the concentration camp and extermination, John decided to let his favorite pullover be lost in the wagon, took his yellow arm band off,

Törzskönyvi szám: 19.

A tanuló neve: Harsányi János Károly

Vallása, születésének helye és ideje: r. kat. Budapest - 1920. máj. 29

Hol végezte középiskolai tanulmányait? I - VIII. (1929/30 - 1936/37) it

Nyilvános vagy magántanuló volt-e? nyilvános

Magaviselete: példis

A tanuló érdemjegyei:

Tantárgy	VIII. osztályú érdemjegye	Írásbelin nyert érdemjegye	Szóbelin nyert érdemjegye	Végleges érettségi osztályzata
Magyar nyelv és irodalom	jelas	jó	jelas	jelas
Latin nyelv és irodalom	jelas	jelas	jelas	jelas
Kezdet nyelv és irodalom	jelas	jelas	-	jelas
Történelem	jelas	.	jelas	jelas
Mennyiségtan	jelas	.	jelas	jelas
Természettan	jelas	.	jelas	jelas

A középiskola többi tárgyában következő előmenetelt tanusított:

Tantárgy	Osztály	Érdemjegy	Tantárgy	Osztály	Érdemjegy
Hit- és erkélestan	VIII.	jelas	Repi	IV.	jó
Geográfia és törté.	VII.	jelas	Filozófia	VIII.	jelas
Földrajz	VII.	jelas			
Tanúsítvány	V.	jelas			

A vizsgálobizottság általános ítélete: a) Ha érett, milyen fokozattal? b) miből, hol és mikor tesz javító- ill. ismétlővizsgálatot? jelesen érett

Az esetleges kiegészítő-, ill. javítóvizsgálat eredménye (a szükséges adatok feltüntetésével):

and in his impressive civilian winter coat he mixed among arriving passengers and daringly walked out of the railway station.¹

Harsányi went into hiding in the college of the Jesuits. The house was searched repeatedly by fascist commandos, looking for Jews, but he was not found, possibly because the commandos had been bribed by the Jesuit fathers. Finally Russian troops liberated Budapest early 1945.

John helped his father restore the pharmacy ruined by street fighting. After having finished his studies in pharmacology, he studied philosophy. In 1947 Harsányi wrote his Ph.D. thesis on *The Logical Structures of Philosophical Errors*:

– Errors occur in exact sciences and in everyday life as well, but these errors are quickly recognized, and this makes the errors harmless. There is no chance in defending a mistaken historical date or incorrect calculation, if someone has already noticed the error. The situation is completely different in philosophy. We observe very rarely that a philosopher convinces another philosopher with rational argumentation. It is easy to understand that the majority of contradicting philosophical theories must be wrong because from among contradictory statements – even in the best case – only one may be right. In spite of this we know that after thousands of years of discussions none of the philosophical models has succeeded in winning over another.

Harsányi showed that philosophical deductions are though simpler than mathematical ones, errors are committed by unjustified generalizations from initial assumptions. This is a hint that he was about to lose his belief in *pure philosophical debate*, and was already inclining toward more pragmatic (but quantitative) models of society. He still owned and ran the pharmacy, at the same time lecturing about Aristotle at the Budapest University as an assistant of the Sociological Department.

In the meantime a communist government gained the power, and the confiscation of private properties – even pharmacies – began. Harsányi decided to leave Hungary – just two months before obtaining a third diploma in psychology. This was possible only in an illegal way. A reliable country plumber – respected for saving Jews during Hitler's time – volunteered to guide Mr. and Mrs. Harsányi to Austria.² But they lost the path leading through the swamp, because in April 1950 the water level was unexpectedly high. Instead of one night, they wandered for three days in the marsh without food and water. They had to drink water from

¹to the author 1996

²to the author 1996

the swamp, full of bugs. Finally they reached a land road. As they climbed up, they faced a military watch tower, but fortunately it was empty of soldiers. They found the house of an Austrian farmer who told them that land mines killed escaping Hungarians night after night. Thus Harsányi considered himself to be a lucky guy.

The Harsanyis emigrated to Australia (1950) but the Hungarian diplomas were not respected there. Harsanyi had to earn money as an unskilled worker. Making shoulder padding was not his talent, therefore each week he worked in a different manufacture. During the evenings he studied economics at the university.³

Obtaining a Rockefeller fellowship the Harsanyis sailed to America. He studied economics at Stanford University and completed a second Ph.D. there. In 1964 he obtained a job at the University of California in Berkeley. In order to earn his salary, he lectured in applied mathematics. In 1957 he wrote to a friend in Budapest:

– I think that after some time the mathematical methods of making models will produce positive results in social studies as well. Such results are yet rare; we are in the stage of developing these methods. But this work is done not by sociologists.

The superpowers' game of the Cold War directed his attention toward game theory, concluding in the 1994 Nobel Prize in economics "*for his pioneering analysis of equilibria in the theory of non-cooperative games*".⁴ The press release of the Royal Swedish Academy said:

"John C. Harsanyi showed how games of incomplete information can be analyzed, thereby providing a theoretical foundation for a lively field of research which focuses on strategic situations where different agents don't know each others' objectives. – Borel and John von Neumann had begun to study mathematical theory of games, but it was not until the economist Oskar Morgenstern met the mathematician John von Neumann in 1939 that a plan originated to develop game theory so that it could be used in economic analysis. – In games with complete information (like chess), the player knows the other player's preferences, whereas the players wholly or partially lack this knowledge in games with incomplete information, and such games (like poker) best reflect many strategic interactions in the real world. Till 1967 no methods had been available for analyzing games with incomplete information. Then John

³The University of Sydney granted him an honorary Ph.D. degree 45 years later, after having received the Nobel Prize.

⁴photo is the courtesy of the Nobel Foundation

G. Harsanyi published three articles entitled 'Games with incomplete information played by Bayesian players.' Harsanyi's approach may be viewed as the foundation for nearly all economic analysis involving information, regardless of whether it is completely private or public."

After having received the Nobel Prize, during a visit to his home country John Harsanyi told us that with the money received he would not gamble on the stock market, but would use it to complement his modest pension, allowing himself to concentrate upon problems that he was now really interested in. At the Hungarian Academy of Sciences he lectured on Napoleon's political decisions, raising the questions: were these decisions rational, even brilliant or not? He stressed that without the analysis of such problems historical studies have little value.

Harsanyi dislikes the overspecialization of experts in Western utilitarian civilization, where physicians read only medical books but no philosophy, technocrats are up-to-date in technology but know nothing about DNA. For him the versatility of LEO SZILARD is sympathetic, and longs for the café house culture of Central Europe, where one can discuss science, music, or philosophy in the mixed company of medical doctors, writers, and engineers. To the end, he feels to be a fortunate man, having had the chance to attend gymnasium in Budapest, having studied different disciplines, and becoming part of American life, which pushed him to the height of the Nobel Prize. (Harsanyi thinks that if he had published the very same papers from Hungary, he would not have got Nobel's gold medal.)

Harsanyi is beyond 75, but even now does not respect borderlines in science. From the circle of JOHN VON NEUMANN he knew *George Pólya* and *Gabriel Szegő* at Stanford, JOHN KEMENY at Dartmouth College, and discussed the philosophical questions of mathematics and its application with them. Harsanyi regularly reads a wide spectrum of scientific journals (from quantum mechanics to sociology), and plans to write a book about the ethics of utilitarianism. He said on Hungarian Radio:

– The main role of moral values is to increase of well-being of humankind. We possess a number of ethical values like democracy, equality, liberty, independence. These all are justified by the fact that societies respecting these values enjoy much better conditions and are happier than societies showing disrespect for these values. Thus I think that a society accepting these values will be not only more ethical but will live under better economic conditions. People will have good reasons to trust each other if the members of the society follow these ethical principles. To be honest is the best behavior also from an economic point of view! I am interested in both the mathematical and philosophical background of this ethics.

Soros György – George Soros

1930–

*I am not a professional security analyst.
I would call myself an insecurity analyst.
I look for conditions of disequilibrium. They
send out certain signals that activate me.*

(G. S.)

– *We have to find not only the moral equivalent of war but also the moral equivalent of the stock market game* – DENNIS GABOR said.¹ George Soros has found it. He drives a 7-year-old Mercedes station wagon in New York but won one billion dollars on busting the British pound when its prestige and value were irrationally high compared to the actual state of the British economy (September 1992). Then he lost 0.6 billion dollars in a day on his venture of trying to bust the Japanese yen (February 1994). Now he spends billion dollars to open up closed societies in Eastern Europe and the Third World. It may be he does this with better instincts, understanding, and success than Western governments do. To find his secret, let's have a look at Soros' game of survival.

His father, Theodore Soros (Schwartz Tivadar) was an ambitious young man, volunteering in World War I and was promoted to lieutenant. Later as a prisoner of war he was sent to Siberia. In the POW camp he edited a journal called *The Plank*, because its pages were nailed to a plank. Thus he became popular and was elected prisoners' representative. When some prisoners escaped from a neighboring camp, in retaliation the Russians shot that prisoners' representative. Theodore Soros preferred survival and broke out of the POW camp. The escaping Hungarian group built a raft and started drifting along a river down to the ocean. But soon they realized that there was a flaw in the plan: the Siberian river flowed northward to the Arctic Sea! So they lived in the wilderness for long months. They had to survive the war and the Russian revolution (1917), until they were able to return to Hungary (1920).

– *This was a formative experience for my father that shaped him, and my father shaped me* – George Soros said.

¹Dennis Gabor: *Inventing the Future*, 1964

In Budapest the young Soros György liked to sit at the windows quietly for hours, watching the Danube flowing by. His father, Soros Tivadar, a wealthy lawyer, was an enthusiastic Esperantist. He taught his son: – *You have to carry your capital in your capital* – (capital means head in Latin). This was needed indeed: when World War II brought German occupation to Hungary (1944), Soros György was just 14-year-old. His father arranged with a high government official to let his son pose, with fake identity papers, as the godson of the official. The official had a Jewish wife, whose hiding was also financed by Soros Tivadar. – *A straight commercial transaction* – as George Soros described it. While the “godfather” travelled around in Hungary to confiscate the property of Jews and send them to concentration camps, the accompanied boy warned some of the victims in advance that they were on the list of deportees.

– *Obeying the law became a dangerous addiction; flaunting it was the way to survive* – the young man concluded.²

– *When you are fourteen, you believe that you can't really be hurt. This was an exciting adventure, in a way it was the happiest year of my life. It had a formative effect. I learned the art of survival from a grand master: my father. Dangers stimulate me. I don't like danger, I like to avoid it. That is what makes my juices flow.*

After World War II, Hungary was not a quiet place for long. Under the excuse of an Esperantist Conference, George Soros left Hungary for Switzerland (1947), then landed in England. – *My optimism in my resourcefulness was culminating in Hungary in 1945. After that, England meant the deepest depression for me: cut off from my parents and friends, I lost the feeling of being important. In Hungary I felt that I was important because I had gone through many interesting adventures and survived. I thought that would interest people. But in England nobody paid any attention to me, which was a sad loss of illusions.*³ – Soros earned money as a waiter, then enrolled in the London School of Economics, and graduated in two years (1952). He started writing a Ph.D. thesis in philosophy on *The Burden of Consciousness*. Soros let his chosen supervisor, Karl Popper, read the manuscript. Popper liked it and gave Soros a date to meet. When Soros introduced himself, Popper took one look at him:

– *But you are not an American! That is terribly disappointing, and I'll explain why. When I got your treatise, I felt that finally an American*

²Soros on Soros, 1995

³to the author 1996

*had understood my teachings about an open society and a closed society. That meant that I had managed to communicate my ideas. But you lived through it all, so you don't count. That is why I'm disappointed.*⁴
– Nevertheless, Popper still encouraged Soros to carry on.

In London George Soros supported himself as a salesman and as an arbitrage trader. The family reunited in the West (1956), and Soros applied for U.S. visa, but it was rejected under the excuse that “*he is too young (26) to be a specialist whose services were urgently required in the United States*”. But a friend with influence at the American Embassy explained that “*arbitrage traders had to be young because they died young*”, and the visa was issued. Soros sailed to New York (1956). His instinct for sensing the coming changes worked well on the stock market. His international experiences helped him notice that the differentials in world market were larger than those within the United States, thus more gain could be made by moving money between New York, London, and Tokyo. In 1979 the Soros Fund was renamed the Quantum Fund.

– *World War II served as an advanced course at a tender age. The Quantum Fund created a quarter of a century later drew heavily on the skills I had learned as an adolescent. The name Quantum Fund was chosen to celebrate the quantum jump in the size of the Fund⁵ and of course I was intrigued by the uncertainty principle of quantum mechanics.*

– *I think that a thinking participant is in a very difficult position because he is trying to understand a situation in which he is one of the actors. Traditionally we think that understanding is essentially a passive role, and participating is an active role. In truth, the two roles interfere with each other, which makes it impossible for the participant to base any decision on pure and perfect knowledge. This creates a kind of uncertainty.*

– *The lack of independence between facts and thought occurred in a milder form in science as well, the best example being Heisenberg's uncertainty relation: the act of observation may affect the observed phenomenon. Scientists do their best to avoid disturbing the object. In finance, however, the main goal of the participant is to shape reality for his own advantage. Therefore the assumption of a strict parallelism between these two uncertainties may be misleading.*⁶

⁴Soros on Soros, 1995

⁵from \$12 million to \$400 million

⁶Soros on Soros, 1995

In his transactions, however, Soros seems to follow the method of scientific research. Instead of a final dogma, – *I work with hypotheses. I form a thesis about the anticipated sequence of events and then I compare the actual course of events with my thesis; that gives me a criterion by which I can evaluate my hypothesis.* – The Quantum Fund doubled the value of its shares every two years throughout the past 26 years, due to the special instinct of the founder. In the 1980s the value of the shares owned by the original shareholders increased three hundred fold. *Financial World* announced that Soros was the most successful businessman of the year 1992, then also of 1993: Soros earned about \$8000 per minute.

MICHAEL POLANYI argued that the belief of impartial objectivity is misleading even in science.⁷ Soros also criticizes economics for imitating the physics of the 19th century. He emphasizes that not only facts influence our thinking but people's ideas and aims influence the market; he calls this interplay *reflectivity*. He is a great admirer of Albert Einstein. He likes to use the word "reflectivity" because it rhymes with "relativity".

– *I believe that the theory of reflectivity contributes considerably to the understanding of the world we live in. Reflectivity consists of knowing when tensions have reached a point where something must give: when a boom is on the verge of a bust, or when an oppressed society is at the point of rebellion. That is when the unexpected can be expected. And I expect it a little better than others.*⁸



Soros had always considered himself to be more a philosopher than businessman and that may even become true. About his interpreting and making history George Soros recently said:

– *In my philosophy, open society is based on the recognition that we all act on the basis of imperfect understanding. Nobody is in the possession of the ultimate truth. Therefore, we need a critical mode of thinking: we need institutions and interests to live together in peace; we need a democratic form of government that ensures the orderly transfer of power, we need a market economy that provides feedback and allows mistakes to be corrected, we need to protect minorities and respect minority opinions.*

– *The trouble is that the idea of our own fallibility does not come naturally to people who enjoy the benefits of open society as birthright. Discussing this in England, somebody said: – "I never realized that I live in*

⁷Michael Polanyi: *Personal Knowledge*, University of Chicago 1958

⁸George Soros: *Alchemy of Finance*, 1994

an open society." – *This is the grave deficiency in an open society. My point of view is shared only by those who have personally experienced the oppression of a closed society. Freedom is like air: one takes it for granted. But in another way it is quite unlike air: if you don't protect it, you are liable to lose it.*⁹

While walking along the street in London, he suddenly felt a hammering in his chest and feared he was having a heart attack. (Fortunately it was not true.) But – *that was the moment when I asked myself: "What is the point?" I felt I had made enough money for my personal needs.* – So Soros decided to divert some of his bounty to philanthropy. He created the Open Society Foundation (1979) because – *my main idea is that our understanding of the world in which we live is inherently imperfect. An open society is based on the recognition of our own fallibility; a closed society on its denial. If we are, in fact, fallible, an open society is preferable to a closed society in which there is no freedom to think and to choose.* – His foundation spend more money on philanthropy than the Ford Foundation, offices work already in 25 countries: Hungary (1984), China (1986), Russia (1987), Poland (1988), Bulgaria, Estonia, Lithuania, Romania, Ukraine (1990), Yugoslavia (1991), Albania, Byelorussia, Bosnia, Croatia, the Czech Republic, Latvia, Macedonia, Moldavia, Slovenia, Slovakia (1992), Kazakhstan, Kirgizia, South Africa (1993), Georgia (1994), and Haiti (1995). In 1989 alone he donated over \$1000000000 to speed up the peaceful transition of Eastern European totalitarian regimes to open societies.

Soros has become most successful in his native country. The communist government had already become interested in economic reforms, and cooperated in creating the *Soros Foundation* in Hungary in 1984, having spent at least three million dollars a year.¹⁰ Soros calls the 1980s *heroic years, the most fantastic, marvelous time we had.* – Nowadays he is again welcome in Hungary and has received a high award from the President of the Republic. The Central European University has been created in Budapest for students of social sciences from Eastern Europe, with English as the language of instruction.

The Open Society Fund supported the Charta 77 people in Prague, the Solidarity movement in Poland. The International Educational Foundation (\$250 million) was to help the excellent Russian schools survive, the International Science Foundation (\$100 million) was to help the Rus-

⁹*Soros on Soros, 1995*

¹⁰Hungarian officials could not accept the name *Open Society Foundation*.

sian scientific elite survive. Thirty thousand Russian scientists received first aid of \$500 each. The Soviet intellectual elite was the best supporter of opening up the Russian society, led by Andrei Sacharov, – “*the most painfully honest man I ever met.*” – But Soros was upset when part of his donation to Russia was diverted into Swiss bank accounts and luxury cars. He reorganized his Russian foundation three times.

Another great enterprise is the economic reorganization of Ukraine, because the new regime is cooperating with his economic advisers. Soros considers the survival of Ukraine to be of vital importance in preventing the revival of Russian imperialism. In the 1990s he complained heavily about *America's failure to seize the revolutionary movement offered by the fall of the Berlin Wall and the collapse of the Soviet Union. He felt the country should have poured money into supporting democratic impulses in the former dictatorships. The genocide in Yugoslavia was also followed only with a belated American response.*¹¹

After the disintegration of Yugoslavia, Soros assisted the small multi-ethnic Macedonia. Vladimir Melcin, president of Macedonia said, – *It's hard to overrate what Soros has done for us. I believe that he has saved our country.* – Well, Soros has the advantage of knowing Central Europe. He had been subject to anti-Semitic attacks there in the early 1940s and in the early 1990s as well. He established the Roma Foundation for gypsies in Europe, offered scholarships to black students in South Africa, financed the reconstruction of schools in Chechnya, sponsored Palestinian cases in Israel.

– *Given the culture in which one lived, being Jewish was a clear-cut stigma, a disadvantage, a handicap. Therefore there was always the desire to transcend it, to escape it. But the assimilationist Jews of Hungary had a deep sense of inferiority, and it took me a long time to work through that. Of course, my whole interest in universal ideas is a typical means to escape from the particular. I think I am doing exactly that by espousing the universal concept of open society. In other words, I don't think that one can ever overcome anti-Semitism if one behaves as a tribe. The only way one can overcome it is if one gives up the tribalness.*

The New York Times announced in an unusual seven columns report¹² that the billionaire announced with Hungarian accent that he redefines charity at home to save the American society because *the conser-*

¹¹*The New York Times*, 17 December 1996

¹²17 December 1996

vatives wish the state to abandon its obligations to citizens, and market values and excessive individualism were permeating the professions of medicine and law, journalism and politics, turning them into business rather than calling. – E.g. he made a \$12 million commitment over three years to the *Algebra Project*, which seeks to improve mathematical skills of public school students throughout America. Noticing the shady sides of the free market in Eastern Europe and in America, he is reconsidering his ideas:

– *In earlier times I saw that there was the open society on the one side, the closed society on the other side, and this duality characterized the world. Now I have changed my view. The open society stands at the center, and extremities threaten it. One extreme is totalitarian thought, like communism, fascism, or nationalism. The other danger is surprisingly laissez-faire. This kind of economic liberalism advocates the perfection of the market, rejecting any intervention by the state. The market is unavoidable indeed but one has to set limits to its power. The existence of society requires a kind of cohesion. Individual interest and competition are today overemphasized; cooperation has been neglected. Therefore some problems have to be solved by political means. When I am not occupied by making and spending money, I think more and more about this question.*¹³ – In early 1997 Soros' paper was printed in Swedish *Dagens Nyheter*, an other European newspaper, saying,

– *It's true that I have made my fortune on the international financial markets, still I am afraid that the rule of liberal capitalism and market value system in our life endangers the future of our democratic and open society.*

– *I like to live on the borderline of stability and chaos because that offers a more complete life.*¹⁴ *But I fear of destructive instability. If I had been taken to a concentration camp, that would have made my youth perhaps more exciting but I was happy that I had survived. My real passion is to find the borderline and I stay just within the border. My ultimate goal is to slow down revolutionary processes like the collapse of the Soviet system. I fear destruction both in politics and the stock market. Instead of destruction I prefer to support progress.*

¹³*Népszabadság*, Budapest 3 February 1995

¹⁴Soros to the author 1996

Bay Zoltán – Zoltan Bay

1900–1992

There is no essential difference between science and art. Both are fed from the same source, from the inherent drive of humans to go ahead, to raise their heads higher. Sic itur ad astra. (Z. B.)

– *There may be a possibility of liberating energy by a chain of nuclear reactions. Will humankind be wise enough to prevent its unexpected and undesired consequences? We have to learn not only how to make fire but also how to extinguish fire. If we succeed, it will be a revolutionary discovery for economic and military aspects as well. Nuclear energy, available in astronomical quantities, would take over the role of coal and oil in the future of humankind.* – These lines were printed in 1941, not in a classified report in Washington, but in a Hungarian journal,¹ written by Professor Zoltán Bay in Budapest. The author remembers (he was a secondary school graduate) that on the day after the Hiroshima explosion, in the newspaper Professor Bay explained in physical terms, how the atomic bomb worked.



Zoltán was born in the southeastern corner of Hungary in 1900, a son of a Calvinist priest. One evening the young boy looked up at the full moon, and wondered:

– *If I climbed the tower, could I touch the Moon?*

His question was eternized on the memorial plaque of the Calvinist presbytery in Gyulavári. According to his last will, he was buried there on Easter in 1993.

Zoltán, as a small Hungarian child, saw Halley's comet (1910), and watched the comet's next return as a professor emeritus of American University (1986). The American Association for the Advancement of Science has named its school science curriculum proposal *Project 2062*, indicating that school children of today may catch sight of the comet's comeback in the 21st century. This perspective has been offered by Professor Bay to his students, among others to the author.



¹ *Természettudományi Közlöny*

The ideal of Zoltán was ROLAND EÖTVÖS, who contributed to the understanding of the gravitational law ruling the Universe by highly accurate laboratory measurements, and helped to exploit the depth of the Earth by a tool created originally in basic science. Eötvös died a few months before Zoltán entered the University of Budapest. After having graduated there, he wrote his Ph.D. thesis on *The Molecular Theory of Magneto-optical Phenomena*. He had chosen two rightlines for life: atoms and light.

As other Martians, Dr. Zoltan Bay made his pilgrimage to Berlin (1926), the capital of modern physics, and attended Laue's seminars. In front of Nobel laureate giants Bay presented his habilitation thesis: in Berlin he showed by spectroscopy that in chemical reactions nascent nitrogen owes its chemical activity to being atomic – and not molecular – nitrogen (1929). The explanation of the chemical activity of nascent nitrogen as atomic nitrogen brought fame: at the age of 30 he became professor of theoretical physics at the new University of Szeged in southern Hungary.

These were the years when the most daring intellectual creation of the 20th century was taking shape: quantum mechanics had been born. Quantum jump was not compatible with classical physics. Quantum mechanics offered a statistical description of it. Niels Bohr became so desperate that he was willing to give up the strict validity of the theorem of energy conservation. According to the Bohr–Kramers–Slater hypothesis only atoms have objective reality as carriers of discrete amounts of energy.

Light and wave function are just auxiliary mathematical tools, enabling us to estimate the probabilities for quantum jumps of the electron to an other orbit of lower or higher energy (1924). These jumps *up and down* average out statistically in such a way that the *time average of energy* remains steady.

The strange dialectics of quantum jumps (so alien for Einstein and Schrödinger) was canonized by Max Born, giving the wave function a probability interpretation. ψ enables us to make probability estimates for future positions and behavior of an electron. Werner Heisenberg formulated the uncertainty relation for *position and momentum*, and for *time and energy*. From Berlin these challenges were brought by Zoltan Bay as intellectual luggage back to Hungary.

As a professor at the Hungarian university, Zoltan Bay felt that atomic physics is something more than weird blackboard mathematics and hair-raising philosophy. Walter Bothe reported at the Ortway Colloquium in Budapest that at the collision of a photon and an electron (Compton ef-

fect) the scattered particles can be detected at millisecond accuracy just in the directions prescribed by energy and momentum conservation. In America Shankland tried to increase the accuracy of the observation, but he did not find an accurate coincidence, thus he concluded that energy conservation was only a statistical approximation.

Compton scattering was studied with Geiger-counters. The electron kicked by an energetic photon produces ions in the gas. The ions can be accelerated by high voltage; in collisions they produce additional ions. The avalanche of ions results in an electronic signal. But the development of the ionic avalanche takes about a millionth of a second – *and a microsecond is a terribly long time in the realm of atoms* – Bay thought, while studying the time resolution of Geiger tubes in Szeged. Electrons are many thousands times lighter than ions! Zworikin (at the RCA, Radio Corporation of America) developed electron multipliers for radio amplification: in vacuum a fast *electron* (accelerated by high voltage) hits a metal surface and produces *more electrons*. Repeated accelerations and impacts create an electron avalanche within one billionth of a second! At Zworikin's visit in Budapest, Bay brought up the idea of using the electron multiplier as a particle counter, but Zworikin did not show any interest.

In the 1940s *Zoltan Bay* and *George Dallos* developed the electron multiplier to a fast counter of photons, electrons, and α -particles. They described the photo-multiplier in the respected British journal *Nature* and in the periodical of the Hungarian Academy: By making one of the signal-carrying wires longer by 1 cm than the other one, the photon-electron coincidence disappeared! In this way Bay proved that at the collision of a photon and an electron energy was conserved within the accuracy of one billionth of a second!

Werner Heisenberg visited Budapest on the 50th anniversary of the Eötvös Society (1941). Being interested in cosmic rays, he asked photo-multipliers for coincidence measurements, which Bay brought to Heisenberg. (Heisenberg took Bay sailing on the Wannsee; they even discussed the prospects for nuclear power.) RCA might have been a bit jealous when Bay's two photo-multipliers were exhibited at the Smithsonian Museum in Washington.

By making use of the high time resolution of the electron multiplier, in Washington Zoltan Bay verified that in Compton scattering energy and momentum are conserved up to 10 picosecond accuracy. These are strict conservation laws, not just statistical approximations! Walter Bothe highly appreciated in his Nobel lecture that his original accuracy of 0.001 s was improved to 0.00000000001 s by Bay with his multiplier.

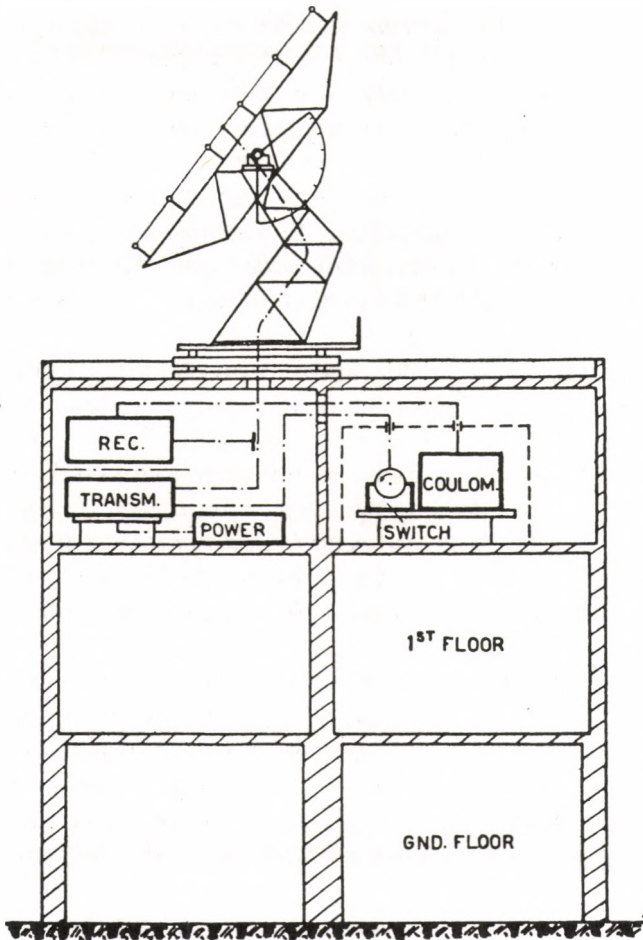
This is the most accurate verification of basic conservation theorems, an achievement comparable to Eötvös' experiment, which showed the proportionality of weight and inertia up to eight decimals, so much admired by the young student.



Bay's achievements in the technique of modern physics make it understandable, that *Lipót Aschner*, director of the Tungstam Company invited the young professor to Budapest, to head the research and development laboratory (1936). Tungstam was the pride of Hungarian industry. Its name had been coined from *tungsten/wolfram*, because this factory introduced tungsten fibers in light bulbs instead of Edison's fragile graphite fibers. Tungstam manufactured durable bulbs for the world market.

The open-minded leaders of Tungstam understood that competitive industry and high technology had to be based on a modern university education. The Budapest Institute of Technology proposed Tungstam to sponsor the creation of an Institute of Telecommunication. Bay was more daring: he suggested to Lipót Aschner establishing a Chair for Atomic Physics instead. During the discussion at the Faculty of Electric Engineering senior professors objected: – *We don't yet know even what atoms are, whether we shall need them at all in the future.* – Lipót Aschner concluded: – *Sirs, please, your words have convinced me of the necessity of creating a Chair for Atomic Physics.* – Zoltan Bay had become the first professor of atomic physics (1938). He brought new spirit into the theory-dominated higher education: the technological realities of the new physics. Zoltan Bay initiated the construction of the first accelerators in Hungary. We, as young students, swarmed to the classes of Professor Bay. After having learned the grand mathematical designs of Einstein and Heisenberg at other universities, at the Budapest Institute of Technology we experienced something different: the promise of the high-tech revolution. Bay was at home in the 20th century, and he wanted us to feel at home in a modern Hungarian society.

During World War II Zoltan Bay was asked to develop vacuum tubes for radio transmitters and receivers, which he had done successfully. Independently of secret British and German efforts, the Bay Group developed radar for the air defense of the city of Budapest (1944). American air raids forced the Laboratory to be evacuated. The German, and later the Russian Army tried to take the most valuable machines of the respected factory for themselves, and they partly succeeded. But production and development still went on, mainly due to the patriotism of Zoltan Bay and the self-interest of the workers.



Within a year after the siege of Budapest, on 6 February 1946 the Bay Group succeeded in receiving radar echos from the Moon. This was second only to J.H. De Witt, who performed lunar echo experiments in the United States on 10 January 1946. The Bay Group had less powerful transmitters; therefore they invented the method of signal summation (realized with a coulometer), to make the echo emerge above the sea of noise. After all the physical destructions and intellectual losses of World War II, this experiment was an encouraging indication for the rebirth of physics in Hungary. Soon Bay observed also radar echos from the Sun. Bay's report was the very first paper published in the *Acta Physica Hungarica* [figure]. Paul Forman from the Smithsonian Institute of the History of Science (Washington D.C.) wrote:

– Beside the American experiment, detecting radar signals reflected from the Moon was also achieved – though relatively little noticed at the time – by a group in Hungary led by Zoltan Bay. The difficult circumstances under which Bay had to work made his accomplishment truly remarkable. During the war he led the team that designed and developed surveillance radar for the Hungarian military – without the assistance of Hungary’s nominal ally, Germany – and in 1944 began to assemble an apparatus for radar detection of the Moon. This he and his collaborators achieved in the spring of 1946, having persisted with the project through the chaos of the final year of the war and the first year of Soviet occupation.²

The achievements of De Witt and Bay are acknowledged as the prelude of the Space Age: the first steps of active experimental astronomy. Zoltan Bay managed to realize the dream of his childhood: *to touch the Moon* by radar beam. Later human hands were to touch the moon rocks.

– Jules Verne dared to imagine that humans would reach the Moon, that they would land there. But even he did not dream that during their moon walk they would talk with terrestrial people, and simultaneously hundreds of millions would watch their steps by television! – Bay said and he went on:

– Science is the fundament of human culture, there can be no doubt of it. If the respect of science fades away, it may cause great trouble. As we search for traces of extraterrestrial life in the Universe, we have to investigate how long civilization is able to live. The most important question is the relation of civilization to culture. A civilization which becomes uninterested in science and art condemns itself to extinction. It gives away its future, it may vanish even without atomic bombs. This is why we must preserve the respect of science and art. I am an optimist. I believe that to the end reason will win out over slogans. We experience today that reality surpasses our most daring dreams. Even the boldest fantasy walks leaden-footed compared to actual progress. Let us think what physics achieved in the 20th century! The main source of my optimism is that the gate of space has been opened up.³ – In fact, Hungary contributed to space exploration: on-board computers made in Budapest helped to visit the Halley’s comet and to transmit the first pictures of the comet’s core – one generation later. But the immediate question was: is there a chance for intelligent life in Hungary?



²Review of *Modern Physics* 67 (1985) 414

³Bay in Budapest 1986

Zoltan Bay – as technological director of the Tungstam Company – made every human effort to save the life of his co-workers of Jewish descent from the Holocaust. They testified [facsimile]:

To the Honorable Dr. Zoltan Bay, professor of the Institute of Technology, on 23 September 1944, Ujpest.

We, the undersigned, wish to express our deepest gratitude for that self-sacrificing show of support which you, Sir, provided in the effort to save our lives and those of our relatives. We are fully aware of how many times you, Sir, rushed to our defence most energetically, even to the extent of putting your position and whole subsistence at risk. We refer, in part, to the events of the 3rd of July: we owe the fact that we escaped deportation solely to your most resolute intervention at that time. We offer you never-dying loyalty and gratitude for all these deeds.

György Dallos, János Katona, György Szigeti, Dr. István Barta, Árpád Ecker, Ödön Kenczler, Ernő Winter, Gyula Viola, György Lakatos, Endre Rédi, Imre Holló, István Goldmann, László Mende.

In the early 1940s Zoltan Bay did his best to assist ALBERT SZENT-GYÖRGYI to create quantum biology, then to help Szent-Györgyi's efforts to get out of the German alliance by establishing a secret radio contact between Budapest and London. Szent-Györgyi wrote later about his underground connection to Zoltan Bay: – *Due to external circumstances, our initiative collapsed. Perhaps that was our luck. If we had succeeded, Bay and myself could have concluded our friendship, hanging from ropes side by side.* – After World War II, Zoltan Bay received the Hungarian Freedom Medal for his participation in the resistance movement.

Szent-Györgyi had a Nobel Prize (1937) as trump card. Zoltan Bay had obtained fame with the lunar echo experiment (1946). Peace brought fresh hope: Szent-Györgyi and Bay together recreated the Hungarian Academy of Sciences. Bay chaired the Mathematics–Science Section of the Academy. The regime tried to court them.

Tungstam had old contacts with General Electric. Zoltan Bay revitalized these contacts on his visit to the United States (1947). Tungstam worked again for export and invested in building new Tungstam factories abroad. But history did not tolerate peaceful progress. The Cold War began and an imminent World War III was expected. Assisted by outside forces and an occupying army, the communists took control of Hungary, their urgent goal being the nationalization of factories. The problems were with companies being partially American interests: America was formally still an ally. One had to prove that capitalists sabotaged production, smuggled

Ujpest, 1944 szeptember 23.

Méltóságos

Dr. B a y Z o l t á n
műegyetemi ny.r.tanár urnak

U j p e s t

Alulirottak legmélyebb hálánknak adjuk kifejezését azért az önfeláldozó kiállásért, amelyet Professor Ur magunk és hozzátartozóink életének megmentése érdekében kifejtett.

Tökéletes tudomásunk van arról, hogy Professor Ur hány esetben állásának és egész létének kockázatétele árán is a legenergikusabban sikra szállt mellettünk. Vonatkozik ez július 3.-i eseményekre is, amidőn egyedül Professor Ur meghatározottabb kiállásának lehet köszönni, hogy megmenekültünk a deportálástól.

Mindezekért fogadja Professor Ur soha el nem múló hálánkat és ragaszkodásunkat.

Dallo György
Klatona János
Kriszti György
Dr. Bente István
Tóth László
Kovács György

Z. Jankó Ernő
Kislapos
Lakatos György
Róka Endre
Herczeg
Goldmann István
Kendheli

hard currency income out of the country in order to undermine the people's power. At such companies police hearings, arrests, conceptional indictments and death sentences followed. The financial director of Tungshram was already under arrest. Zoltan Bay (a former underground resistance hero) was considered to be a suspect (due to his American connections); he – as technological director – experienced nightly interrogations by the political police. In early 1948 he took a train heading westward.



In Washington, Zoltan Bay received a letter from JOHN VON NEUMANN [facsimile]:

Dear Zoltan, Los Alamos, 7 January 1948
I can't describe appropriately how delighted I was learning from your New Year greeting that you are outside of the endangered zone, and settled in America. I already heard about it indirectly, but your New Year card was the authentic information. Excuse my being late in answering, but since 15 December I am off Princeton, thus your letter arrived with a delay. Around the 20th of January I'll be again in Princeton. I hope that soon we shall see each other. You may perhaps know that recently I started working with high-speed automated computing machines – just now we build one in the Institute for Advanced Studies, in Princeton. The present, even more the future technique of these machines have several touching points with your high-speed counters and amplifiers. I would be delighted if we could speak about these possibilities. – In middle of February I plan to be in Washington for a few days. But don't you come to New York or Princeton before that? See you soon!
With many greetings Neumann Jancsi

The discussion about the use of the multiplier for nanosecond electronics went on:

Dear Zoltán, 21 June 1949, Los Alamos
I would like to tell you once again how delighted I was that I had the chance to meet you before I returned home, and that we had the opportunity to discuss the problems involved with the "electron multiplier" and the computer, including their common aspects. I see how important points have you taught me, and I am more convinced than ever that the electron multiplier may be a vital component in the computer, and presumably in the future of this whole field. Meanwhile I have thought further about the possibilities of a grid-controlled electron multiplier, and have reached

IN REPLY
REFER TO:

1948 January 7.

Kedves Poltan,
nem tudom kedően látni, miúgya nagy
szöveggel tudtam meg a Kedves Ujvár
üdvözléséről, hogy vigye a verset
ezzen kívül nagy, és Amerikában teleped
fél k. Indirect híreket arról már
hallottam, de az Ujvár lapod volt
a pozitív és autentikus írás
Doris meg hogy csak ilyen elcsúsz
félét, de December 15-ike óta el vagon
Princetonból, és így a levelet csak
kecséssel és keményen írtal. Január 20-ika
körül megírt Princetonban levelet.
Nagyon remélem hogy hamarosan
látni fogjuk egymást. Valan tudod, hogy
én az utóbbi időben lefolyóbbra
nagy sebességgel, automatikán, ~~széles~~
számszó gépekkel foglalkoztam - jelenleg
több munkatársal együtt egy ilyen
gépet ~~széles~~ konstruálunk az Institute
for Advanced Study keretén belül,
Princetonban. Az a fően használt, és
még inkább a jövőben használandó
technikáknak sok érintkezési pontja van
a Te nagy sebességgel számszóló ~~széles~~ és
írásos eljárásaidal. Nagyon örülök,
ha ezekről a dolgokról egyszer
elbeszélgethetünk.

En február közepé felé alighanem
Washingtonban lesznek pár napig -
de nem kéne Te esetleg korábban
New York és Princeton közötti?

A ~~széles~~ mielőbbi viszontlátásig
szöveggel üdvözlök

Neumann Január

the conclusion that it would be wisest to write to Dr. Rees, head of the Department of Mathematics in the Organization of National Research. I did this today. I brought your electron multiplier to his attention, recommending it as strongly as possible. N.B. I would be most grateful to you if you wrote me telling how your discussion with ONR are going otherwise. – I know another group in government circles which will soon, I think, show interest in your electron multipliers. But I prefer not to write about it until it takes a more definite form. – Sending you all good wishes, until we talk and meet again, yours truly,

(Neumann) Jancsi

At George Washington University Bay concluded his coincidence measurement to eleven decimal accuracy. As director of the Department of Atomic Physics at the National Bureau of Standards (1955) he played an influential role in the high-tech era.

Bats, dolphins and submarines use their *ears* (as sonar) for orientation in *space* (measurement of distance, recognition of shape). Since World War II, distances were measured by radar on the sea, in the air, and in outer space: the measured flight *time* of microwave pulses to the object and back, multiplied with the speed of light c , and divided by two, giving the spatial *distance* of the object. (Even speeding cars are caught by the police with radar detectors.) In this way, radar technology utilizes the *unity of space and time*, declared by the theory of relativity. It may be considered historical accident that the Parliament of the French Revolution codified the units of space (meter) and time (second) independently of each other. c is essentially a conversion factor between these two arbitrarily chosen but interrelated units.

The invention of laser opened a new era in applied physics. The future-sensitive Bay recognized that laser light – possessing a thousand times shorter wave length, combed to be very monochromatic – offers a chance to *materialize* the Einsteinian idea: to connect the standard of *meter* to the standard of *second* by atomic clocks. But it is a long way from this attractive idea to the technological utilization and legal acceptance. One has to prove that the speed of light in vacuum is independent of the light source, direction, frequency, and observer, up to an accuracy what is requested by modern metrology. One has to bridge the gap between the high frequency of laser light and the low frequency of atomic clocks. Twenty-five years of hard experimentation and argumentation brought results: in October 1983 the International Committee of Weights and Measures decided: “1 meter is the length of the path travelled by light in vacuum during a time interval of $1/299792458$ of a

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Zoltan L. Bay, 92, Major Figure In Developing Radar Astronomy

By BRUCE LAMBERT

Zoltan L. Bay, a pioneering physicist in the United States and his native Hungary, died Sunday at his home in Chevy Chase, Md. He was 92 years old.

He died of emphysema, his family said.

His experiments with microwaves reflected from the Moon in 1946 helped start radar astronomy, in which celestial bodies are studied by bouncing radio signals off their surfaces. His electron multiplier devices for counting particles are on permanent exhibit at the Smithsonian Institution. His work at the United States National Bureau of Standards led to new measurements of the speed of light and a new international standard for a combined measurement of time and length.

His specialties included electroluminescence, atomic and molecular spectroscopy and high-energy radiation ionization. His work led to several patents, including one for generating light burning carborundum.

Work With Nitrogen

Dr. Bay was born in Gyulavari. He earned his doctorate at the Pazmany Peter University of Natural Sciences in Budapest. In the 1920's he did research at an international physics center in Berlin, where he gained attention by proving that active nitrogen gas contains free nitrogen atoms.

At the age of 30, he joined the University of Szeged in Hungary as its youngest full professor in 1930. He moved to the University of Technical Sciences of Budapest in 1937 as chairman of its atomic physics department. He was also head of the Mathematics and Natural Sciences Division of the Hungarian Academy of Sciences.

During World War II, he protected Jewish colleagues from Nazi persecution. As the research director and general manager of Tungstram, a major electronics company, he tried to save its factory from destruction by Soviet troops.

Fearing imprisonment after the Communist takeover, he fled in 1948. In 1990, as Communism was collapsing, the Hungarian Government awarded him its Order of the Flag.

In the United States, Dr. Bay became a research professor at George Washington University and in 1955 he joined the staff of the National Bureau of Standards. Since 1973 he was a senior research scientist at American University.

His first marriage ended in divorce.

Surviving are his wife of 45 years, the former Julia Herczegh; a son, Zoltan K. of Chevy Chase; a daughter, Julia Hasizume of Hartsdale, N.Y., and three grandchildren.

second." From this day on one does not have to strive for more and more precise measurements concerning the speed of light; its value is $c = 299792458$ m/s once and forever. Not only physicists and engineers but school children as well learn today that *length* can be measured by a *clock* because *space* is not independent of *time*. Good-bye, Euclid! Welcome, Einstein!



– *I have visited Hungary several times. I have never denied my being Hungarian. I will remain Hungarian as long as I walk on Earth.*⁴ – After 25 cold years, after 25 years of absence, Bay Zoltán put his feet again on Hungarian soil. At the invitation of the Eötvös Society he lectured in the three towns which consider Bay to be theirs: in Debrecen (where he attended the Calvinist Gymnasium), Szeged (where he was professor at first), Budapest (where he studied at the University of Science, and taught at the Institute of Technology). Since then he returned bi-annually, published papers in Hungarian, and became an honorary member of the Eötvös Society.

He was the only member of the Hungarian Academy of Sciences who gave acceptance lectures three times: When he was elected corresponding member, he spoke about the *photo-multiplier* (1938). As ordinary member, he lectured about the *Moon echo* (1946). Then the Academy excluded him because of his leaving Hungary. When he was re-elected honorary member, he lectured about the *new meter* (1989). In 1990 Bay turned ninety. Due to lung problems, his doctors did not let him fly. Árpád Göncz, the President of the Hungarian Republic brought him personally one of the highest awards, the Order of the Flag with Rubins, to Washington (1990). In his acceptance speech Zoltan Bay expressed his thanks and recalled what he did for Hungary even economically at the Tungsram Company, saving it from German, then from Russian troops. He asked the President to take care of Tungsram in the coming era of regained freedom.

In 1948 Tungsram, the pearl of the Hungarian industry was nationalized. In 1992 the company was reprivatized and sold to General Electric.

⁴Budapest 1986.

Szent-Györgyi Albert – Albert Szent-Györgyi 1893–1986

*To see what everyone has seen but to think
what no one else has thought. (A. Sz.-Gy.)*

For humankind, Albert Einstein has become the symbol of the scientist. For Hungarians, Albert Szent-Györgyi is the popular hero of science. Fate assisted him to become a romantic hero in the 20th century. He separated vitamin C (nowadays the most popular “medicine”) from *paprika* (the red-hot pepper is the national spice of Hungary). He is the only scientist who brought Nobel Prize to Hungary; the gold medal can be seen in the National Museum. The Nobel Prize was given for his research and understanding of vitamin C; *Time* magazine announced it as the “*Paprika Prize*”. Among his students, his nickname was “*Saint George*”, with a hint to the Hungarian meaning of his name. He fought dragons.

Albert Szent-Györgyi originated from noble families, abounding in medical careers; he intended to have a research career in life science. He was born in the “*lilac-scented Budapest*,” baptized in the Calvinist religion, as the son of a well-to-do educated family. He graduated from the Medical School of Budapest, collected some direct experiences on the fronts of World War I. After the collapse of the Austrian–Hungarian Empire, his brother, Pál Szent-Györgyi became an active social democrat, just to be imprisoned by the short communist regime, and a few months later by the right-wing military rulers as well.

Szent-Györgyi worked at the University of Pozsony, when at the time of partition of Hungary, Pozsony became Bratislava, the capital of Slovakia. For Szent-Györgyi this offered chance for adventures like illegal border crossing through the Danube, smuggling out laboratory equipment, and a romantic night in the boat with Soror Angelica. The military rulers in Budapest tried to turn the arms of the clock back to the 19th century. That was not promising for the forward-looking Albert, thus in 1919 he started his wandering years through Europe and America.

He made a long march in science as well. Szent-Györgyi was interested in the energy producing oxidation within the cell. He found a compound which did not burn but catalyzed and regulated oxidation. It was extracted from the adrenal gland of cows, that needed a lot of adrenal and a lot of

money. This is why Albert had to move around, looking for sponsors of his research. His results brought him more fame than money.

In 1928 Count Kuno Klebersberg, the enlightened Minister of Education, invited the young scientist to visit Budapest. He told him that modern science, especially experimental biology was considered to be important for the future of Hungary. The Minister offered the promised Rockefeller fund to Albert Szent-Györgyi, in order to create an Institute of Biochemistry at the new University of Szeged. This offer was so impressive that Szent-Györgyi gave up his promising career in Cambridge.

In January 1931 the young and modern professor arrived to Szeged. He liked driving and flying, became soon the idol of the youth. He invited students for visits at his home, and for relaxing excursions. (On sunny days they decided to swim a bit in the river Tisza, in spite of the fact that nobody had swimming suit with. About half of the medical students were girls.) Talented researchers grew up around the "Prof." He wrote to the Rockefeller Foundation:

– In a small country like Hungary scientists of some renown should be patriotic enough not to expatriate themselves, otherwise the country would be rapidly depleted.

There were advantages of the work at Szeged, that Albert enjoyed. On the campus he met ZOLTÁN BAY, the youngest professor in Hungary, and Albert told him: – *I am happy indeed that my fate brought me together with a physicist because it is my conviction that the future development of biology will be strongly influenced by quantum mechanics.*¹ – The strange compound – extracted from the adrenal glands – were still at the focus of his interest. In the original manuscript of his paper Szent-Györgyi named the sugar-like compound of unknown structure *ignose* (don't-know-sugar), but the strict editor of the respected *Biochemical Journal* objected. The second naming *godnose* (a sugar-only-god-knows) was rejected as well. The editor proposed *hexuronic acid*, indicating the sour taste and the six carbon atoms contained in the molecule. Orange is rich in *hexuronic acid*. One evening Szent-Györgyi got the idea to test the fresh paprika, left over from the dinner, and it turned out to be a treasure chest of *hexuronic acid* containing six times more of it than orange (2 g per kg). The paprika does not contain other sugars which makes the separation easy. Instead of grams, now the compound became available in kilogram quantities. By experiments on guinea pigs it was proven in Szeged that the compound cures scurvy, thus it ob-

¹Ralph W. Moss: *Free Radical*, 1988

tained the scientific name *ascorbic acid*, but we know it now as *vitamin C*. Szent-Györgyi distributed large samples of ascorbic acid to chemical laboratories world-wide, thus its exact molecular structure was determined. Even mass production became a reality. Professor Szent-Györgyi recognized that vitamin C is not only a medicine to cure scurvy but it is an important food ingredient to preserve health and to prevent sickness, due to its central regulating role in the oxidation processes of the cell. He encouraged creating a company to produce a kind of spice enriched in the vitamin C from paprika. The patented trademark became *Pritamin* (coined from *paprika* and *vitamin*).

The identification of vitamin C brought Albert Szent-Györgyi the Nobel Prize in physiology and medicine (1937), followed by a huge celebration at his students – and by jealousy at some other professors. The false rumor was spread that the results were tampered with. When – fifty years later – the 80-year old Prof relaxed with the author in a sea-food restaurant at Cape Cod, he recalled: – *After having received the Nobel Prize, the new minister of education² visited the University of Szeged, to open the academic year of 1938/1939. The rector introduced me to the minister. The Excellence reacted: – “Oh yes, the Nobel Prize for vitamin C! I know that all that is a humbug, but please, advertise it: we can sell more paprika abroad!”* – The Prof went on: – *After the Nobel prized discovery, I received several honors abroad. Finally, in 1939 a cable arrived, inviting me to an audience at the Governor of Hungary.³ Well, I entered the Governor’s office, he shook my hands, and gave me the gold Corvin Chain. Then we started chatting about horse-back riding and the advantages-disadvantages of different breeds.⁴ After a while the Governor’s adjutant indicated with a small cough that the time of the audience was over. I thanked to the Governor for the honor and left. At the exit the adjutant officer excused: “The next one on the audience list to obtain the Corvin Chain would be a horse-trader, and possibly the Governor mixed up the two honorees.” I reacted: “Poor trader, he has now to chat about biochemistry!”* – It was illuminating to listen to Szent-Györgyi’s comparison of different science politicians like Klebelsberg and Hóman.⁵

²Bálint Hóman

³That time landlocked Hungary was formally a kingdom, ruled by an admiral as Governor, who prevented the last Habsburg king from regaining his throne.

⁴Admiral Horthy used to appear on a stallion in military parades. Szent-Györgyi learned to enjoy horse-back riding in Cambridge.

⁵to the author 1981

World War II approached Hungary. In 1940, at the time of the Soviet attack against Finland, Szent-Györgyi expressed his sympathy by donating his Nobel medal to the Finnish Red Cross. (Niels Bohr did the same in Denmark.) At the auction, a Hungarian–American businessman bought the gold medal of Szent-Györgyi, and donated it to the Hungarian National Museum.

When Szent-Györgyi was made the Rector of the University of Szeged, he paid special attention to the appropriate orientation of the students. He helped to establish the SZEI (Szegedi Egyetemi Ifjúság, Szeged University Youth), which became an island of free thought in the militarized climate of the 1940s. Hungary became involved in the war on Germany's side. – *Szent-Györgyi's war-time adventures could make a cheap spy story.*⁶ – The face of the Nobel laureate scientist was known practically to each Hungarian, that made him troubles in the underground.

After World War II he became professor at Budapest University, established an Institute for Biochemistry and began to educate new co-workers for muscle research: how the energy obtained from ATP results in muscle contraction. (The author was student at that time. He remembers that the Prof played volley-ball with his students on the campus during lunch breaks. This was not a common sight in Hungary: neither a Nobel laureate, nor the professor playing with students.)

In Hungary, Albert Szent-Györgyi participated in building a modern democratic society, created a progressive Scientific Academy, in competition to the Hungarian Academy dominated by conservative historians and politicians. He collected food for the members of the academy with the help of his friend, the entrepreneur István Ráth. He became the president of the Polgári Demokrata Párt (Democratic Party of Citizens), thus a member of the Parliament. But democracy did not last long for Hungary in the late 1940s. While Szent-Györgyi lectured in Switzerland, Mr. Ráth – as capitalist – was arrested and tortured by the communist police. Having learned this, Szent-Györgyi sent his strongest protest to the Hungarian authorities. Ráth was released, he was allowed to leave the country, leaving his properties behind. In Switzerland Ráth told Szent-Györgyi about his torture. In 1947 the Prof decided *not to return to Hungary*.



Restarting a scientific career in America was not easy. For a short period, Oppenheimer invited him to Princeton. The greatest American institutions are ready to accept educated immigrants for modest salaries, to

⁶Ralph W. Moos: *Free Radical*, 1988

work under the leadership of American directors. They are less interested in accepting an alien arriving with messianistic ideas both in politics and in science, who wants to be the boss himself, and is considered by the FBI to be suspicious. Szent-Györgyi found a solution: he established a private laboratory in Woods Hole, in the Marine Research Laboratory at Cape Cod, financing his work and that of his co-workers from foundations. With the support of entrepreneurs, like István Ráth, Hungarian scientists worked for his "lab without walls."

Woods Hole slowly became an informal brain center for America. Szent-Györgyi invited ZOLTÁN BAY, JOHN VON NEUMANN, *George Gamow*, *James Watson*, and other characters to his house named *Seven Winds*: (Only the northern winds were blocked by a cliff.) Watson wrote a part of his best-selling book *The Double Helix* at Szent-Györgyi's house. Visiting scientists from Hungary were always welcome. (The author smuggled red-hot cherry paprika from Hungary through U.S. customs, to remind the Prof of his success with this spice. The Prof placed the paprika chaplet happily onto the marmor bust of himself.) After the Sputnik shock, larger brainstorming conventions were organized in Woods Hole, with dozens of Nobel laureates attending, financed by the U.S. Government, like those catalyzed by KÁRMÁN and WIGNER.

– *We cannot build, unpunished, H-bombs by science, and run them with the 18th century egoistic, narrow, sentimental, and deceitful political thinking. It makes no sense to shoot astronauts out into space to reach other planets and erect ten-feet concrete walls to separate man from man on Earth. In its own time pre-scientific thinking did build a stable world. But science irretrievably undermined the acquiescence in misery as the attribute of human existence, and has undermined the old hierarchies of gods, princes, barons, haves and have-nots, well-fed and hungry, developed and underdeveloped* – Szent-Györgyi said in his autobiography,⁷ that he published under the title "*Lost in the 20th Century*". He was a new-comer in the U.S. but he tried to save the world in the style of Szilard and Teller.



– *Think boldly. Don't be afraid to make mistakes. Don't miss small details, keep your eyes open and be modest in everything except your aims* [facsimile]. – The Prof was more than willing to follow his *ars poetica*.⁸

⁷*Annual Review of Biochemistry* 1963

⁸written to Ralph W. Moss

Think boldly, don't be
~~afraid~~ afraid of making
mistakes, don't miss
small details, keep your
eyes open and be
involved in everything
except your aims.

– If you shake a matchbox full of matches, nothing happens. But if you take out a few matches, when shaking it you hear matches moving inside – the Prof said,⁹ to explain his ideas about the ultimate question: what is life? – For me the main attraction of biology is offered by its extreme sensitivity, the speed and delicacy of reactions. DNA is inactive for most of the time, proteins do the work. But a single protein molecule alone is just a huge body in the cell with forbiddingly high activation energy. I am convinced that to understand life we have to watch how smaller units behave. In Szeged, in the 1940s I published a paper stating that proteins might conduct electrons. Chemically isolated proteins are white. We have to take electrons off to make the protein red: the color indicates that it's a conductor. When I published this hypothesis, the whole world attacked me. When I met Linus Pauling on the street, he shouted me already from a distance: "Proteins are not semi-conductors!" In a way this general rejection encouraged me. If my idea had been accepted too easily, I would become suspicious: my discovery may be not extraordinary at all! – This quotation indicates not only the boldness of Szent-Györgyi's idea, but the critical reaction of the scientific world as well. With "his heavy Hungarian accent" he announced that – there is no real difference between the grass and he who mows it. – This

⁹Budapest lecture 1978



National Foundation for Cancer Research

P.O. Box 187 • Woods Hole, Massachusetts 02543

Scientific Director
Dr. Albert Szent-Gyorgyi
(617) 548-3705, Ext. 393

1/11/94

Kedves Sándor,

János népi Lindában régt veres
és Compressum, a társas felelősen "titokban"
pár napra. Meggyőzően kezdtem menni
hisz Postát megérett. Embertől. Legyél
Kéne és előadás munkáimról. Ezzel
a fizikai társulat kezeli belül meg
lehelme Barabasi minden hí- és nélkül.
Mi 5-ös jár nek. Úgy.

Melleg utóirat-

Szent-Györgyi ked.

P.J. "Ez az érdekes életem!" az "elő" alatt?
Az interkombinál állapotban lenni.

is why the Prof published his ideas more in books than in well-established scientific journals. He called his programme bioelectronics. The octogenarian Prof tried hard to learn both: windsurfing and quantum mechanics:

– Things can be imprinted into the brain only at an early age; the brain freezes up later and is no longer malleable. I experienced this myself. I was in my fourth decade when I started to work in quantum mechanics and tried to understand the atom. It was too late. I could pick up ideas with my brain but they never got into my blood, and I found that I had to avoid discussions on atomic physics with high school students. They have the atom in their blood as well as in their brain.



The Prof visited Hungary in 1973 and gave a formal lecture at the Hungarian Academy of Sciences. After the lecture my physics students surrounded him, asking to talk to *them*, that the Prof gladly accepted. Turning the pre-arranged protocol timetable over, he came to the University of Budapest, and spoke to the students boldly as we quoted. Physicists understood him better than biologists. In 1978 he came again to Hungary, in order to show his native country to his fourth wife (he always liked a young wife's company) [facsimile of a letter to the author].

Dear Friend, at the end of June I shall take part on a congress in Lindau. After that my wife would like to pay a "secret" visit to Hungary, in order to see Budapest. You mentioned your interest about a lecture on my research. It may be that it can be held in the Eötvös Physical Society without much fanfare. We will return on the 5th August. With warm greetings,
Szent-Györgyi Albert
P.S. The possible title of my talk is "The Living State." We shall stay in the Hotel Intercontinental.

In Hungary, his last lecture was given for the Eötvös Society in the Department of Atomic Physics at Eötvös University. Here the Prof presented electron spin resonance investigations, showing that living structure proteins contain unpaired electrons, in a sense they are semiconductors indeed. He expressed his hope that he might understand cancer. On Hungarian television he sent a message to the Hungarian people:

– I am a Hungarian as I was in the past. As a Hungarian I wish Hungary to belong to the "great nations." The true greatness of a nation does not depend upon its size and military might. The political boundaries of a country cannot be extended without hurting others. In intellectual life, however, growth depends only on one's brain. It is in this sense that I wish Hungarians become one of the greatest nations in the world.

The late years were filled with happiness for understanding how live proteins work, and with bitterness because his bold ideas were not appreciated enough. His life history shows a negative characteristics of Martians: they have such rich historical experiences that they easily become interested in a distant future: they rely more on intuition than on step-by-step progress; they are distracted from regular scientific work by their efforts of saving humankind. – Occasionally they may even succeed.

Albert Szent-Györgyi lived almost 100 years. To the end he was an optimist: he believed in the 21st century and believed in the youth. He wrote about the *Crazy Ape*:¹⁰

– *Our present world is a gerontocracy, dominated by people whose brains froze up before the atomic age. Gerontocracy is a good system at times when changes are slow, and the main problem is the preservation of values. But gerontocracy becomes highly dangerous in periods of rapid change, such as the present period represents, when human existence depends on the ability to adjust to and create a new world. Today parents were born in the pre-cosmic era, but their kids are already children of the cosmic era.*

– *How can we get out of the fatal grove we are in, the one that is leading towards the brink? Only the youth can make it by building a new world. It is impossible to create a new world by science and then run it on the basis of outdated, sentimental principles like fear. A world created by science can be run safely only by the spirit and methods of the science which has created it and created science itself.*

¹⁰Albert Szent-Györgyi: *The Crazy Ape*, 1970

Oláh György – George A. Olah

1927–

We are living in a fool's paradise. Much of what nature has provided us over the aeons is going fast. We must find ways through chemistry to substitute them. (G. O.)

If anyone (e.g. a student) is asked about the chemical valence number of carbon, the straight answer will be: – *Four* – without any hesitation. If someone responded: – *Sometimes the carbon atom can bind five* – he would fail the examination. But if somebody succeeds in proving it, he will receive a Nobel Prize.

Oláh György is the son of a Budapest lawyer. He studied in the Gymnasium of the Catholic Piarist Order [facsimile]. This school has educated two Nobel laureate chemist for mankind: Hevesy and Olah. In the school George was impressed by the direct personality of his physics teacher: *József Öveges*. He was perhaps the most respected teacher of physics in Hungary, widely known for his ingenious experiments indicating the potentialities of modern physics and high technology. But the young George was more interested in literature and the medieval history, full of exciting collisions of East and West, North and South, than in science. – *I believe that getting attached too early to a specific field frequently shortages a balanced broad education.*¹ – During his teen years George experienced World War II, – *It was a stimulating atmosphere to grow up in, except for the darker political sides.* – Thus after the war he decided to study chemistry – a Martian habit – because chemistry seemed to offer more realistic perspectives in the war-torn country. He fell in love with chemistry as freshman at the Budapest Institute of Technology. – *One cannot tell precisely why one has fallen in love, but I still love it. Perhaps because chemistry is a very wide science reaching from life and medicine to fuels and new materials.*²

As he recalls, what the Budapest Institute of Technology offered was much more chemistry than chemical engineering. This might be the root why George Olah considers organic and inorganic chemistry, experi-

¹Olah in his autobiography written on the occasion of the Nobel Prize, 1994

²interview on the Hungarian Television 1997

Anyakönyvi szám: 33

A tanuló neve:

Olah György Anatól János

Yellése, születésének helye és ideje:

Budapest 1927. október 22. é. m.

Mel. végzett képzéseket tanulmányait:

1- VIII oszt. Budapesti Levegőtisztosítóképző Gimnázium 1947/48 - 1948/49

Művelődési vagy magántanuló volta:

nyilvános

Megvizsgálata:

jól

A tanuló érdemjegyei:

Tantárgy	VIII. osztályú érdemjegye	középső nyelvi érdemjegye	Számbeli nyelvi érdemjegye	Végleges átlagos osztályzata
Magyar nyelv és irodalom	jól	jól	jól	jól
..... nyelv és irodalom	-	-	-	-
Történelem	jól	-	jól	jól
Latin nyelv	jól	-	jól	jól
Matematika	jól	jól	-	jól
Földrajz	jól	-	jól	jól
Természetismeret	jól	-	jól	jól
Hangverseny	jól	-	jól	jól

A gimnázium többi tantárgyában tanulmányi eredménye a következő volt:

Tantárgy	Osztály	Érdemjegy	Tantárgy	Osztály	Érdemjegy
Műt. és orvosi ismeretek	VIII.	jól	Természetismeret	V.	jól
Geográfia és idom. földrajz ismeretek	VI.	jól	Fizika	VI.	jól
Élett. és egészség.	VII.	jól	Élett. és egészség. ismeretek	VII.	jól
..... nyelv és irodalom	VIII.	jól	Magyar nyelv és irodalom	VIII.	-
Biológia	VIII.	jól	-	-	-

A vizsgalábizottság általános ítélete: a) Ha igen, milyen fokozattal? b) lehet-e javító-, illetve ismétlés-vizsgálatot? ha igen, mikor? jelöltem írást

mental and theoretical chemistry, basic chemistry and chemical engineering to form a single unity: the goal of science is to explore Nature and thus to create new materials.

He was attracted to organic chemistry by Professor Géza Zemplén, who was a disciple of the Nobel laureate chemist Emil Fischer and investigated the reactions of sugars. Olah got the very heretic idea that implanting fluor – which is the most active chemical element but does not play a significant role in biochemistry – may be a good marker for the transformation of carbohydrates and other chemical reactions. But these were the years immediately following the destruction of the war. There was neither suitable laboratory space nor chemicals for such “exotic” work available. Olah was essentially given some space on the converted balcony of the institute

overlooking the Danube from where he could not pollute the clean “organic” experiments. The tall assistant was considered also most useful as the goalkeeper in the soccer team of the Department. Olah’s early results, however, created a favorable international acceptance. For example, the famous German chemist, Hans Meerwein read his papers and sent him a cylinder of pure BF_3 as a present to help his work, which was an unexpected blessing for the young fluor-addict organic chemist. Olah completed his Ph.D. thesis under Zemlén and continued his research on the staff of the Budapest Institute of Technology.

In the 1950s the new communist regime supported science in order to accelerate the industrialization of the country. After having created a national laboratory for physics (1950), a similar laboratory for chemistry was organized (1954). George Olah became one of the organizers and soon its deputy director. He became able to go on with his research in fluor-assisted organic chemistry.

History, however, took again a new turn: Hungary revolted against the Soviet rule and the Hungarians were defeated by the Red Army (1956). For the young people, the situation became unpromising and 200 000 Hungarians – most of them young and talented – left the country through the temporarily opened borders. Among them was George Olah with Mrs. Olah, a fellow chemist. Their first way led to England, to Mrs. Olah’s relatives (1956), then further to Canada, to his mother-in-law (1957). – *I am a chemist, this is my luck, because chemistry is an international venture. There is no Hungarian or German chemistry, Russian or American chemistry. The change was not difficult for me because I was able to do chemistry even with a poor knowledge of English and a strong Hungarian accent.*⁵

He obtained a job at the Canadian branch of Dow Chemicals, an American company. Thank to his successful work, he was transferred to the research laboratory of Dow Chemicals in Massachusetts (1964). His fame and career soon got a new momentum westward: Olah was invited to the university in Cleveland (Ohio, 1965). When his son started university studies in California, Olah accepted the invitation of the University of Southern California (Los Angeles, 1976). As Olah said,

– *I always felt that working with talented young people is an essential precondition for the success of a long-range research program. The greatest blessing of my career is to be a university professor allowing me to work with young associates. My students are indeed members of my scientific family: up till now I have worked with more than 200 gradu-*

⁵interview in the Hungarian Television 1997

ates and postgraduates. This steady flow of talented young people creates the atmosphere of any good university department or institute. – (As a teacher, Professor Olah did not miss a single class even in the glory of the Nobel Prize.) At the University of Southern California George Olah is the director of the *Loker Hydrocarbon Research Institute*.

– *Hydrocarbons are the compounds of hydrogen and carbon. They make up natural gas and oil and they are essential for our modern life. Burning hydrocarbons is used to generate energy in power plants and heat our homes. Derived gasoline and diesel oil propel our cars, trucks, airplanes. Hydrocarbons are also the feed-stock for practically every man-made material from plastics to pharmaceuticals. What nature is giving us, however, must be processed and modified. We will eventually also need to make hydrocarbons ourselves, as our natural resources are depleted.*⁴

The still frequently used name of saturated hydrocarbons is paraffin, it is coined from the Latin words *parum* (meaning little) and *affinum* (meaning attraction). The reason is that they generally show limited chemical reactivity. How could we force these inactive organic compounds to react at our intentions? Well, as he said in a chat,

– *Chemistry in a way is not different from the arts. In theoretical chemistry – as in the arts – individual ideas, even inspiration play a great role. If an artist paints, he does not do it for selling the picture but to express his soul. I used to work 80–100 hours a week but I don't get tired. When I look at my watch, it means that I don't enjoy the work; then it's time to quit.*

The acids contain highly electron-attracting (electronegative) elements which pull the electron cloud off from the hydrogen atom. Thus acids are proton-donors: they are inclined to drop the naked positive hydrogen nucleus (the proton) easily. Thus the positive proton may stick to the negative electron cloud of other molecules. In this way acids are corroding materials; this property of concentrated sulfuric acid is well known. Acids are used in chemical industry but the chemistry of life relies upon milder agents. The paraffins are not attacked even by sulfuric acid.

Olah's revolutionary approach was based on his discoveries of acids up to trillion times stronger than sulfuric acid, for long considered the strongest mineral acid. These acids are now called superacids. Among superacids the fluor-containing acids excel because fluor is the most electronegative (most electron-attracting) element. The appropriate mixture of HF + SbF₃ (hydrogen-fluoride + antimony-trifluoride) is so strong

⁴1994 Nobel Lecture by George Olah

that at a Christmas party a student of Olah placed a candle into it and the candle was dissolved! This is how the mixture – being 1000 000 000 000 times stronger than 100 % sulfuric acid – has got the name *Magic acid*. These superacids are so powerful that they can force one of their protons onto saturated hydrocarbon molecule where the poor proton immerses itself into the modestly negative cloud of an electron pair. This is how methane (CH_4) was forced to take one proton more to make the CH_5^+ ion in which an electron pair is shared not by two but three atoms. In this way the carbon atom binds *five* hydrogens simultaneously (1967). Olah named this *carbonium* ion (1972). (The Pauli principle is not violated: there can be no more than eight electrons in the octet shell of the carbon atom, but they not necessarily are involved only in two electron–two centers bondings.)

There were previously indications that positive hydrocarbon ions (i.e. carbocations) take place in organic chemical reactions, but they were considered only transient structures, reacting further immediately, within a microsecond (0.000 001 s). George Olah succeeded not only in producing them but giving them longer lifetimes in superacidic environment (superacidic solvents diluted with SO_2 or SO_2F_2). Capturing a most evasive object was like recalling a flying dream!

– *Carbon is very important on Earth, it is the base of life and food and fuels. In the 19th century Kekule has shown that carbon can not bind more than 4 atoms or groups (its valence is 4). But I succeeded to show that under certain conditions the valence of a carbon atom may be 5 or even 6. One cannot be surprised that departing from a 150 years old dogma was not easy. A very long, occasionally bitter discussion followed. But this discovery opened new avenues, for example contributing how to make gasoline of high octane number.*

– *It is something in our nature, in the character of Hungarians that we don't go always along the well traveled main road. We are interested to leave the wide road in order to explore new trails. If you find something really interesting off the road, then it is worthwhile to stand up for your discovery, because if you yourself do not believe in its importance, why should others follow you.*

Traditional organic chemists were shocked by this crossbreeding of *organic chemistry* (hydrocarbons) with *inorganic chemistry* (superacid), resulting in unlikely creatures like carbon atoms with five arms. A long period of controversy and discussion followed. With the help of new techniques learned from *physicists* – like nuclear magnetic resonance and electron spectroscopy – Olah succeeded, however, in investigating the structure of his carbocations and verified his heretical claim: a lasting

existence and nature of carbocations. (The first decisive NMR and ESCA spectra are framed in Olah's study.) Eventually he received the undivided 1994 Nobel Prize "for his contribution to carbocation chemistry." Olah keeps also the saying of GEORGE VON BÉKÉSY on the wall of his office, as a reminder of the lengthy controversy relating carbocations:

– *One way of dealing with errors is to have friends who are willing to spend the time necessary to carry out a critical examination of the experimental design beforehand and the results after the experiments have been completed. An even better way is to have an enemy. An enemy is willing to devote a vast amount of time and brain power to ferreting out errors both large and small, and does this without any compensation. The trouble is that really capable enemies are scarce; most of them are only ordinary. Another trouble with enemies is that they sometimes develop into friends and lose a good deal of their zeal. It was in this way the author lost his three best enemies. Everyone, not just scientists, need a few good enemies!*

In natural gas and oil the carbon atoms form simple straight chain molecules or cyclic compounds which can be separated by distillation.

After having understood the carbocations, one can design and make a broad variety of hydrocarbon products. This knowledge paved the way for making improved branching hydrocarbons (serving as leadfree gasoline) out of linear ones, cracking long chains (making light gasoline out of heavy oil), making liquid gasoline out of methane gas, even new ways of liquefying coal (making gasoline out of coal). As the Royal Swedish Academy of Sciences summed up his achievement: – *The direction of this field did change completely through the original and imaginative work of the Nobel Prize laureate George A. Olah.*⁵ – As his friends said:

– *Chemistry has not been the same since.*

George Olah continues to be an active professor, author of scientific books, and an ardent researcher. He keeps his contact alive with Hungary, being a member of both of the U.S. National Academy of Sciences and the Hungarian Academy of Sciences.

– *In America scientists of Hungarian roots have achieved high respect. If I managed to contribute to this, I am happy about it.* – He may be a happy man indeed;

– *Scientists, including myself, are basically rather selfish individuals. Most scientists pursue science because they have a built-in curiosity. They try to find the unexpected. To see, however, someone's work also to contribute to our society's overall goals, is rewarding.*

⁵photo is the courtesy of the Nobel Foundation

Kürti Miklós – Nicholas Kurti

1908–

Is it a sad reflection of our civilization that we can and do measure the temperature in the atmosphere of the planet Venus, but we don't know what goes on in our soufflé. (N. K.)

– *By low temperature common people understand snow and frost. For physicists, however, it means something colder than the environment. And this is the essential point. Nobody is surprised if the oven is warm in the cold winter; it is easy to make water boil by fire. But anybody would be highly surprised if a glass of water left on the table would freeze to ice in the sunshine. We have to pay for air conditioning and refrigerating in the hot summer: for local cooling we have to produce more heat elsewhere. (Touch the back of the fridge!) This fact is expressed by the Second Law of Thermodynamics. If we see hot stars shining on the night sky, we can explain it. But if we found a place which were colder than the overall temperature of outer space (2.75 K or -270°C), we would consider it to be an indication of technology and intelligence.¹ – Well, in the 1970s the coldest spot of the Solar System was in the lab of Nicholas Kurti, a definite sign of superior intelligence! It was then the lowest temperature achieved, 10^{-6} K above absolute zero. This record had been registered in the Guinness Book of Records.*



Nicholas' father was the vice-director of the Pester Commercial Bank, he changed his name from Karfunkel to the Hungarian Kürti at the end of the 19th century. The father died when Nicholas was three years old, thus the education of the boy depended largely on his mother. His mother's uncle was József Pintér (former Binder from Abony, 1858–1928), who played an important role in laying the foundation of modern industry in Hungary. Pintér studied electric engineering in Darmstadt, worked in Berlin, Brussels, Geneva, London. In Budapest he became the technological director of a factory producing equipment for telecommunication (1883), and initiated the fabrication of incandescent lamps. Pintér was an active partici-

¹Nicholas Kurti, *Fizikai Szemle*, Budapest 1992

pant at the creation of the Tungram Company² hundred years ago (1896), became vice-director, later director of the company. Now there is a Pintér József Street in that Northern district of Budapest.

The young Nicholas was enrolled in the Minta Gymnasium; his schoolmate, EDWARD TELLER was one year older than Kurti, – *Edward was not overpopular, the students considered him to be a bit pushy.* – Nicholas enjoyed Greek and especially playing piano, five hours a day. His math teacher was *Ferenc Kármán*, fifteen years younger than his brother, THEODORE VON KÁRMÁN; Kurti liked his classes. But the physics teacher (Kornberger) was less exciting, a rather dry *lecturer*. Another teacher, however, Oliver Geduli paid attention to the young talents in the afternoons. – *Tomorrow we shall make distillation! Everyone should bring one liter of wine!* – Kurti's mother was suspicious, she offered a bottle of rather sour wine. The next afternoon Geduli distilled spirit from that bottle, the other bottles brought by students were consumed. Thus they all went home in a rather happy state. This was the only experiment he saw in the Minta Gymnasium.³

The boy was not interested in law, to become a medical doctor would take too long for the poor family, thus it was decided he would become an engineer. His contemporaries, NEUMANN, TELLER, WIGNER chose chemical engineering, before turning to mathematics and physics. When Nicholas became 16, his mother asked for the advice of Jacob Salpeter, an Austrian who was the production director of Tungram in the 1920s. Jacob Salpeter met Nicholas Kurti twice, and finally told Nicholas' mother: – *Oh no, there are too many chemical engineers. In the future chemistry will not be as important as it is today. Let the boy study applied physics!* – In 1924 it was a prophetic foresight to consider physics to be the science of future technology. This is how Nicholas decided to become a physicist. (Salpeter's son, Edwin Salpeter lived in Budapest as a teenager, later becoming professor at Cornell University, a member of the U.S. National Academy of Sciences, and the Royal Society. He collected fame by his studies of thermonuclear reactions in stars.)

The closing exam at the gymnasium included Hungarian grammar and literature, Greek, Latin, German, history, mathematics, and physics.

– *In the 1920s the political situation was not very pleasant. For the Jews there was a numerus clausus at the universities. I was a good student, probably I could be admitted to the University, but it was questionable*

²United Incandescent Lamp Co.

³Kurti to the author 1997

whether after university graduation I would get a good, interesting, and well-paid job in Hungary. My family – including myself – thought it would be a better idea to study abroad. According to Salpeter's suggestion I began studies at the Sorbonne. I also attended Marie Curie's lectures on radioactivity. She entered the lecture room in black dress, everyone stood up. Then she lectured for 40 minutes. In the next 20 minutes she repeated the content of the lecture, but now illustrated it with experiments.

– I admired Paris. I was not a transient tourist, I enjoyed the Parisian milieu. I loved the French people. But I never thought of settling in France.

Kurti had a letter of recommendation to Paul Langevin. He advised Kurti not only to attend lectures, but to take exams as well. Thus Nicholas obtained the first degree in general physics and mathematics. After the Paris years (1926–1928), Kurti followed the advice of MICHAEL POLÁNYI and went to Berlin (1928–1931).

– This time – I think – Berlin was the scientific center of the world. I regularly attended the Physics Colloquia Wednesday afternoons from 5 to 7. On von Laue's colloquia 8 or 10 Nobel laureates were sitting in the first row, in the second row other professors, then in the third row young talents like Wigner, Szilard, and Lanczos. There was a fantastic atmosphere. For the students speaking about (and criticizing) papers of prominent physicists in this journal club was a frightening and an inspiring experience at the same time. I reported articles on ferromagnetism. Once Fritz London spoke about the rotational spectra of triatomic molecules. Schrödinger interrupted him by saying: "You can make the calculation easier by making the simplifying assumption that the three atoms of the molecule lie in a plane!" There was frozen silence for a moment then a burst of laughter followed which included also Schrödinger himself.⁴

Kurti liked Pohl's sparkling experimental demonstrations but was more interested in Schrödinger's lecture about statistical mechanics. Schrödinger – an excellent lecturer – talked about how a paramagnetic salt would behave in high magnetic field at very low temperature. So Kurti went to Professor Franz Simon and said, – I am interested in low temperatures and magnetism. – Simon said: – Low temperatures are all

⁴Kurti said to the author: – During my practice year I met DENNIS GÁBOR at Siemens-Halske. He was engaged in studying the mitogenetic radiation. I found this as a beautiful example of smart industrial thinking: Siemens allowed studying a whole year something which did not have the slightest interest for the company! – See also the next chapter in this aspect.

right but I am not doing any work on magnetism. But wait a minute! Debye wrote an article two years ago, he thought that one could cool a paramagnetic salt to very low temperatures by adiabatic demagnetization. – The electron spins of the substance are ordered in high magnetic field. By turning the field off the spins become disordered and the associated magnetic entropy is so big that the corresponding entropy loss cools the crystal lattice near to absolute zero. Kurti asked: – *Can we experience this large magnetic heat capacity at low temperatures? There must be an anomaly in the specific heat of paramagnetic substances!* – Kurti decided to measure the specific heat of GdSO_4 at low temperatures. Gadolinium is a rare earth element, the Berlin laboratory had got 0.5 gram of this salt from Paris. Kurti found that the specific heat of this salt is three times as big as postulated at 4 K (boiling point of helium) and is hundred times larger at 1 K temperature. (These data made possible to predict what temperatures could be reached by magnetic cooling. Later the temperatures actually reached by electron demagnetizations agreed with 10 % accuracy with his prediction.) Thus Nicholas Kurti had become an experimental low temperature physicist. Kurti dedicated his Ph.D. thesis on “*Magnetic and Calorimetric Properties of GdSO_4* ” to the memory of Joseph Pintér (1933).⁵

– *In Berlin there was a fantastic atmosphere, not only in science but in arts as well. Marvelous theaters, concerts, operas. But I felt once again that this is not a country where I wished to settle. With my professor, Franz Simon, I went to Breslau/Wroclaw (1931–1933). But as the Nazis came to power, Professor Simon foresaw what was going to come and accepted the invitation to the Clarendon Laboratory at Oxford University. He arranged for me to join him as his assistant.*

– *I arrived at Oxford on 15 September 1933 late. The next morning was a lovely sunny September Sunday, dew glittered on the green Oxford lawns. A friend of mine took me around in Oxford to show the colleges. We walked half a day, there were few people on the streets but the birds were singing. Then I asked myself: “Why would I ever leave this country, this town?” I live in England since more than 50 years, and I have spent all these years in Oxford, in the very same laboratory.*⁶



⁵After the early death of Nicholas' father, József Pintér and the Pester Commercial Bank – which financed the Tungsram Company – supported the university studies of Nicholas Kurti.

⁶to the author 1992

Let us cool a piece of magnetized copper, in which all the nuclei (as tiny magnets) have been aligned parallel by an outside magnetic field. Let us switch the magnetic field off! The nuclear magnets – tiny arrows pointing in the same direction until now – may begin to rotate, randomly gaining their rotation energy from elsewhere, from the motion (vibration) of these nuclei, thus cooling the assembly.

– *Nuclear demagnetization was everybody's idea. E.g. a gas may be cooled by adiabatic expansion until interactions among molecules become more relevant than thermal motion; then the gas condenses to fluid. Among electron spins there is a magnetic interaction. This limits the temperature which can be reached by adiabatic demagnetization of the electrons. But nuclear magnetic moments are thousand times smaller than those of electrons, therefore the nuclear magnetic interactions are million times smaller, thus in principle it's possible to reach million times lower temperatures!*

– *Adiabatic nuclear cooling was the straight continuation of my previous experiments begun in Berlin. In paramagnetic salt the electron spins are coupled to the crystal lattice. Nuclear spins, however, are decoupled from the lattice. That made the difference. Nuclear cooling does not mean that the copper as such will be cold: its electrons don't notice the change, they remain "hot." It is like the party of soccer players after the Fradi–Arsenal game. The Hungarians have won. But the Englishmen don't understand Hungarian, few Hungarians speak English, the two teams cannot communicate. The Hungarians are happy and noisy, the Englishmen a bit sad and silent, for a while. But later – under the impact of some whisky – the differences level out. This happened with the nuclei and electrons in my experiment. I had to rush before the cold nuclei gained further heat from the electrons!*

– *But the experiment did not go as smoothly as expected. We knew that the ultracold state of the nuclear magnets lasted 0.01–0.02 seconds, and this had to be long enough to find out their temperature by measuring their nuclear susceptibility. But it never worked: the nuclear magnets never cooled to the expected low temperature!*

– *I remember, it was 6 June 1956 at 4 o'clock in the morning. After an unsuccessful experiment my graduate student asked: – "May I make a stupid suggestion? We are measuring the nuclear susceptibility by sending a current through the coil to produce a magnetic field of 0.01 Tesla. What happens if we reduce the current intensity?" – So we did and it worked! At first we did not understand why. We understood only later that at turning on the current the induction of the increasing magnetic field heated the conducting electrons up to a very high tem-*

perature. This high temperature was transferred to the nuclear magnets within a few hundredths of a second. This is why the nuclear spin system was very hot at turning the magnetic field off. Sometimes a successful experiment requires a "stupid idea"! Till now even 10^{-12} K has been reached. But to reach this temperature was technologically difficult. It took years before an other laboratory succeeded to repeat our experiment. – Nuclear refrigeration (cooling the whole substance by adiabatic nuclear demagnetization) is a different task. In this case one makes use of the coupling between nuclear spins and electron spins, and can cool the substance to 10^{-6} K.⁷

Nicholas is a practical and pragmatic man. He studies cold for understanding and for future use. In America corpses of some rich people have been preserved in deep freeze with the promise that with the progress of medicine they will be revived, to cure their terminal illness with 21st century drugs, but this is science fiction. Preservation of food by freezing is a reality. It may be – Kurti speculates – that during the coming decades of interstellar travel from star to star, the biological processes in the astronauts will be slowed down by cooling, as happens in Nature in the case of hibernating frogs.

Another hope is the large scale application of superconductor for long distance transmission of electric power. In order to reduce heat loss in the transmission lines, the magnets of the transformers may be made of superconductors, as it is already done in the case of the magnets of the largest particle accelerators. Superconducting computers may reduce the heat production, temperature, and noise within the machine.

Nicholas Kurti received the first Fritz London Award of the International Union for Pure and Applied Physics for his achievements in low temperature research. The story of his contribution to war efforts (diffusion separation of ^{235}U) has been told elsewhere in this book.



– Early in the morning on 5 December 1952 a dense fog covered London. This is not a very exceptional event because the London fog is a worldwide known specialty of the British capital, as the British Museum, Buckingham Palace, and Westminster Abbey are. This event was, however, made peculiar because it was associated with a strong temperature inversion: on the ground the air was cold, the upper layers were warm. This inversion blocked up-down convection. Harmful gases – such as SO_2 – furthermore soot released by household fire places, factories, and

⁷Kurti's lecture in Hungary, *Fizikai Szemle* 1992

coal power plants remained near the ground. This resulted in tragic consequences: on the week following the smog the number of deaths almost tripled compared to the cases of the previous year, meaning 4000 surplus deaths – Kurti told in Hungary.⁸ This talk reflected the interest of the Oxford professor during those decades, and his work as a member of the British Energy Panel.

– A few thousands sudden causalities were necessary to be able to overcome the traditional reliance on cheap coal heating, to force the Parliament to act. In four years the Clean Air Act was accepted by the representatives. Thanks to this law, the houses of London are no longer black and laundry bills have also decreased.

– A second similar shock was caused by the Oil Crisis in October 1973, as the outcome of a minor conflict in the Middle East, to make a roar from the previous soft signs of the global energy crisis: the supply of oil is limited, it can be used as a weapon in the hand of oil producers! This alarm affected the design, costs, and extent of using cars with internal combustion engines.

– An important conclusion of the Oil Crisis was that electric power and heat for households can be produced economically by co-generative plants. This makes possible the suppression of the 91 million tons of CO₂ released in England every year.

– What will come if the oil and gas reserves are exhausted in the coming decades? The dominant source of energy will be nuclear, perhaps with a small share of solar energy. But nuclear reactors are big structures. People, however, will insist on using cars. How to substitute petrol in cars? It's very probable that hydrogen will be used as fuel. A nuclear power plant can produce hydrogen simply by the electrolysis of water. The big plants can be placed on the sea coast, even in the sea, and the produced hydrogen can be conducted to the continent by pipelines. It is possible that in the future people will drive electric cars, using liquid hydrogen as fuel. It will not be burned in combustion engines, because the efficiency is low. It may be used in electric cells. The produced exhaust will be steam, and water is not a pollutant. A hydrogen economy may offer a solution to our present energy and pollution problems. But it's important that scientists and engineers should think and work on it. – An attractive dream of the professor, and a fine lesson for the new generation.



⁸at a conference on energy education in 1989

Kurti visited Hungary in 1934, and his home country had to wait for his next visit until 1964. When the political chill was turning into a milder era, he was asked by Hungarian television:⁹ – *Why were the Hungarian emigres able to make a fine career in the West?* – The professor answered:

– *This is a very interesting question. At first, there was a strong pre-selection: the family paid attention to send only those boys to study in the West who could be expected to gain from their studies abroad. But this alone would be not enough. Those who studied abroad, and did not have the option to return home, knew that they had to stand upon their own feet because in their new country they don't have roots to support them. Who had talent, had to use it abroad up to 100 %.*

Professor Kurti had used it: he is the member of the Royal Society and of the Academia Europea, now also that of the Hungarian Academy of Sciences. Kürti Miklós is not only an honorary member of the Eötvös Society but one of the most celebrated speakers and authors as well. We quoted mostly from his talks given in Hungary. His lectures (given in English) charmed British scientists, and his talks (given in Hungarian) enthused Hungarian physicists and Hungarian school children. They were always enriched by a human flavor.

– *Creating a new dish for a meal may contribute more to the happiness of people than the discovery of a new star* – or the discovery of a new particle, Kurti added when quoting Brillat de Savarin. Well, Kurti has made such a culinary discovery. His most celebrated lecture is *The Physicist in the Kitchen*.¹⁰ This illustrated not so much the content of physics but the spirit of physics, and that of the high technology. In his lecture demonstration he made “*Baked Alaska*” at first: a strange American delicacy, a piece of ice cream enveloped in pancake batter and quickly fried in hot oil. Its flavor is due to the surprising *temperature difference*: hot outside and cold inside. – *How to make an inverse experience?* – asked the Professor. He filled a cream puff with apricot jam, enriched with a bit of apricot brandy. Then he enveloped it with ice cream and put the whole structure into a freezer. At the lecture demonstration he took it out of the freezer and placed it into a microwave oven. In the vibrating electric field of the oven, the polar molecules of the jam vibrated along, absorbing energy from the electric field, and became hot. On the other hand, the molecules of the frozen ice cream were fixed, they were unable to respond to the vibrating electric field. The filled ice

⁹to Béla Kardos 1982

¹⁰given in the Royal Society (1969), and in the Eötvös Society (1985) as well

cream – named “*Frozen Florida*” by the Professor – was taken out of the microwave oven and served to the audience. They were puzzled: how was it that the filling of the cold ice cream was hot? The Professor explained with another demonstration: He took a prepared cup made of ice, filled it with liquid water, and placed it into the microwave oven. In the vibrating electric field the frozen water molecules were fixed and remained cold, but the movable molecules of the liquid water were shaken by the electric force, moved more and more intensively, thus the water started boiling in the ice container!

Kurti’s culinary wizardry offered further impressive demonstrations of the power of physics. To conserve meat and to enrich its taste, it is a usual custom to place it in a marinade for one day or two. Kurti used blue-colored marinade to show that the penetration depth is not more than 1 cm in 36 hours, not enough for a leg of lamb. He recommends the use of a hypodermic syringe to inject marinade (or meat tenderizer) for a faster effect and perfect efficiency. He used a vacuum pump to enlarge the whipped cream, and thermocouple to follow the thermal state of the soufflé in the oven. Is it a misuse of our selfish attraction to delicious meals? Not at all! The Royal Society started as a Dining Club (1696), and so did the Eötvös Society (1888). Kurti’s last book¹¹ is an encyclopedia of the culinary experiences and experiments of the members of the Royal Society, starting with Michael Faraday and closing with the present Nobel laureates. The Professor’s message is clear:

– *Science has always to be used for making life better and more interesting. Experiments in the kitchen are at least as exciting as those in the laboratory but the outcomes are much more delicious!*

¹¹Nicholas and Giana Kurti: *But the Crackling is Superb*, 1988

Gábor Dénes – Dennis Gabor

1900–1979

The future cannot be predicted, but futures may be invented. (D. G.)

Dennis Gabor disliked being called a physicist, he considered himself an engineer. He gave up this principle only on one occasion, when he accepted the Physics Nobel Prize in 1971.

Gabor's imprinting for becoming an inventor can be explained by the influence of his family. Bertalan Günsberg was born in Eger, in northeast Hungary, descendant of immigrants having arrived from Russia in the 18th century. His ancestors might have been from the Cerim (Kazar) tribe which took up the Jewish faith in the late Middle Age. Bertalan Günsberg married Adrienne Kálmán in 1899, and changed the family name to the Hungarian Gábor. Gábor Dénes was their oldest son.

The family had strong interests and talents in technology. The father became director of the Hungarian Coalmines Company (MÁK). He spoke of Thomas Alva Edison and read Jules Verne to his 6-year-old son. They together visited the Deutsches Museum of science in Munich. At home Dénes learned German, French, English. (Later in his life he added Italian as a fifth spoken tongue.) Dénes attended the Toldy Gymnasium in Budapest, was mostly ahead of his teacher in mathematics and physics, because his father was willing to buy any (scientific) book that Dénes asked for. The young boy was amazed about Abbe's theory of microscope resolution, among others. At home the 15-year-old boy had a separate laboratory room where he experimented with wireless transmission, X-rays, even radioactivity. The young man enjoyed jumping and excelled in playing tennis. He liked music, singing Hungarian songs and opera arias.

World War I passed by. At the end of the war, the family converted to Lutheranism, for reasons similar to that of the Wigners. Dénes was enrolled at the Budapest Institute of Technology (1918) to study machine engineering. At the end of the first academic year he won the Prize in Mechanics. But Hungarian internal politics convinced the young student that it would be better to follow the path of other contemporary Martians to the Berlin Institute of Technology (1921). As he

remembered, most of the topics taught were already known to him. He learned more at the Tuesday Physics Colloquia at the University of Berlin.

His most unforgettable experience was Einstein's seminar on Statistical Physics (1921–1922), initiated by Leo Szilard. In his autobiography Dennis Gabor wrote:

– *When at last I had my Diploma (1924) I asked my father for permission to live on his money for another two to three years more to get my Dr.-Eng., and he thanked me for it! This veneration of learning in the Jewish middle-class of Budapest is probably the main reason why there are so many Hungarians in science.*

The topic for his Doctoral Thesis was chosen by himself. Short electric transients were a serious problem in electric networks of high voltage. Gabor succeeded in recording them with a high speed oscillograph of appropriate design, enabling even internal photography. The thesis was printed both in German (1926) and in Hungarian (1928).

Gabor did not stick to electric engineering. There were claims that growing onions emitted a kind of radiation, inducing nearby onions to sprout. He investigated these rays with his brother André, who studied medicine. (The experiments – performed at the morgue of the Charité Hospital, in a room full of ugly smelling human specimens – indicated positive effects.) Years later Gabor wrote about their 1928 paper: – *To this day nobody knows what these experiments really mean.* – Now we know about the luminescence of living cells. In the medical technology laboratory of Siemens Gabor also became interested in the biological effects of ultraviolet light of the gas discharge and improved plasma lamps for Siemens.

Hitler gained power in Germany in 1933. A few weeks after that Gabor's contract at Siemens expired, and returned to Hungary. The director of the Tungstram Company, *Lipót Aschner* welcomed him, and Gabor tried to realize his idea of the plasma lamp. The light source worked, but remained impractical due to its short life time: about 100 hours. From this Budapest period Gabor's lasting achievement was his paper with a deep theoretical analysis of Langmuir plasma (1933).



The political prospects in Central Europe deteriorated rapidly; therefore DENNIS GABOR, together with other competent scientists of Tungstram, MICHAEL POLANYI and EGON OROWAN left for England (1934). (Later all the three became fellows of the Royal Society.) Many of those who stayed in Budapest were annihilated in the Holocaust. In spite of Bay's efforts, *George Dallos* (developer of the photo-multiplier), and *Imre*

Bródy¹ (developer of krypton-filled light bulbs) became victims. In the 1930s the tolerant pragmatism of England played the most important role in receiving and training Hungarian scientists, especially in experimental and applied research. That completely corresponded to Gabor's taste:

– *The theory of gas discharges has lagged behind invention in most cases and the best it could do was to help improve the devices invented by experimentalists.* – Gabor worked at the Thomson–Houston Company for 15 years. Within two years he married the daughter of an engineer of the company, made friends, lectured about science–technology–society, and went on working on plasma lamps. In a few years, however, World War II erupted. In order to prevent German air raids, most of the British scientists worked on radar development. But Gabor's name was put on the Register of Aliens with Special Qualifications. He was denied access to classified information and was not allowed to pass through security fences. Gabor worked mostly at home, e.g. on using Hamilton's analogy of mechanics and optics in order to improve electron optics, and wrote a book on the electron microscope (1944). He was a bit unhappy that in the 1920s he missed inventing the electron microscope. But he obtained about 100 patents of inventions through his life. Gabor was in contact with the liberal Association of Scientific Workers. Possibly under the influence of *Brave New World*, written by his friend Aldous Huxley, he designed *The Scientists' Hippocratic Oath*:

We scientists represent the greatest body of men and women schooled in thinking, in a field in which lies do not exist, and no amount of shouting will make a mathematical error right. We are accustomed to be critical of ourselves as we work under an unbribable critic, unmoved by any flow of eloquence. But this very fact is also our greatest weakness: we may be masters of all kinds of engineering and yet ignorant in regard to the engineering of human consent.

Finally the war was over. After the long chill, on a beautiful sunny Easter morning, on the tennis court in Rugby a mental flash illuminated Dennis' mind. "Effortlessly" he discovered, how to store a three dimensional picture of an object on a photographic plate. He invented and developed holography (1947–1951).

¹Imre Bródy, one of the most genial physicists was taken to Auschwitz, where he contracted typhoid fever. On the personal instructions of Mengele, he was sent to the gas chamber in August of 1944. As Dennis Gabor wrote: – *My murdered friend, Imre Bródy was not only a good, kind, and innocent man but intellectually outstanding. (Inventing the Future)*

In 1949 Gabor became a member of Imperial College of London University, and within ten years he was promoted to professor. His Inaugural Address was on "*Electronic Inventions and their Impact on Civilization.*"

He had to wait, however, until 1963, when the discovery of laser made wide coherent light beams available, and the importance of holography became evident. Then holography invaded not only optics; reconstruction of three dimensional shapes has been realized by radar, acoustic, seismic, and electron waves as well. The top secret Project Michigan of the U.S. Air Force developed the method of three dimensional aerial mapping with radar beams. Gabor dreamt of panoramic holography: looking at a large flat holographic picture should be like looking out through a window, seeing three dimensional houses and mountains. (By actual holography one can achieve only a few meters of depth.) Actual three dimensional holographic landscapes can be fabricated only as works of art. Holographic art and advertizing became fashionable; even Gabor's friend, Salvador Dali attempted to use holograms to create artistic three dimensional pictures. In his Nobel lecture (1971) Gabor said:

– I am one of the few lucky physicists who could see an idea of theirs grow into a sizeable chapter of physics. I am aware that this has been achieved by an army of young, talented and enthusiastic researchers and I want to express my heartfelt thanks to them.

Gabor regarded his research students as his most precious products. P.G. Kalman, his Hungarian student characterized the professor:

– He was a very kind man but a hard taskmaster. Demanding the utmost from himself, he simply could not see how others could do otherwise. Because he had an uncommon insight into the complexity of phenomena he could not see that lesser mortals found his example hard to follow. He would juggle with various would-be solutions, bending the rules as he went and straightening out the mathematics afterwards. Once, seeing that I had been taken aback by his method he burst out laughing: – "Do you really think anything was ever invented in an other way? First you have to know the answer, logic comes afterwards." – As Kalman consulted Gabor on the appropriate length of the thesis he was about to write, he received this answer: – Well Kalman, that depends. Fermi wrote his thesis on the back of a postcard but in your case I should make it a bit longer.

– The prime condition of the survival of industrial civilization is abundant energy – Gabor wrote. – Wind power and solar power we can dismiss summarily. Wind power may be ideal for a very sparse population in inclement climates, but it is quite inadequate for our already overpopulated world. Solar power appears to be a very attractive proposition until one looks at it economically. The sun radiates about one

kilowatt of power per square meter in tropical countries. If one could convert this with only 5 % efficiency, the Sahara alone could supply about forty times the electric power now consumed on the globe – but at a completely uneconomical price. Hydroelectric power is ideal in many respects. Unfortunately, the total potential water power of the globe is estimated as only half a million megawatt – about equal to the present electricity consumption and, therefore, clearly inadequate for future needs. Geothermal power has been exploited only where there are hot springs. Normally the temperature of the rocks reaches the boiling point of water only below 10 km. At present nuclear fission power, usually called atomic energy, uses only ^{235}U , and all known uranium reserves would be hardly sufficient to supply the world's electric power at the present rate for two hundred years. Breeder reactors would make the known uranium and thorium reserves equivalent to several times the recoverable coal reserves of the world. Our boldest hope at present is fusion power, a reaction of the type which is the source of solar energy. There is enough deuterium in the oceans to keep humanity, however extravagant, supplied with energy for many millions of years. – In 1961 Gabor made a longer visit to America in order to discuss plasma confinement for thermonuclear reactions, but without a firm conclusion.



In the last decades of his life, Gabor's imagination was captured by the new technological miracle: the television. *Peter Goldmark* (1906–1977) was his fellow-countryman and friend since the Berlin years, who invented the long-playing record and created the color television (1940), became later director of CBS (Columbia Broadcasting System).² Goldmark offered Gabor the position of CBS Staff Scientist for life in America (1965). Gabor was interested in flat TV tubes (like pictures hanging on the wall and serving as windows to the world), in three dimensional color broadcasting etc. CBS bought several patents from him, e.g. one on sonar holography. But he was not willing to leave Imperial College.

Dennis Gabor named his dog *Zsa Zsa (Gabor)* and, like his compatriots from Mars, was ready to save the Earth, performing this work instead of politicians. His lecture on "*Inventing Education for the Future*" at University of California in Los Angeles (1965) made a memorable impact in America.

– I am no longer afraid of retirement because I have acquired a new hobby: writing on social matters. Now that my future is mostly behind me, I am passionately interested in the future which I shall never see,

²father of Peter Goldmark, Jr, president of the Rockefeller Foundation

but I hope that my writings will contribute to a smooth passage into a very new epoch. – One year after retiring he participated in the foundation of the *Club of Rome* (1968) which intended to teach humankind the lesson of the finiteness of the Earth (*Limits to Growth*). Gabor's books *Inventing the Future* (1964), *Innovation* (1970), *The Mature Society* (1975), *Beyond the Age of Waste* (1978) indicate how active he was before the onset of his terminal illness. Dennis Gabor was not a historian or physicist but an inventor. His *Inventing the Future* was published in Dutch, English, French, German, Italian, Japanese, and Spanish.:

– The most urgent problems of the technology of today are no longer the satisfactions of primary needs, but the reparation of the damages wrought by the technology of yesterday. – He noted that different people, different cultures live on Earth. – *We are now living in one world with Russians, Chinese, Indians, and Africans, but we are not contemporaries. Millions are born every year who will never have a full meal in all their lives. In other parts of the world millions are living who will never enjoy a hearty meal for fear of putting on weight.* – *But do we really want a Chinese village to look like a Californian suburb?*

In his youth Gabor liked Jules Verne (as EDWARD TELLER and ARTHUR KOESTLER did), later read H.G. Wells, then Aldous Huxley: they all tried to invent optional futures. But he criticized heavily recent Western science fictions. He admired I. Yefremov, the Russian biologist turned sci-fi writer, whose books he was able to read in Hungarian translation. In his attempt to invent the future Gabor, too, superimposed engineering, computer technology, biology, sociology, and imagination:

– The great dilemma is that Homo Sapiens appears to have stepped too suddenly onto the biological scene. Paleontologists cannot allow more than two million years for this development from ape-like arboreal ancestors. This means about 100 000 generations. But according to J.B.S. Haldane it takes about 300 generations for a single successful gene to establish itself. Is this time enough to explain man's evolution by random mutations, of which the deleterious ones are eliminated and the beneficial ones stabilized by natural selection? When we have more precise information on the number of genes involved in man's evolution, on the frequency of random mutations, and on the survival value of beneficial mutations, it may be possible to play out the game of man's evolution on the giant electronic computers of the future – not once but many millions of times. We may then be able to assess the probability or improbability of man's survival.

In Sir George Thomson's essay volume on *The Foreseeable Future* Gabor wrote in 1954: – *For the first time in history we are faced with the possibility of a world in which only a minority need work to keep the great*

majority in idle luxury – a nightmare of a leisure world for which we are socially and psychologically unprepared. – Since then the unemployment of the unskilled labor force and the high taxation of entrepreneurs and inventors, under the excuse of social welfare, has become well known in Europe. – Education for leisure must start much earlier, and it would be called more properly education for happiness in a complex civilization. – Gabor considered overconsumption, advertising, bureaucracy, and armaments to be a weak defense reaction of society against the problems of leisure. – There is a snobbish prejudice that any handmade article is ipso facto superior to the cheap stuff turned out by machines. – Man dreamt on wings, technology gave him an easy chair which flies through the air. Man wanted to see things invisible and afar, he got commercial television and can peep into a studio. We complain that there is a lot of crime in the most industrialized countries, but the eyes of the people are glued to the television screens, and the number of murders on television exceeds that of the murders on the street by more than an order of magnitude. As ARTHUR KOESTLER observed, every new invention is a threat to democracy.³ Among uneducated people it raises psychological resistances by running counter to long established habits, and it is tempting to overcome this resistance by coercion rather than by re-education and persuasion. – Gabor's ultimate hope was still laid in science:⁴

– Science developed a logic of nature, the still mysterious art of forecasting by thought things and processes which have never existed. But the fusion of science and the humanistic tradition will become vital in the future when science will start to interfere with the fate of man as never before.

– We have the wonderful cathedral of science; but it is invisible to most people, even to many of our students, even to some of our professors. It may be more important in the future to make it visible to as many minds as possible than to build onto it. A civilization whose grandeur is appreciated only by a vanishingly small fraction of the population is not a very safe one.

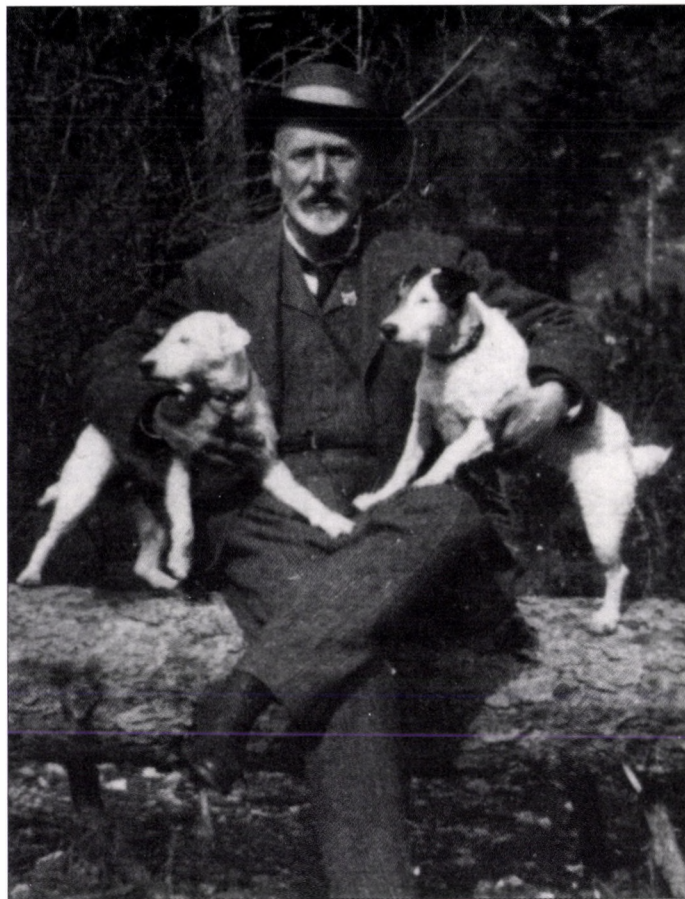
– At present science is one of the few remaining outlets for noble adventure. Young people can still choose their problems so long as they have direct access to the latest information. This may not be avoidable in large scale technological developments, but pure science must and can keep this free access.

³Arthur Koestler: *Darkness at Noon*, 1940

⁴Dennis Gabor: *Inventing the Future*, 1964



Roland Eötvös, the professor



Roland Eötvös, the landlord



Nobel laureate Philipp von Lenard



Nobel laureate John Polanyi



Nobel laureate Dennis Gabor



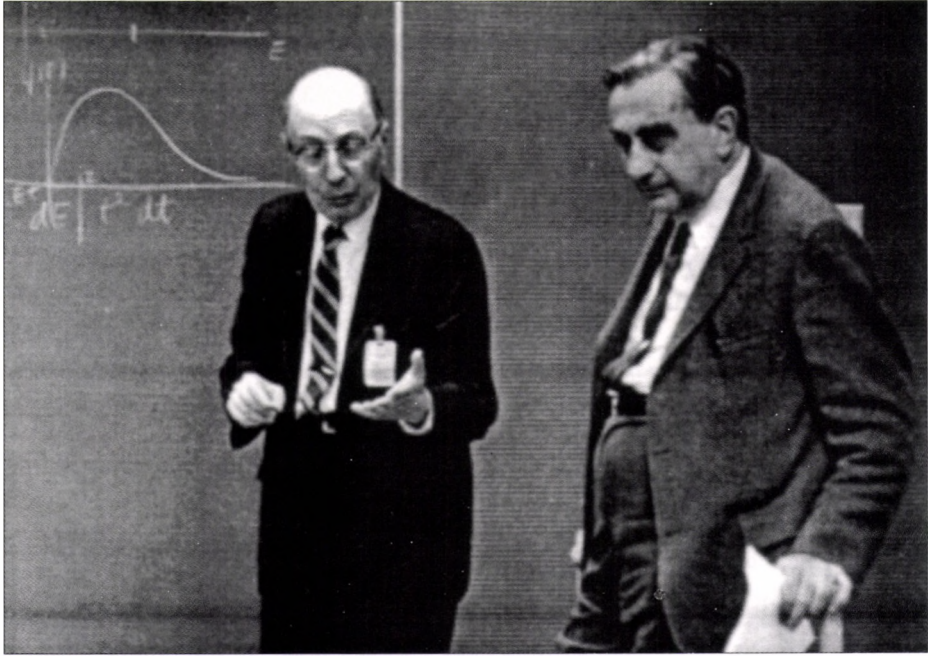
London Prize laureate Nicholas Kurti in the kitchen



Marcel Grossmann with Albert Einstein



Wolf Prize laureate Valentine Telegdi with Cornelius Lanczos



Eugene P. Wigner with Edward Teller



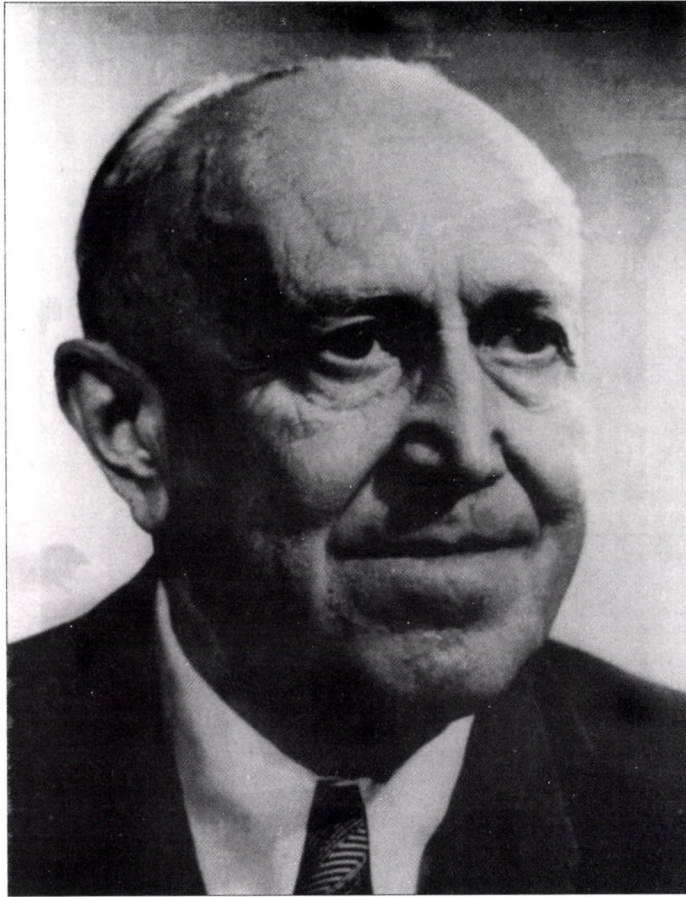
George Klein with the author



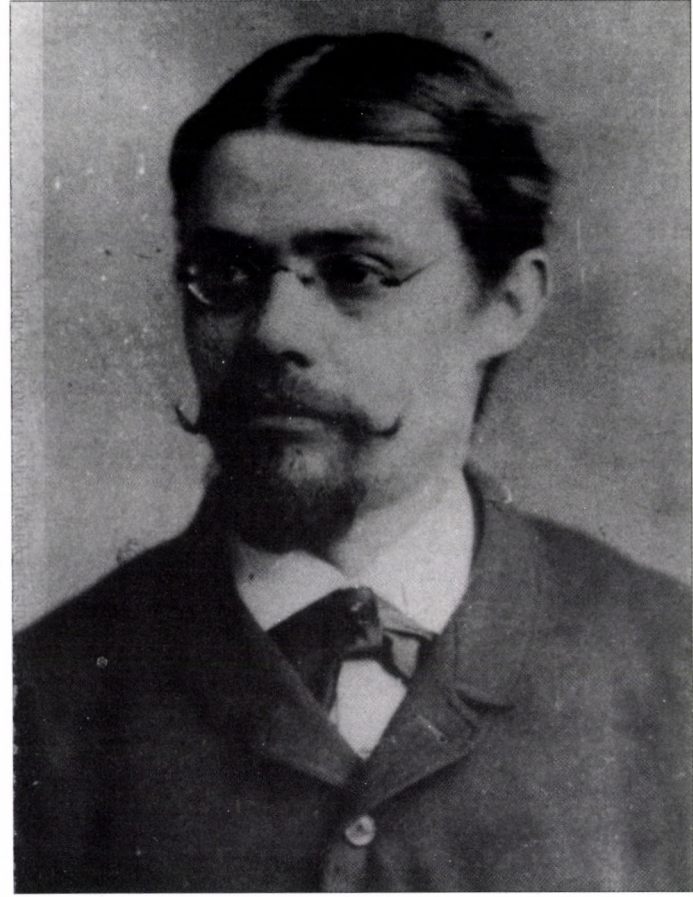
László Rátz, math teacher of Neumann and Wigner



Sándor Mikola, physics teacher of Eugene P. Wigner



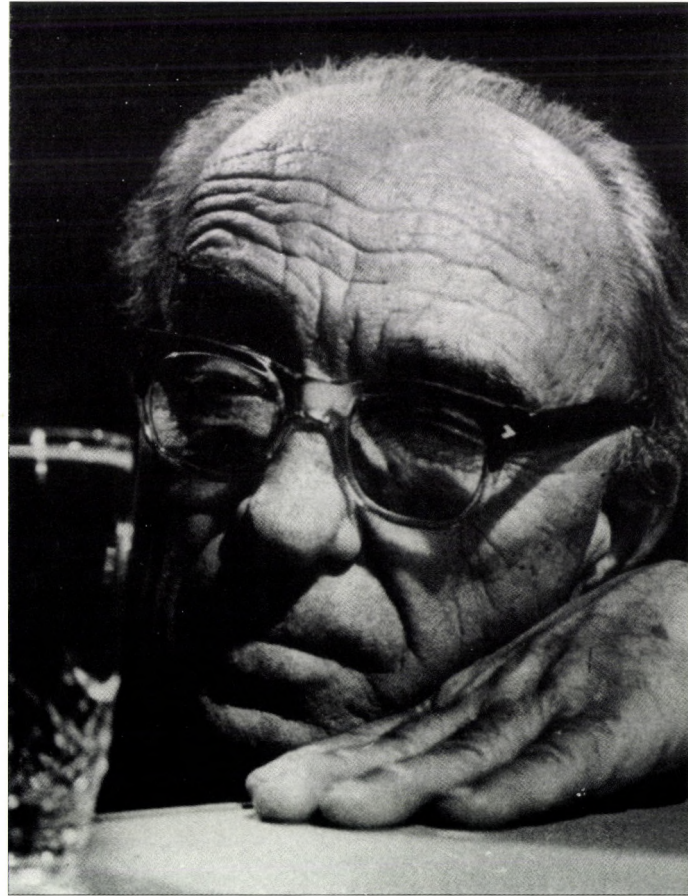
János Renner, physics teacher of John Harsanyi



Virgil Klatt, physics teacher of Philipp von Lenard



Ányos Jedlik, the monk professor



József Öveges, physics teacher of George Olah



A peculiar child from Budapest: Leo Szilard



George de Hevesy, later student of the Piarist Gymnasium in Budapest



Leo Szilard, student of the Kemény Zsigmond Gymnasium in Budapest



Edward Teller, student of the Minta Gymnasium in Budapest



Eugene P. Wigner, student of the Fasori Lutheran Gymnasium in Budapest



Theodore von Kármán, student of the Minta Gymnasium in Budapest



Michael Polanyi, student of the Minta Gymnasium in Budapest



Arthur Koestler, student of the Kemény Zsigmond Gymnasium in Budapest



Cornelius Lanczos, student of the Cistercians in Székesfehérvár



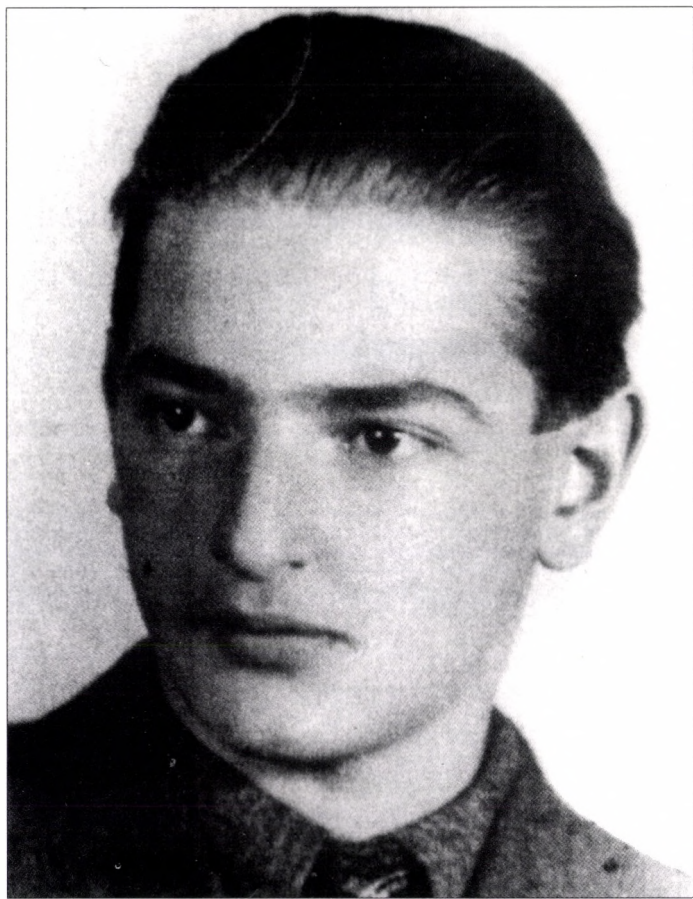
Zoltan Bay, student of the Calvinist Gymnasium in Debrecen



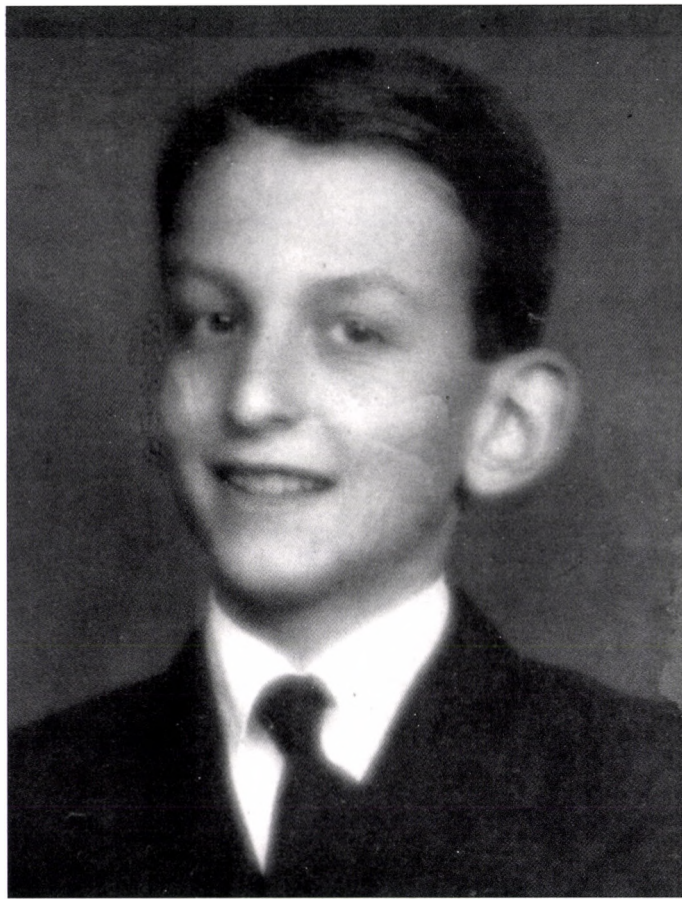
Theodore Herzl, student of the Fasori Lutheran Gymnasium in Budapest



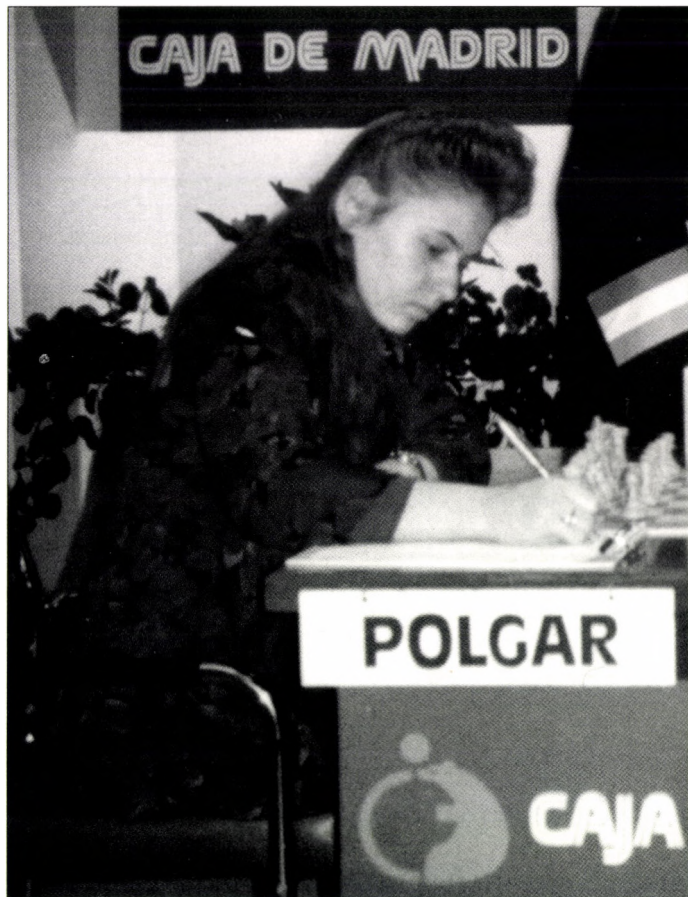
Edwin Salpeter, student in Budapest



John G. Kemeny, student of the Berzsényi Gymnasium in Budapest



George Olah, student of the Piarist Gymnasium in Budapest



Judith Polgar



Zsuzsa Polgar

Recalling Hungary

Provision for a Long Journey

Nearest to the genius is the child.
(Cornelius Lanczos)

What did the school, the *alma mater*, give to her sons, who left for a lifelong journey beyond the Ocean? Some of the great scientists of our century were born in Hungary, graduated mostly from Austrian and German universities, and made their greatest professional achievements overseas, in America or in England. Can they be claimed as parts of Hungarian culture in any sense? Let us read their authentic confessions and the report of their American biographers about the role that the Hungarian high school, the *gymnasium*, played in their life.

LEO SZILÁRD was born in Budapest (1898), attended the Kemény Zsigmond Realgymnasium. Leo told a story to his brother, Béla:

– Very often it is difficult to know where one's set of values comes from, but I have no difficulty in tracing mine to the children's tales which my mother used to tell me. My addiction to the truth is traceable to these tales. I remember one story, which made a deep impression on me, about my¹ grandfather. My grandfather was a high school student at the time of the Hungarian Revolution in 1848. In high school, when the children were waiting for the teacher to turn up, it was customary in Hungary for one child to keep watch. In the particular case of the story my mother told me, a revolution was on in Hungary. A troop of soldiers was marching by the school² and a number of children violated orders by leaving the classroom, lining the street and cheering the soldiers. My grandfather, who was supposed to keep watch on disorderly children, joined those who left the school building and cheered the soldiers. When the teacher turned up for class, all the children were back in the classroom and my grandfather rendered his report. He gave the teacher the list of those children who had violated orders and went out to the street, and this list included his own name. The teacher was so much taken aback by his frankness that no-

¹maternal

²in Debrecen, Hungary's second largest city

body was punished.³ – *The Realgymnasium in the 6th district of Budapest had the reputation of having the best experimental equipment in Hungary. The teachers were uncertain about the intellectual abilities of Leo Szilárd; in reply to his parents they said: – “He is a unique child.”*⁴ – Szilard won the Eötvös Student Competition.

PHILIPP VON LENARD was born in Pozsony (Hungary, 1862), in a town with a considerable German population (which is why the town also has the German name Pressburg); now it is the capital of Slovakia called Bratislava. He attended the Royal Hungarian Realgymnasium in Pozsony/Bratislava, the same school where the composer *Béla Bartók* studied. In his (unpublished) autobiography he wrote:⁵

– *At home we spoke German but in the school I learned in Hungarian. I cannot forget my teacher Mr. Print, who taught me Euclid’s consequent methods and strict mathematical proofs but excelled also in the education of character. At the age of 13 we learned chemistry from Mr. Lucich in a room which looked like a dreamland full of sparkling glass instruments. Lucich gave real experimental demonstrations in chemistry which offered the greatest pleasure for me, I saved in myself lifelong what I have learned there. In physics, Mr. Klatt has shown every phenomenon on instruments made by himself. My main desire became to assist my physics teacher whom I listened and watched with great pleasure. Before physics lessons I was waiting on the corridor connecting the physics cabinet with our classroom, looking for the opportunity to help in carrying demonstration instruments. Later I was allowed to come here also Sundays. From these weak beginnings a regular cooperation developed in the physics cabinet. Virgil Klatt’s work on producing luminescent stones interested me very much. I got an insight in his work which relied on Becquerel’s book “La Lumiere.” Klatt ordered one of the discharge tubes described by Crookes. But we did not want to restrict ourselves to commercial instruments. I learned glass technology. To produce appropriate vacuum in the tubes, Mr. Klatt and I worked after each other, pumping with our full power.*

When Virgil Klatt died, the *Grenzboten* printed Lenard’s letter about his physics teacher written from Heidelberg [facsimile]:

³William Lanouette: *Genius in the Shadow*, 1992, p. 5

⁴William Lanouette: *Genius in the Shadow*, 1992, p. 31

⁵Gabor Palló, *Fizikai Szemle*, Budapest 1997

Ein Brief aus Heidelberg

Nobelpreisträger Prof. Dr. Lenard über seinen Preshburger Lehrmeister weil. Virgil Klatt

Lenards Schreiben an den Grenzboten. — Das physikalische Schulkabinett in der alten Realschule.

Von einem weltberühmten Preshburger, unserem Landsmann, dem Nobelpreisträger Geheimrat Prof. Dr. Philipp Lenard in Heidelberg, erhalten wir eine hochinteressante Aufschrift, in welcher sich der einstige Schüler des kürzlich verstorbenen Realschulprofessors Virgil Klatt mit der Persönlichkeit seines Preshburger Pfortleiters beschäftigt und ihn, sowie sein ganzes wissenschaftliches Wirken und Streben charakterisiert. Eine „Erinnerung an Preshburgs verdienstvollen Förderer der Naturforschung“ betitelt Professor Dr. Lenard seinen Aufsatz, der wortwörtlich folgendes enthält:

„Aller große Fortschritt in der Naturerkenntnis kommt von der großen Freude an Naturbeobachtung, verbunden mit der steten Unermüdblichkeit des Arbeitens und Denkens dabei. In dieser Weise war mein einstiger Lehrer Virgil Klatt veranlagt, und so waltete er in seinem physikalischen Kabinett, stets neben dem Schulunterricht mit allerlei Naturbeobachtungen beschäftigt, die er durch eigenhändige Zurechtlegungen ermöglichte. Er war dabei ganz ohne literarischen Ehrgeiz, ohne das mindeste Streben mit irgend einer Ertrungenschaft etwa früher herauszukommen als Andere, und doch war er mit seiner Bearbeitung geheimnisvoller Dinge still, wie im Versteck, auf dem Wege zu Erkenntnissen, die später als große Ertrungenschaften erkannt und anerkannt wurden. Phosphore und Kathodenstrahlen waren seine Lieblingsgegenstände. Damals, vor 50 Jahren, wurde solche Beschäftigung in den eigentlichen Fachreisen der Physik für wenig angemessen erachtet; heute weiß man aus den Erfolgen, daß gerade diese Gegenstände die großen Fortschritte zur neuern Physik gebracht haben. Klein aus Liebhaberei, aus Freude an der Sache war Klatt damit beschäftigt. Nicht anders aber sah ich auch

Bunjen in Heidelberg arbeiten, der einst mit Kirchhoff die Spektralanalyse, die Entdeckungen neuer Elemente und die Ermöglichung der chemischen Analyse der Sonne und der Gestirne gebracht hatte. Aber nicht nur in der Art der Arbeit, sondern, wie schon gesagt, auch in der Wahl der Gegenstände war Virgil Klatt außerordentlich; was ihn interessierte war gar nicht so sehr hochwissenschaftlich; es war aber inhaltsreicher an Unbekanntem, daher wurde es auch zukunftswichtig. Wer jetzt von Elektronen redet, mit denen man die mächtigen Vetterwellen der großen Rundfunkender macht, ebenso auch die kleinen aufgefängenen Teile der Wellen verstärkt und zur Hörbarkeit bringt, oder wer die Fortschritte der Beleuchtungsmittel erwägt, der möge auch Klatt's Arbeiten mit den elektrischen Entladungen in verdünnten Gasen und mit den Leuchtsteinen oder Phosphoren denken. Ich weiß keinen Ort der Erde, wo man in so frühen Jahren mit gleichem Eifer bei den Arbeiten gewesen wäre, die nachher diese Erfolge ermöglichten, ja die noch immer weitere Wege zeigen, — keinen Ort außer William Crookes' Laboratorium in London und Virgil Klatt's physikalisches Schulkabinett in Preshburg.

Sch war glücklich, schon zu meiner Schulzeit an diesen Arbeiten teilnehmen zu können, wie ich auch den Genuß von Klatt's gediegenem physikalischen Schulunterricht zu den freundlichsten Glücksfällen meines Lebens rechne. Wir arbeiteten Sonntag vormittags und zu Ferienzeiten, und dies setzte sich auch über die Jahre meines Hochschulsstudiums und meiner späteren Assistententätigkeit fort und gab dann auch den Anfang eines Teiles meines eigenen wissen-

schaftlichen Lebensarbeit. Die Ergiebigkeit der gewählten Gegenstände war sehr groß; es lagen darin Entdeckungen verborgen, die wir garnicht alle selber machen konnten. Ich erinnere nur an die Namen Becquerel, Rutherford (Radioaktivität) und Röntgen als Fortsetzer. Dabei halfen wir uns sehr gut mit den einfachen Mitteln der Schulsammlung. Was fehlte, stellten wir selbst her, so wickelten wir auch einmal ein großes Induktorium mit 50 Kilometer Draht und 25 Zentimeter oder mehr Funkenlänge, das dann der Schulsammlung verblieb. Ein zweites Induktorium, das dabei nebenher auch noch gemacht wurde, diente mir später in Bonn, Heidelberg und Kiel zu all meinen Arbeiten über Kathodenstrahlen. Der alte, einst in Preshburg berühmte Zudehbäder A s s e g h i, damals schon im Ruhestand, half uns dabei — ebenfalls rein aus Passion. Die Anfertigung eines späteren, noch größeren Apparates geschah unter Mitwirkung des Herrn Stefan Hunkoics, derzeit Kriminalreferent der hies. Polizeidirektion, der damals Schüler der Anstalt war. Zwischen durch kamen bei Klatt auch Apparaturen an die Reihe, womit seine Lehrerkollegen ihn manchmal sehr überhäufeten. ☽☽☽

Verdeh wurde immer sehr wenig, wie das überhaupt Klatt's Eigenart war. Es war auch garnicht weiter nötig; zu uns redete die Natur, die wir durch unsere Versuche zur Äußerung brachten. So gingen Jahre dahin; vielleicht waren es Klatt's glücklichste Jahre in jenem alten Gebäude hinter der Jesuitenkirche und dem Rathaus, zwei Treppen hoch, in dem großen dreiflügeligen Zimmer, das damals das physikalische Kabinett der Realschule war.

P. Lenard.“

– Each great progress in understanding nature originates from the joy of observing nature and tireless thinking about it. This is the way how my teacher, Virgil Klatt taught not only in the classroom but in physics laboratory as well, offering us different observations and experiments, himself fabricating the required equipments. He did all these without any ambitions in writing publications, but in his hide-out he gained new knowledge about phenomena previously unknown which paved the way for great discoveries and achievements to come. Phosphors and cathode rays were the favorite objects of his research. At that time, fifty years ago these topics were not yet considered to be important but today we are well aware that these phenomena have brought the huge progress of physics. Klatt was interested in these phenomena only by curiosity and joy. Klatt was extraordinary not only in his way of working but also in selecting the objects of his interest. He was not interested in doing high science; he was attracted by the unknown and that made him future sensitive. When we speak today about electrons, used to create aether waves by huge radio transmitters, when we use electrons to amplify faint signals, when we apply them for illumination, we may think on Klatt's pioneering work with electric discharge in rarefied gas. I don't know any place on Earth where one worked in this field so early with the same insistence what enabled later the achievements mentioned above – with the exception of the laboratory of William Crookes in London and that of Virgil Klatt in Pressburg.

– I was fortunate to take part in this work already in my school years. I consider the pleasure of this work and the school instruction under Klatt to be the exceptional luck of my life. We worked Sunday mornings and during the holidays, our joint work continued during my university studies, when I was university assistant, even in a part of my research career. The chosen topics had turned out to be very fruitful; it contained a possibility of discoveries which I could not achieve alone. In these investigations we used the simple equipments available in the realgymnasium. If something was missing we produced it ourselves. We made e.g. a big spark inductor using 50 km long wire, producing 25 cm or even longer sparks, that remained in the lab collection of the school. We made also an other inductor what I used later on in Bonn, Heidelberg, and Kiel in all my work with cathode rays. The old retired pastry cook of Pressburg, named Kőszeghi, was at our help – also just for pleasure. The construction of an even larger installation was assisted by Mr. Stefan Hunkovics, criminal inspector at the local police – who earlier studied in the same school. We spoke very little, as it was usual at Klatt. There was no need of talking; nature spoke to us herself, whom we

asked with our experiments. In this way the years were rushing; it may be these were Klatt's happiest years in the old school building behind the church of the Jesuits and the town hall, in the large room with three windows, which was the physics lab of the realgymnasium at that time.

Lenard received the Nobel Prize "for his work on cathode rays". In 1904 (one year before obtaining the Nobel Prize) Lenard and Klatt⁶ submitted a joint paper to the Hungarian Academy of Sciences. Lenard wrote to the Academy:

*– Mr. Klatt was my physics teacher at the gymnasium in Pozsony and I owe him gratitude. In the past fifteen years we worked together on many occasions during my holidays in Pozsony; at other times we worked separately, proceeding each of us in our own ways. I ask with emphasis to have Mr. Klatt's name before mine as author of the book and I hope very much that my request will be met.⁷ – As a matter of fact, the request was not met. The Lenard–Klatt paper was published in Hungarian in the journal of the Hungarian Academy, and in German in the *Annalen der Physik* in the same year.*

CORNELIUS LANCZOS was born in Székesfehérvár, the ancient capital of Hungary (1883) and studied in the local Cistercian Gymnasium:

– In Hungary there was a selection process: not everybody had the opportunity to study in gymnasium. We considered it a privilege to take part in intellectual endeavors, and certain duties were connected with these privileges. We had to work hard. I obtained an education of a high level in the Cistercian Gymnasium. It was not the question what one learned but the attitude that accompanied the person throughout his life. We found it wonderful to be exposed to all those ideas which the human race created. This emotional aspect was especially important in the cognitive years spent in the secondary school, in the years of puberty. We had several subjects: science, arts, languages, humanistic subjects. This classical background (Latin, optionally Greek) was very pleasant and very good. Our humanistic education opened channels in very different directions, and we took advantage of that. My mathematics teacher was an excellent man in spite of the fact that he drank too much. Besides the compulsory classes he organized exercises. There he called somebody to the blackboard to explore e.g. calculus. Now we call this the exploratory technique. It was a good introduction to me which I

⁶the photo of Klatt is from the collection of Julius Radnai

⁷the letter in Hungarian is in the archives of the Hungarian Academy of Sciences

*appreciate very much. We had a club where the students could sit together. We were able to discuss our intellectual adventures. Some of us were interested in poetry, some in arts or science. By presenting essays we wrote, we came to a framework of mind where our brain recognized the importance of such debates. We succeeded in keeping a distance from dogmatic thinking, because we could see that one and the same issue had various aspects and we discussed those various aspects. We were used to that.*⁸

THEODORE VON KÁRMÁN was born in Budapest (1881), attended the Minta Gymnasium created by his father, Mór Kármán, won the Eötvös Student Competition, graduated from the Budapest Institute of Technology. In his autobiography⁹ he wrote:

– At the age of nine I gave up the joys of life at home with a tutor and enrolled as a student at the “Minta”, a school which my father founded. The Minta Gymnasium was a gem of my father’s educational theories. It was designed to be directed by a professor at the University but to maintain an independent status. It became the model for all Hungarian high schools and today is quite famous in Hungary, though little known in the West. Recently, however, its high standing over the years was noted by a writer for the London Observer, who called the Minta a “nursery for the elite”, and compared it with such schools as Eton for Conservative MPs and Le Rosey for ex-kings and socialites. The Minta graduated two of Britain’s top economists, Dr. Thomas Balogh of Balliol College (a son of one of my cousins) and Nicholas Kaldor of King’s College, Cambridge.¹⁰ For me the Minta was a great educational experience. My father was a great believer in teaching everything – Latin, math, history – by showing its connection with everyday living. In our beginning Latin class, for instance, I remember that we did not start with rules of grammar. Instead we were told to walk around the city and copy the Latin inscriptions on statues, churches, and museums. There were many of these to be found, since Latin was the official language in Hungary until 1848. When we had collected the phrases and brought them to class, the teacher asked us which words we already knew. We usually could recognize a few words among the phrases. If we didn’t we looked them

⁸interview taped at the University of Manchester in 1965

⁹Theodore von Kármán: *The Wind and Beyond*, 1967

¹⁰both became Lords

up. Then he asked us if we recognized the same word in different forms. Why were the forms different? Because they showed different relationships to other words in the inscription. We continued in this way until we understood each phrase and why it was placed on the monument. As a result of this practice, we all accumulated a Latin vocabulary which we retained, and we deduced some fundamental rules for inflection of the Latin word. We also learned something of Hungary's past.

– Mathematics, which I studied eagerly, was taught in terms of everyday statistics and it had a fascination for me all over again. For instance, we looked up the figures on the production of wheat in Hungary for several years. We set up tables and then drew graphs, so we could observe the changes and locate the maximum and the minimum wheat production. In the diagrams we searched for correlations, and we learned about “the rate of change,” which brought us to the edge of calculus. We thus learned in a practical way that there was a relationship between quantities that varied, and, as with Latin, we learned at the same time something of the changing social and economic forces in the country. – At no time did we memorize rules from a book. Instead we sought to develop them ourselves. I think this is a good system of education, for in my opinion how one learns the elements of reasoning in school will determine his later capacity for intellectual pursuits. In my case the Minta gave me a thorough grounding in inductive reasoning, that is, deriving general rules from specific examples – an approach that remained with me throughout my life.

– The Minta was the first school in Hungary to put an end to the stiff relationship between the teacher and the pupil which existed in the Empire at that time. In the corridors of the Minta the teachers moved constantly among the pupils. Contrary to the practice in other high schools, students could talk to the teachers outside of classes and could discuss matters not strictly concerning school. The charter of the Minta declared in writing for the first time in Hungary that a teacher might go so far as to shake hands with a pupil in the event of their meeting outside class.

– The Minta, like other Hungarian high schools, encouraged competition among students of the sciences. Each year the high schools, through a competition, awarded a national prize for excellence in mathematics and scientific reasoning. It was known as the Eötvös Prize, after Roland Eötvös, the son of Franz Joseph's great Minister of Education who had become a famous physicist at the University of Budapest, and was internationally known for his work on gravitation. Selected students were kept in a closed room and given a difficult mathematics problem, one which generally required university-level preparation and demanded

creative and even daring thinking. The interesting feature was that the teacher of the pupil who won the prize would gain great distinction, so the competition was quite keen and the teachers worked hard to prepare their best students. – I tried out for this prize with students of great attainments, and to my delight I managed to win. Now I note that more than half of all the famous expatriate Hungarian scientists, and almost all the well-known ones in the United States, such as Edward Teller, Leo Szilard, George Polya of Stanford have won this prize. Between Teller and me there is almost thirty years difference in age, so one sees the continuity started by this competition. I myself think that this kind of contest is vital to the American educational system and I would like to see more such contests encouraged here in the United States and in other countries.

EDWARD TELLER was born in Budapest (1908), attended the Minta Gymnasium, won Eötvös Competition in mathematics and physics. Blumberg and Owens write:

– Whether it was the educational system or a particular combination of circumstances during these painful years in Hungary, the flowering of talents from the gymnasia in Budapest is a fascinating field of speculation. An uncanny procession of brilliant men emerged from those troubled classrooms. Many of them made their way to the United States where they contributed mightily to American scientific advancement and especially to the development of nuclear physics and the release of nuclear energy. This collective brilliance has given rise to the romantic notion that all of these men were stimulated by the same exceptional teacher.¹¹ What all of them shared was the remarkably exhilarating intellectual climate of Budapest, even in the midst of a turbulent and discouraging era. Knowledge was pursued vigorously in the gymnasia, including the one founded by Moritz von Kármán, father of Theodore von Kármán. This gymnasium was called Minta, roughly translated as “Model” which is to say it was a demonstration school for the teachers.

– In the spring of 1918 Teller’s parents had to decide where he would go for his high school education. The decision of Edward’s parents was made after rejecting two other possibilities. The first was the school operated by the Catholic Piarist Order, but those who attended were expected to become Christians. The second possibility was the Lutheran Gymnasium which included Eugene Wigner and John von Neumann among

¹¹which is not true

its students. Finally the parents agreed that the Minta was a better choice for Edward. He went off to the gymnasium a trifle timid. He became an enthusiastic reader, with a particular passion for the vintage science fiction of Jules Verne. In the school he enjoyed everything except Latin. His particular problem, however, was mathematics, toward which, from the start, he was apathetic. Predictably, the cause of the apathy was not ignorance but boredom. He was far ahead of his classmates. Eventually, the school exempted him from the study of mathematics during his first year, but before this wise decision was rendered, there was considerable hardship for Edward. Some people think that the ultimate humiliation for a teacher is to be outshone by one of his pupils. That is precisely what happened to Dr. Karl Oberle, who was not only Edward's mathematics teacher but principal of the Minta.¹² Oberle had worked out an algebraic equation on the blackboard to his own satisfaction and presumably to the satisfaction of the forty-odd boys in the class. When he turned around, ten-aged Teller's hand was raised: "Is there something wrong, Teller?" he asked, sarcastically. Edward suggested there was a better way of doing it. "Then come up here and do it," said the irritated teacher. Edward did, and with more dispatch than his teacher. Oberle's response was to the point: "So you are a genius, Teller? Well, I don't like geniuses." – Edward was about fourteen when he acquired a book on Einstein's special and general theory of relativity. His physics teacher, however, took it away from him and said he wasn't ready for it yet. Edward, after plowing through these theories that many physicists could not understand, conceded the teacher was right. Later, after he had completed his course and passed the final exam, the teacher returned the book. "Now you are ready", he said, and once again he was right.

NICHOLAS KURTI was born in Budapest (1909), attended the Minta Gymnasium. In an interview he told the author:

– I was enrolled in the Minta Gymnasium in 1918. It was a very good school; the students felt themselves rather free there. The reason was that the teachers did not teach by lecturing but they did – with only one exception – by asking and answering questions. The Minta Gymnasium still exists. When I revisited it in 1976, at the 50th anniversary of our school leaving, it made a very good impression on me. They checked my records carefully: – "Kurti was an excellent student but twice he failed

¹²since the establishment of the right-wing regime in late 1919

in gymnastic!" – It was a refreshing happy visit. The good old educational methods which I enjoyed in my youth are still alive. I visited the class of Ms. Körner, the chemistry teacher. I was delighted by seeing that she conducted the class by questions and answers. This method distinguished the Minta Gymnasium, it was a very rewarding way of teaching. Recently I was invited to an other school by János Ujj, a physics teacher, to talk about low temperatures to the students, but before that I visited a physics lesson done again by questions and answers. It seems now to be a rather general approach in Hungary.¹³

PETER LAX was born in Budapest (1926), attended the Minta Gymnasium, performed well at student competitions. He told the author:

– The importance of the mathematics competitions is shown by the fact that in the 1950s George Polya and Gabor Szegő introduced similar competitions in California.

GEORGE OLAH was born in Budapest (1927), studied in the Gymnasium of the Piarist Fathers, a Roman catholic order, in Budapest.

– For a scientific career the most important is a solid foundation, because a scientist has to keep learning through his or her whole life, I am learning even today. I grew up between two World Wars and I was fortunate to receive a rather solid general education in Hungary. I attended a Gymnasium at one of the best schools in Budapest run by the Piarist Fathers, a Roman Catholic order. A strict and demanding curriculum heavily emphasizing the humanities included eight years of Latin, with German and French as other obligatory languages. My main interest was in history and literature. I was (and still am) an avid reader and believe that getting attached too early to a specific field frequently shortchanges a balanced broad education. Although reading the classics in Latin in school may be not as fulfilling as it would be at a more mature age, few scientists can afford the time for such a diversion later in life.¹⁴ – Then he told the author: – To be frank, I don't remember who taught me chemistry. From among my teachers I remember one: he was physics teacher. József Öveges made physics interesting. It was not a boring schoolbook subject, but we have seen a lot of experiments. I remember Mr. Öveges always with the greatest respect and love. Mr. Öveges made a very deep impression on me not only by his way of teaching

¹³interviews in the *Fizikai Szemle* 1975, to the author 1996

¹⁴autobiography for Nobel Fest

physics but with his humanity as well. At that time the teachers did not consider young pupils completely as fellow humans. Mr. Öveges, however, was able to create such a human contact with his students that was unique. I am highly indebted to him.

EUGENE P. WIGNER was born in Budapest (1902), attended the "Fasori" Lutheran Gymnasium. In the speech at the Nobel Banquet he said:

– I wish to say on this occasion a few words on a subject about which we think little when we are young but which we appreciate increasingly when we reflect on our intellectual development. I mean our indebtedness to our teachers. Man's knowledge has become mankind's knowledge because he has developed codes in which sound signals correspond to objects and actions and he can learn one of these codes early in life in some mysterious way. Hence, people can communicate their knowledge and teach each other. Much of what we know, and most of the science which we know, was taught to us in this way. This process may be called manifest teaching–learning. Much can be said about this, in fact much has been said about it, but this is not my concern this evening. What I wish to draw attention to is how much of our interest in science, and how much of our attitude toward science, we owe to our teachers. My own history begins in the gymnasium in Hungary where my mathematics teacher, Rätz, gave me books to read and evoked in me a sense for the beauty of his subject. I cannot mention all to whom I am indebted but I do wish to mention the inspiration received from Michael Polanyi. He taught me, among other things, that science begins when a body of phenomena is available which shows some coherence and regularities, that science consists in assimilating these regularities and in creating concepts which permit expressing these regularities in a natural way. He also taught me that it is this method of science rather than the concepts themselves (such as energy) which should be applied to other fields of learning. We have not only teachers who are older than we, we learn also from contemporaries and younger colleagues. The contemporary from whom I learned most – in fact immensely much – was von Neumann but that was mostly mathematics.¹⁵ – Later on, in his Recollections to Szanton (1992), Wigner added:

– In 1915 Budapest was filled with fine high schools. But in an alley called Fasor was located my Lutheran Gymnasium. It was likely the best high school in Hungary; it may have been the finest in the world. The

¹⁵Nobel Lectures 1980

virtue of a small gymnasium was that few teachers were needed and they could be chosen with great care. Our teachers were superb. Several of them did independent research, but most enjoyed teaching more than anything else. Our gymnasium teachers had a vital presence. To kindle interest and spread knowledge among the young – this was what they truly loved. They were preoccupied with teaching and they impressed us all not only with their array of facts but with the intense and loving attitude they held toward knowledge. Gymnasium teachers ate together. On Saturday afternoons they often met at a coffeehouse to discuss their work with university colleagues. I was invited to join a few of these meetings. In American high schools, such social mingling of students and teachers rarely seems to occur. Hungarian teachers watched their best students closely. So we learned a fantastic amount at the Lutheran Gymnasium. Six days a week we attended, and no one grumbled. We did not just memorize facts coldly, we put them into our heart.

– We had a small student circle at the gymnasium. It was voluntary, but nearly everyone joined. I gave a short lecture to this group on relativity theory. Afterward, our physics teacher, Sándor Mikola asked me bluntly why I believed in relativity theory. I described with some animation the implications of the Michelson–Morley experiments. Mikola did not like being reminded of that. But he accepted my enthusiasm with the comment: “Well, the grass is always greener in the next pasture.”

– There were many superb teachers at the Lutheran Gymnasium, but the greatest was my mathematics teacher, László Rátz. I still keep a photograph of Rátz in my workroom because he had every quality of a miraculous teacher. He loved teaching, knew the subject and how to kindle interest in it. He imparted the very deepest understanding. Rátz was known not only throughout our gymnasium but also among many of the teachers in the country schools. He edited a mathematical journal KÖMAL for secondary schools which came to be read all over the nation. He ran the journal for twenty years, often mailing it with his own money. – Rátz was the only teacher to invite me into his home. There were no private lessons. But Rátz lent me many well-chosen books, which I read thoroughly and made sure to return in good condition. Rátz also compiled for his students a book of “common-sense” mathematical problems. I solved a few of them, but most I found fantastically hard. (Often in the years since, when I have been in no mood for work, I have taken Rátz’s little book from the shelf and studied those “common-sense” problems.) – László Rátz took special interest to find his better students and to inspire them. Rátz felt so privileged to tutor a phenomenon like Neumann Jancsi that he refused any money for it. You

might say: "Well, von Neumann was one of the great mathematicians of our century. Of course he deserved private classes as a boy." But look at this from the teacher's point of view. He appears to be a genius. But, of course, he is not yet famous at all. His brain is not adult. He did not yet publish anything. He was just a startling ten-year-old boy, working next to twenty other bright ten-year-olds. How can you know that this precious ten-year-old will someday become a great mathematician? You really cannot. Yet somehow Rátz did this. And he did know it very quickly.¹⁶

JOHN VON NEUMANN was born in Budapest (1903), attended the "Fasori" Lutheran Gymnasium.

– In Europe, compared to the United States, there seems to be a difference of at least two years in specialized education, due perhaps to a more intensive schooling system during the gymnasium and college years. However, Johnny was exceptional even among the youthful prodigies. His original work began even in his student days. His first paper was composed while he was not yet eighteen.¹⁷

– Johnny entered the Lutheran Gymnasium in 1914, when the scholastic achievements of Budapest gymnasia were at their height. László Rátz was his math teacher, and Wigner's as well. Eugene P. Wigner was asked in the late 1970s (sixty years after leaving the Lutheran Gymnasium): "Do you remember Rátz?" Wigner answered: "There he is!" and pointed to a picture of Rátz on his office wall. Rátz's recognition of Johnny's mathematical talents were instant. He paid a visit to Max von Neumann. It would be nonsense, and perhaps sinful, to provide the boy with no more than conventional education in mathematics, than the Lutheran Gymnasium, and Rátz himself, could offer, excellent in his own terms as that might be. Rátz proposed instead to make it his responsibility to see that a great deal more was provided, if there was no parental objection. There was no educational price to be paid. Max was at once agreeable. Rátz turned his student over to the mathematicians at Budapest University, themselves men of no small renown. Professor Kürschák asked Gabriel Szegő, to give some university teaching to the lad. Before he finished high school, Johnny had been accepted by most of the university mathematicians as a colleague. Johnny's first published research paper was sent to publication when he was seventeen. – Rátz

¹⁶Andrew Szanton: *The Recollections of Eugene P. Wigner*, 1992; pp. 23–56

¹⁷Stanislav Ulam, *Neumann Memorial Volume*, 1958

contributed a lot to Johnny's career, in this time before it budded. It would not have been difficult for Johnny to have gone off the rails as a boy and as a young man. Many other infant prodigies among mathematicians have done so and are not always remembered with the affection that embraced Johnny in most of his doings. He needed somebody to guide him also into the real world. In 1914–21 Rätz did this.¹⁸

JOHN C. HARSÁNYI was born in Budapest (1925), studied in the "Fasori" Lutheran Gymnasium. In Nobel Autobiography he wrote:

– *The high school my parents chose for me was the Lutheran Gymnasium in Budapest, one of the best schools in Hungary, with such distinguished alumni as John von Neumann and Eugene Wigner. I was very happy in his school and received a superb education. In 1937, the year I graduated from it, I won the First Prize in Mathematics at the Hungary-wide annual competition for high school students.* – In Harsanyi's formal Nobel autobiography the list of awards begins with the First Prize in Mathematics at the National Student Competition, and ends with the Nobel Prize in Economics. He told the author (1995):

– *I was enrolled in the "Fasori" Lutheran Gymnasium. I was interested in the classical subjects and in mathematics as well. My first mathematics teacher was Mr. Faluba, a bit of a crazy man; later he left the school and became a Buddhist. He was followed by Mr. Csernák as my teacher in mathematics. He inspired me the most. In the 7th grade he gave us optional problems to be solved, and at least half of the class worked them out enthusiastically. Noticing my interest, he asked, why do I not solve the problems of KÖMAL? I solved them. In the meantime I discovered on my own, how to generalize powers to negative exponents, and what the value of the factorial of a negative number could be. When Mr. Csernák left the Gymnasium, János Renner became my teacher both in mathematics and physics. He was a good physicist, a student and former assistant to Roland Eötvös, who participated in Eötvös' pioneering gravitational experiments and field measurements. Finally I won the High School Mathematics Competition.*

– *The English school system is overspecialized. I know excellent economists, but I was surprised when it turned out, that they don't know what the liver or the kidney is for. The American medical doctors excel as well, but they read only special books of medicine. The Hungarian schools have been very good. When I attended the gymnasium, every-*

¹⁸Norman Macrae: *John von Neumann*, 1992

body had to learn Latin, Mathematics, Physics. The Latin grammar is a good logical introduction to foreign languages. (I became third at the National Student Competition in Greek.) I was fortunate for having attended gymnasium in Budapest.

LÁSZLÓ TISZA was born in Budapest (1907). While revisiting Budapest, he recalled:

– At age 14 I read a book about calculus. Seeing my interest in mathematics, my parents took me to the author, Professor Manó Beke, to test my abilities. He was encouraging. When I was between 15 and 17, in the Werbőczy Gymnasium¹⁹ my math teacher, Alajos Baumgartner invited me to his house week after week. The other math teacher, Viktor Makoldi followed my progress, when I was long over high school knowledge. Another teacher, Kálmán Magyar, showed me his papers published on philosophy. I also attended the lectures of a further teacher, Dr. Samu Szemere held on philosophy outside of the school; these influenced my later research considerably. I revisited him just recently. I read the student journal KÖMAL and sent in the solutions of problems regularly. Later on, when I studied at the University, the editor, Andor Faragó asked me to send new problems to the Journal. On the National Physics Competition I performed as second best. I won the Eötvös Competition in 1925, together with Edward Teller.

ALBERT SZENT-GYÖRGYI was born in Budapest (1893). About his school years in the Calvinist Gymnasium of Budapest, he said to his biographer, Ralph Moss:²⁰

– Religion was a powerful force at the turn of the century in Hungary, but it had little influence on the enlightened family. Albert Szent-Györgyi was baptized in the Calvinist church in Pest. At one point in his childhood, Albert himself became an ardent believer. This changed when he entered the gymnasium: “There was one teacher in high school who had much influence on me, who was very intellectual and awoke my interest. And this teacher was an atheist.”

ZOLTAN BAY was born in southeast Hungary (1901), he attended the Calvinist Gymnasium in Debrecen, and then the Budapest University. Francis S. Wagner wrote:

¹⁹now Petőfi Gymnasium

²⁰Ralph Moss: *The Free Radical*, 1987

– *The gymnasium of Gyula, the neighboring town, used to organize popular lectures in the small village.*²¹ *One Sunday afternoon the physics teacher demonstrated several physics experiments. He noticed that the little boy stood transfixed in the forefront of the crowd, wide-eyed and holding his breath while staring at the operation of the air pump and the Segner wheel. The physics teacher turned to him and asked the little boy to repeat the principles of operation for these instruments. Spellbound by the miracles he had seen, the little boy stood mute. At home his father who had witnessed everything dejectedly concluded to the family: “This boy will never amount to anything.”* – Later on Bay himself recollected at a visit to Debrecen (1988):

– *I think with gratitude of the eight years spent in the Calvinist Gymnasium of Debrecen. We were proudly aware of the fact that this school had operated for 450 years without interruption. My teacher, Marcel Szabó explained to us the motion of the Moon and planets, and gravity already in the 7th grade. – I noticed how much our gymnasium had followed the development of science when being in the 12th grade I found a folio edition of Newton’s “Principia” in the school library, on its first page with the inscription: “George Maróthy.” He bought the book in the 1700s, rather soon after its publication in 1687! I was tempted to translate it into Hungarian from the Latin. I began to do so, but then I noticed that it was a naive idea, because the content of the book was already widely known. – I have to add that our school was very liberal: discussions were encouraged even in religion classes. The teachers’ authority meant only that the students were not supposed to make malevolent jokes, but the teachers acknowledged without hesitation when the students were right. It was a Calvinist school which educated without the constraint of religious dogmas.*

JOHN G. KEMENY was born in Budapest (1926) and attended the Berzsényi Gymnasium. In an interview given to Lynn A. Steen²² he recollected:

– *Certainly, for mathematicians and theoretical physicists, the school system in Hungary was very good. Let me give you an example. I attended seven and half grades in Hungary. I had a mathematics teacher who would have been well qualified to teach at a good college. Mr. Bölcsbázy just did an enormous amount to strengthen my interest in mathematics. I had liked mathematics before that. But being inter-*

²¹already in the early 1900s

²²Albers-Alexanderson: *Mathematical People*, Boston 1978

ested and knowing something is very different. This teacher was better than any teacher I had in high school in the United States, really, significantly better. – There was a mathematical contest for high school seniors in Hungary which was a very big thing. It was a great honor, not just for yourself, but for the school. – There is another interesting story about that teacher. When in 1940 we left for the United States, my whole class came out to the train to see me off, and my math teacher did too. It was really nice. He said something that has stuck with me all the time. He said that he was terribly happy for me that I was leaving for the United States, because he was worried about the future of Hungary. On the other hand, he said, he had only one regret. He had never had a winner in the math competition. Look, for God's sake, I was four and a half years away from the exam, and he was already thinking that maybe I could make it to the top in the competition.

– Let me contrast my experiences this way. New York City had a competition when I was in school – it was the Pi Mu Epsilon Contest. We happened to hear about it purely by chance. We heard that at other schools people got help in practicing for this exam. In our high school of 5000 students we could not get one math teacher to help us with it. So two of us went and took the exam in our junior year²³ just to find out what was on it; then we worked the next year drilling each other. [In my senior year, in the 12th grade] I think I came in third. Considering that I didn't have any coaching, I thought that was pretty good. But it is incredible that in a school of 5000 students there wasn't a single teacher willing to help, let alone encourage you to take it. That sort of thing makes the real difference. The Hungarian competitions go way back, very far back. – Contests are not everything. They are just symptoms of the status of mathematics teaching. I happened to be good at that. – I think that a system that encourages problem solving is in effect showing that mathematics is important.

M.J. Antal comments:²⁴ *– In the last decades the role of competitions has been acknowledged in the U.S., e.g. by the state of New Jersey. This has been verified by the good performance of the United States at the latest International Student Olympiads. – Indeed, the Bronx High School of Science in New York educated about as many Nobel laureates as Hungary.*

²³11th grade

²⁴to the author 1996

GABRIEL SZEGŐ won the Eötvös Competition in mathematics (1912), completed his studies in Budapest. For the centenary issue of KÖMAL (1994) he said:

– *For the success of a student competition one has to arouse public interest. In Hungary, this was achieved by the student journal KÖMAL. I remember vividly the time when I participated in the problem solving competition of this journal (1908–1912). I would wait eagerly for the arrival of the monthly issue. My first concern was to look at the problems section, almost breathlessly, and to start grappling with the problems without delay. The names of the others who were in the same business were quickly known to me, and frequently I read with considerable envy how they had succeeded with some problems which I could not handle with complete success, or how they had found a better solution (that is, a simpler, more elegant, or wittier one) than the one I had sent in.*

FERENC MEZEI was born (1942) and studied in Budapest. He received the Hewlett-Packard Prize, the highest award of the European Physical Society.

– *When I was enrolled in the Rákóczi Gymnasium,²⁵ at the suggestions of my enthusiastic teachers I ordered the student journal KÖMAL from the pocket of my parents, but I put them aside without reading. But during the summer holiday, on rainy days I began to solve the problems in the Journal. After one month I counted my score. It turned out that I would have won the school-year-long problem solving competition, if I had mailed the solutions back to the Journal. Thus in the next school year²⁶ I mailed the solutions regularly to the Journal. For this reason I missed one day from school each month. My summer exercise was certainly helpful: I won the problem-solving competition far ahead of other students! So I had been seduced. I had only to decide: should I become a mathematician or a physicist? Finally the hard facts and unexpected traps of measurements attracted me to experimental physics. Nature treats benevolently those who keep questioning her respectfully and lets them occasionally explore one or two of her secrets.²⁷* – Ferenc Mezei won the National Mathematics Competition (1959). He came in top at the Kürschák Mathematics Competition of the Bolyai Mathematical Society and second-best at the Eötvös Physics

²⁵9th grade

²⁶grade 10

²⁷KÖMAL centenary issue 1994

Competition of the Eötvös Physical Society (1960). He received a gold medal at the International Mathematics Olympiad (1960).

PAUL ERDŐS was born in Budapest (1913), studied in the St. Stephan Gymnasium, repeatedly won the KÖMAL problem solving competition but succeeded less at the Eötvös Competition.

*– Erdős' parents were math teachers and good friends of Andor Fara-gó, the editor of our KÖMAL. No wonder that Paul regularly solved the problems given in the Journal regularly. Professor Erdős sent problems for the Journal. The World Federation of National Mathematics Competitions (created in Australia in 1984) founded an Erdős Prize for those, who excelled in the organization of mathematics student competitions. The Erdős Prize emphasizes the relevance of such competitions for education and for mathematics itself.*²⁸

VALENTINE TELEGDI was born in Budapest (1922) and attended schools abroad. He received the Wolf Prize for his physics experiments. At the Assembly of the Eötvös Physical Society he concluded in his specific style (with a bit of exaggeration):²⁹

– In the everyday practice of education we have to strive for truth. The knowledge obtained by the students is proportional to the knowledge of the teacher, and it's proportional to his intention of transferring it as well. The longest-lasting impact of Eötvös upon Hungary was not at the university but in schools. He did everything for the goal set by him: that teachers should understand physics. When Hungarian scientists abroad think with gratitude at the Hungarian gymnasia and teachers, then the praise is right. This is the real heritage of Eötvös. – In the U.S. there is no real high school. Until the age of eighteen they learn very little; the main goal of schooling is "social adjustment." It may be that the abundance of excellent Hungarian scientists is not remarkable at all. We may be surprised that there are good American physicists as well.

ROLAND EÖTVÖS was born in Budapest (1849); he graduated from the Gymnasium of the Piarist Fathers, in Budapest. When he was Minister of Education for half a year (1894), the Eötvös Competition was established. He created the Eötvös Society (1891), where professors of mathematics and physics shared the benches with teachers. He launched the

²⁸Centenary issue of the KÖMAL 1994

²⁹1989

student journal KÖMAL (1894). The first in-service-teacher training course was organized by the Society (1895), now a yearly event. At the foundation of the Society, Eötvös proclaimed:

– If we succeed in realizing the goal that everyone who teaches physics and mathematics in the country is a real physicist and mathematician, then we do a great service not only to the school, but to Hungarian science as well. We need teachers who are scientists. If our Society fulfills the duty of self-education in a devoted and serious way, it will have the result that prominent researchers and propagators of science will emerge from Hungary.

How he succeeded in achieving this goal is very recently described by the Nobel laureate Leon Lederman, past director of Fermilab, an unbiased American witness:

– Baron Eötvös's research on the high precision proportionality of inertia and gravity was his most noteworthy scientific work but by no means his major contribution to science. More important, Eötvös became interested in science education and in the training of high school teachers, a subject near and dear to me. Historians have noted how Baron Eötvös's educational efforts led to an explosion of genius – such luminaries as the physicists Edward Teller, Eugene Wigner, Leo Szilard, and the mathematician John von Neumann all came out of Budapest during the Eötvös era. The production of Hungarian scientists and mathematicians in the early 20th century was so prolific that many otherwise calm observers believe Budapest was settled by Martians in a plan to infiltrate and take over the planet.³⁰

Let us conclude with the words of GEORGE OLAH:³¹

– In the approaching 21st century – which is not so far away – the future of a nation will depend on the fact, how much can it offer in the education of its youth. Education is the best investment for the future, because we are entering a very competitive era. One has to learn not only to read but to use computers. The science is an international undertaking, one country cannot develop it alone. But in a country which is not especially rich in natural treasures, the greatest treasure is the human. Hungarians are good and innovative workers, this is why I do believe in the future of Hungary.

³⁰Leon Lederman: *The God Particle*, Boston 1993

³¹on Hungarian Television 1997

Where did the Martians come from?
(A quarter of Budapest, east of the Danube)



- | | |
|--|---|
| <p>1 Dennis Gabor, Rippl-Rónai utca 25.
7 Toldy Gimnasium</p> | <p>6 Arthur Koestler, Szív utca 16.
2 Kemény Zsigmond Realgymnasium</p> |
| <p>2 Andrew Grove, Király utca 73.
4 Madách Gimnasium</p> | <p>7 John von Neumann, Bajcsy-Zsilinszky út 62.
3 Fasori Lutheran Gimnasium</p> |
| <p>3 George de Hevesy, Akadémia utca 3.
6 Gimnasium of the Piarist fathers</p> | <p>8 Leo Szilard, Városligeti fasor 33.
2 Kemény Zsigmond Realgymnasium</p> |
| <p>4 Theodore von Kármán, Szentkirályi utca 22.
5 Minta Gimnasium</p> | <p>9 Edward Teller, Szalay utca 3.
5 Minta Gimnasium</p> |
| <p>5 John Kemeny, Bajcsy-Zsilinszky út 36.
1 Berzsényi Gimnasium</p> | <p>10 Eugene P. Wigner, Király utca 76.
3 Fasori Lutheran Gimnasium</p> |

The Hungarian Gymnasium

You must excel just to keep abreast!
(Max Teller to his son Edward)

When Adalbert the Saint was on his way from Prague to Rome, at the request of Géza, chief of Hungarians, Adalbert stopped on Hungarian soil and founded the first *Benedictine monastery and school* in 996, thousand years ago. Starting from this point the thousand-year long development of Hungarian schools has been uninterrupted, leading to the Benedictine monk professor *Ányos Jedlik*, then further on to the 20th century, to the heroes of our story. Throughout the troubled centuries of Hungary, the autonomy of schools and the quality of teacher training at universities have always played a decisive role in preserving the cultural heritage and cultural level of the nation.

According to a myth all Martians graduated from the same gymnasium as students of the same teacher¹ but it is not true. It is almost true.

In earlier centuries the churches raised Hungarian schools to a high level. Besides the Benedictines, *the Roman Catholic School of the Piarist Order* in Budapest deserves mentioning, where the physicist ROLAND EÖTVÖS, the Nobel laureate chemists GEORGE DE HEVESY and GEORGE OLAH studied, among others. The quality of the Piarist School was due to their legendary teachers. *József Öveges*, the teacher of George Olah, introduced nuclear experimentation with scintillator detector and Geiger tube for students already in the early 1940s. His simple but shocking experiments presented on television made him a favorite of the whole nation. He received the Prometheus Prize of the Eötvös Society for spreading scientific thinking among people. An other school teacher, *Mihály Kovács* built computers with his students in the 1960s, making him to one of the first propagators of the computer era in Hungary. (Personal computers were distributed to each Hungarian secondary school free of charge in 1983. Since then thousands of students leave secondary school year by year with BASIC programming knowledge. Geiger counters for scanning radioactivity in the

¹Stanley A. Blumberg – Gwin Owens: *Energy and Conflict*, 1976
Leon Lederman: *The God Particle*, 1993

environment have become everyday school equipment. Mr. Öveges and Mr. Kovács might be happy to see these developments.)

Calvinist schools as well have four to five century-old traditions; ZOLTÁN BAY attended the Calvinist School in Debrecen, ALBERT SZENT-GYÖRGYI did in Budapest. But most legendary is the "Fasori" *Lutheran Gymnasium* in Budapest, its fame having been propagated by its Nobel laureate alumni, EUGENE P. WIGNER and JOHN C. HARSANYI, furthermore JOHN VON NEUMANN. *Theodore Herzl*, founder of Zionism, also graduated from this school.² As the biographer of Neumann, Norman Macrae (former editor of *The Economist*) put it:

– *The early twentieth-century Hungarian education system was the most brilliant the world has seen until its close imitator in post-1945 Japan. The usage of the word "gymnasium" was borrowed by most of German-speaking Europe, and by any country that looked to Germany for educational leadership. France called its version a "lycée," and Britain called its version "grammar school." The modern Japanese – who adapted an extreme, and extremely successful, version of the gymnasium system – call their schools "high school," as if they were just like open-to-all American high schools, which they are not. The advantage of the gymnasium system is that, in the best gymnasia, students can be pressed toward the limits of their capacities. They are exposed to an intellectual rigor that is not usually reached in more democratic countries' high schools. In particular, the gymnasium system gives dignity to those who provide instruction in top secondary schools. A scholar or scientist who knows that his talents lie in pedagogy rather than in research does not feel he is falling back if he spends his whole life teaching in such a school. A fine teacher retiring at the age of sixty e.g. from the Minta Gymnasium in Budapest or from Winchester College in England would find many of the most famous men in Hungary and Britain in his debt because they had passed through his or her hands. Enthusiasts say that the most democratically successful of these gymnasium systems in history has been the one in the post-1945 Japan. The most elitely successful of these gymnasium systems in history was arguably that of little Hungary from about 1890 to nearly the 1930s. The average Japanese 18-years-old is today more advanced in math than all except the top 1 % of American 18-year-olds. The same would have been true of gymnasium pupils in Budapest in 1914. Japan grades competition in excellence between schools by university entrance results. Hun-*

²Herzl attended the Eötvös Realgymnasium (downtown Pest), but graduated from the "Fasori" Gymnasium.

garian schools entered their brightest 18-year-olds each year for the Eötvös Competition in mathematics and in physics.

Eugene P. Wigner quoted the merits of the legendary teachers of the Lutheran Gymnasium: *László Rátz* in mathematics and *Sándor Mikola* in physics. One cannot find a Neumann Street or Wigner Street in Budapest, but there is a *Rátz László Street*. Today, the János Bolyai Mathematical Society distributes the Rátz Prize for the best mathematics teachers, the Roland Eötvös Physical Society gives the Mikola Prize for the best physics teachers of the country every year. These prizes – decided by the teachers' nationwide community – have a respect higher than any official acknowledgement. Sándor Mikola was elected a member of the Hungarian Academy of Sciences for his research in materials science. Later on, further teachers of the Lutheran Gymnasium excelled: *János Renner* (the teacher of John C. Harsanyi) was a student of Roland Eötvös; he improved Eötvös' experiment on the proportionality of mass and gravity and received the first Eötvös Medal of the Society. An other teacher, *Miklós Vermes* conducted research on electronics already in the 1940s. Vermes Medal is awarded now for special excellence in experimental education.

At the arrival of the industrial revolution, *József Eötvös*, the minister of culture decided to introduce secular schools with an enlightened spirit. He asked *Mór Kármán* to do the job, who then created a Model: *the Minta Gymnasium* in Budapest, made famous by its students like THEODORE KÁRMÁN, NICHOLAS KURTI, EDWARD TELLER (in physics), MICHAEL POLANYI (in chemistry), THOMAS BALOGH, NICHOLAS KALDOR (in economics), and PETER LAX (in mathematics). The pedagogical achievement of Mór Kármán were not left unnoticed: he was ennobled by the emperoring Franz Josef in 1889. (To excel as school teacher is in not an everyday way of becoming a nobleman.)

There are other secular schools without any privilege, excelling through the efforts of their teachers. *The Berzsényi Gymnasium* gave the world JOHN G. KEMENY, GEORGE KLEIN, GEORGE SOROS, in addition to politicians like *Count Mihály Károlyi* (president of the democratic republic in 1918), *Tom Lantos* (senator of California in the United States), and a long sequence of recent winners of student olympiads.

One of the characteristics of these schools and their physics teachers was that they were open to the stormy development of science. *Virgil Klatt* (teacher of Lenard), *Sándor Mikola* (teacher of Neumann and Wigner), *Miklós Vermes* (from the Lutheran Gymnasium), *Karl F. Novobátzky* (regular speaker of the Ortvy Colloquium), recently *Esther Tóth* (past secretary of the Group for International Research in the Education of Physics) published research papers in avant garde international physics journals. *Irene-*

us Károly (teacher at the Premonstratensian Gymnasium in Nagyvárad) demonstrated the wireless telegraph through a distance of 10 km in the same year that Marconi invented the radio (1895); he established an X-ray laboratory within a year after Röntgen's discovery (1896). On 15 February 1896 pupils demonstrated X-rays with their own equipment in the Catholic Gymnasium of Kolozsvár/Cluj-Napoca, three months after the discovery (1896). Even recently, electron diffraction tubes, cloud chambers, Geiger counters, computer-interfaced experiments are rather common in schools. *József Öveges* wrote a book for teenagers on ionizing radiation, *Miklós Vermes* on relativity, *Mihály Kovács* on computers already around 1960. Hungarian gymnasiums measured the Chernobyl fallout in 1986. Hungarian physics teachers visited Three Mile Island and Chernobyl power plants (to obtain first hand information by performing their own measurements after the nuclear accidents). When Hungary became a member, physics teachers and competition-winning gymnasium students visited the laboratories of CERN. High temperature superconductivity was demonstrated nationwide a few months after the discovery; thus students could explain the experienced phenomenon to their parents when the Nobel Prize for it was announced. Doctor degrees are not uncommon among Hungarian teachers. Since John von Neumann to our times it occurred that gymnasium students publish research papers in reputed physics journals.

The driving force behind the activity of teachers is the Eötvös Society. One of the vice-presidents is regularly a school teacher. The first vice-president was *József Szigártó* (teacher of Teller), followed by *Ireneus Károly* (initiator of physics competitions), *Sándor Mikola* (teacher of Wigner), etc. The most respected teachers like *Árpád Csekő*, *Mihály Kovács*, *Rudolf Kunfalvi*, *Miklós Vermes*, were elected even to honorary presidents. Teachers may feel themselves at home in the Eötvös Society.

Prof. *Roland Eötvös* organized the first in-service-teacher-training seminar in 1895. The physics teachers' meetings have operated for hundred years, attended by hundreds of school teachers every year. The program of the meetings is decided by the teachers themselves, selecting the speakers from among prominent professors and the best school teachers. Prof. *Rudolf Ortway* organized teacher training on quantum mechanics already in 1930, distributing to them even his booklet on the subject.³

³The exam question for the author at his gymnasium graduation was the probability interpretation of electron waves, included in Renner's schoolbook. During afternoon meetings in the early 1940s *Mihály Kelemen*, our school teacher introduced us to special relativity, and spoke enthusiastically about Dirac's introduction of quantum theory.

About one hundred years ago a mathematics teacher, *Dániel Arany*, got the idea to create a problem solving journal for secondary school students (1894). This student journal was second only to *Vuibert's Journal de mathématiques élémentaires* (1876). The *Középiskolai Matematikai és Fizikai Lapok* (KÖMAL) celebrated its centenary in 1994. The journal operated regularly 1893–1914, 1925–1939, and from 1947 till today. Its problem solvers included PAUL ERDŐS, JOHN HARSANYI, FERENC MEZEI, LÁSZLÓ TISZA, furthermore *George Polya*, *Gabriel Szegő*, just to name a few. To have one's name on the list of the successful problem solvers has always been a source of pride for the school as well. The journal is published monthly by the Eötvös Society in 8000 copies.

Perhaps the highest reputation has been reached by the *Eötvös Competition*, initiated also in 1894, and continuing since then for secondary school graduates by the Eötvös Society. One source of its reputation is that its present winners find forerunners like THEODORE VON KÁRMÁN, LEO SZILÁRD, EDWARD TELLER, as well as *Lipót Fejér*, *Marcel Riesz*, *Gabriel Szegő*, and LÁSZLÓ TISZA, JOHN HARSANYI, FERENC MEZEI, among earlier medalists. The other source of its reputation is that for the top ten winners free entrance is offered to any university in the country. (This is not a small award because only a fraction of applicants are accepted to physics or medicine, after strenuous entrance exams. The Eötvös Competition is the favorite route to a university carrier for unusual – a bit crazy – talents. The professors immediately pay respect to an Eötvös medalist.) THEODORE VON KÁRMÁN and JOHN G. KEMENY recommended such competitions for the U.S. In the 1950s *George Polya* (1887–1986) and *Gabor Szegő* (1895–1986), professors at Stanford University, organized competitions in California according to the pattern of the Eötvös Competitions.⁴ JOHN VON NEUMANN from Berlin wrote a letter to his professor *Lipót Fejér* in Budapest (1929):⁵

Dear highly honored Professor, I had the opportunity several times to speak to Leo Szilard about the student competitions of the Eötvös Mathematical and Physical Society, also about the fact that the winners of these competitions, so to say, overlap with the set of mathematicians and physicists who later became well-respected world-figures. Taking the general bad reputations of examinations world-wide into account it is to be considered as a great achieve-

⁴Peter Lax to the author 1994

⁵Neumann Archive, OMIKK, Budapest, facsimile

ment if the selection works with a 50 % probability of hitting the talent. Szilard is very interested in whether this procedure can be applied in the German context and this has been the subject of much discussion between us. However, since we would like above all to learn what the reliable statistical details are, we are approaching you with the following request. We would like: 1. to have a list of names of the winners and runners-ups of the student competitions, 2. to see marked on the list those who were adopted on a scientific basis and those adopted for other work, 3. to know your opinion about the extent to which the prizewinners and the talented are the same people and, for example, what proportion of the former would be worthy of financial support from the State in order to make their studies possible. Please forgive me for setting such a tiring task but we would be very grateful to you for receiving of the information herein requested or, otherwise, an indication of how such information may be obtained.

Thanking you in advance, I remain your grateful pupil,

Neumann Jancsi

The Eötvös Competition is not the only one run by the Eötvös Society. The talent search begins already in the lower secondary schools. Competitions carry the names of famous school teachers like *István Hatvani*, *Ireneus Károly*, *Sándor Mikola*, *József Öveges*, *Miklós Vermes* etc. Leo Szilard might be happy to know that the Nuclear Power Plant (Paks) sponsors a Szilard Competition for high school students each year. The centenary of the Eötvös Competition was celebrated in 1994 in the presence of leading representatives of the International Union for Pure and Applied Physics, the International Group on Research in Physics Education (GIREP) and the European Physical Society.

The *International Students' Physics Olympiad* was conceived as a Czech–Hungarian–Polish initiative (1964). The first one was organized in Poland, the second one in Hungary, the third one in Czechoslovakia. It moved around Europe, then went to America and Asia. The 24th Olympiad was hosted by the U.S. (1993), the 25th Olympiad by China (1994), the 26th Olympiad by Australia (1995), the 27th Olympiad by Norway (1996), with about fifty countries participating. The 28th Olympiad has been invited by Canada (1997), the 29th Olympiad by Iceland (1998), the 30th Olympiad by Italy (1999). This indicates that the International Physics Olympiad has a real international character. As a rule, the theoretical and experimental problems are selected by the host country. In 1991 the Physics Education Medal of the International Union for Pure

INTERNATIONAL PHYSICS OLYMPIADS

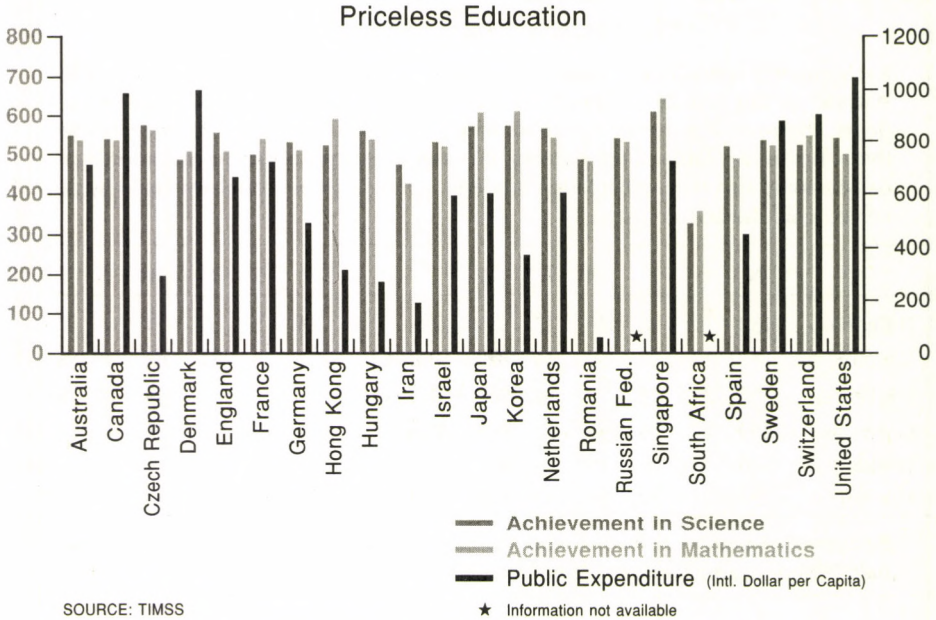
Each country sends five students, irrespectively of the size of the country. This statistics of the first 27 olympiads indicates the total *Number* of participated students, the overall numbers of *Gold, Silver, Bronze* medals and *Honors* won by them, finally the *Ratio* of the successful students (having obtained medal or honor) compared to the participating students. Only "golden countries" having received gold medals are listed.)

	N	G	S	B	H	R		N	G	S	B	H	R
Bulgaria	132	10	12	26	37	64%	Iran	24	3	9	9	4	75%
Czech.Slov.	137	17	28	34	33	82%	Poland	132	14	21	32	36	81%
P.R.China	55	29	13	9	2	96%	Romania	132	21	33	35	21	83%
Germany	109	12	19	40	27	86%	Russia	134	46	36	28	16	96%
Holland	75	4	8	16	23	71%	U.K.	65	8	14	19	13	83%
Hungary	132	22	22	48	29	92%	U.S.A.	55	12	7	17	9	82%

Furthermore France, R. Korea, and Vietnam received two gold medals, Finland, Italy, Sweden, and Turkey received one gold.

and Applied Physics was given to the International Students' Physics Olympiad. Jan Nilsson, secretary general of IUPAP, handed a copy of the medal to *Rudolf Kunfalvi*, co-founder of the Olympiad. In each year the five best students represent each country, irrespectively of its size. At the first 27 olympiads, Hungarian teenagers collected 22 gold medals (third only to China and Russia, countries a bit larger than Hungary of ten million people). When the U.S. decided to join the international competition, they invited French and Hungarian students to their preparatory training camp (1988). For example, from the 1993 olympiad, hosted by the U.S., only two countries succeeded in collecting three gold medals by their five-member teams: Russia and Hungary. But not only Hungarian boys excel. *Kate Varga* turned out to be the best girl in the world at the 1991 physics olympiad, *Edina Rosta* the best girl at the 1994 chemistry olympiad. (Recently, however, Chinese girls have excelled.)

Chess is a sport of the brain. It differs from card games: it is not influenced by the chance of initial conditions. The first teenager to become a grand master before the age of 16 was the American wizard, Bobby Fischer (1979). His success was surpassed by a Hungarian girl, *Judith Polgar* (1992), who, by the age of 15 years and 5 months became a grand master. But now a Hungarian boy has overcome even her achievement: *Peter Lékó* was born 8 September 1979, and won the grand master title



SOURCE: TIMSS

Outcome of the Third International Assessment of school children in science and mathematics (average performance in grade 8 age 14). Organized by the International Association for Measuring Educational Achievements (Science, 22 November 1996).

on 30 January 1994. (Today the best lady chess players of the world are *Judith Polgar*, several times among the top ten on the *male* list, and her sister, *Zsuzsa Polgar*, world *woman* chess champion.) In 1997 the International Chess Writers' Association gave four Chess Oscar Awards: to Anatoli Karpov (a Russian), as best male player, to *Judith Polgar*, as best lady player, to her father, *László Polgar*, as best chess pedagogue, to *Pál Benkő*, as best chess composer (three Hungarians).

Let us hope that the successes of Hungarian teenagers in science carry the promise of new generations of scientists who will contribute to the culture of humankind. A necessary condition is given: these decades are stormy again in the history of Hungary. The words of Max Teller to his son EDWARD TELLER⁶ have become timely again.

⁶*Time*, 18 November 1957, used as the motto for this chapter

The Eötvös Society

We will not let everyday politics dominate our lives. It is with great concern that we see science become dominated here and there by politics, and that some states with significant cultural heritages move toward scientific autarchy. This may have a devastating effect on science. There is no such thing as German physics, French mathematics, or English astronomy. These concepts are atrocious creations of national chauvinism. Truth is one and indivisible throughout the world.

(Gustav Rados, president of the Society 1937)

Once upon a time, a thousand years ago, Hungarian chiefs felt that to preserve independent Hungarian statehood it would be essential to join Christian Europe. In order to compensate for the threatening presence of the German–Roman Empire, they turned to the Pope in Rome asking him to send a royal crown. With this Holy Crown the first Hungarian king was crowned in the year 1000. A new Millennium had begun.

Italian clergymen brought Christianity and the Latin alphabet to Hungary. For centuries European culture streamed through Italian connection to Hungary. This influence has been preserved throughout the country e.g. in the Italian roof structure (descending toward the street, as opposed to German roofs being perpendicular to the street). Even Dante talks about Hungary in the *Divina Comedia*. In the Middle Ages Hungarian students studied mostly at Italian universities in Bologna, Ferrara, and Padova. (In the Students' Hall in Bologna the heraldic symbol of Hungary can still be seen today.) Louis the Great, who was king of Hungary and Naples as well, founded a short-lived university in Pécs in the 14th century.

In the 15th century King Mathias Corvinus married Beatrice, princess from Naples. From Italy she brought the Renaissance to Hungary: the science and art of the Renaissance took root. The King's library was the third largest in contemporary Europe, the largest one outside Italy. Mathias' educator, Johannes Vitéz was interested in astronomy and established an observatory. *Martin Ikus* was Royal Astronomer.

The king sent Bishop Johannes Vitéz with Bishop Janus Pannonius (a poet who wrote in Latin) to Pope Paul II with a message: – *“Many talented students study abroad, but it has become important for Hungary to have our university. I ask for the privileges for a Hungarian university such as the University of Bologna had received and served it well.”*

– In 1465 the Pope gave permission in a letter beginning with the words *Fiat ut petitur...* Mathias' university was opened in Pozsony (now Bratislava) in 1467.

One of the greatest scholars of contemporary Europe, Johannes Müller (1436–1476) – alias *Regiomontanus* – worked at this university. He constructed tables for spherical trigonometry, called the *Tabula Directorum*, which were used by Columbus while sailing westward on the ocean five hundred years ago. Even Copernicus borrowed heavily from this *Tabula*. Regiomontanus was born in Königsberg, and studied at George Peurbach (Vienna). Peurbach was in close scientific contact with Nicolas of Cusa. Cusa's book *Learned Ignorance* (written in 1440, printed in 1514) said: – *Since the Earth cannot be the center, it cannot be entirely devoid of motion. It is clear to us that the Earth is really in motion though this may not be apparent to us, since we do not perceive motion except by comparison with something fixed.* – Regiomontanus lived before Copernicus, but was interested in Aristarchos' heliocentric system: – *It is necessary to alter the motion of the stars a little because of the motion of the Earth.* – In a letter he wrote already in the spirit of the Renaissance (1464): – *I cannot get over my amazement at the mental inertia of our astronomers in general who, like credulous women, believe what they read in the books, tablets, and commentaries as if it were the divine and unalterable truth. They believe the authors and neglect the truth.*¹ – With the permission of the King, Regiomontanus left for Nürnberg to establish an astronomical *observatory* (1471). Copernicus' great work on *The Revolutions of the Heavenly Spheres* was edited in Nürnberg (1543).

– *Regiomontanus had arrived at the same conclusions as Aristarchos and Copernicus, but was prevented from going further by his untimely death. He died at forty, three years after Copernicus was born. At the universities where Copernicus studied, the tradition of Cusa and Regiomontanus was very much alive. His principal teachers in astronomy: Brudzewski in Cracow, and Maria Bologna, both called themselves pupils of Regiomontanus. The ideas of a moving Earth, and of the Sun as*

¹letters quoted by L. Prowe: *Copernicus*, Berlin 1883

*the true ruler of the planetary system, belonged to the antique tradition of cosmology, and were much discussed in Copernicus' own time. Copernicus was a crystallizer of thought; and the crystallizers often achieve more lasting fame and influence on history than the initiators of new ideas.*²

King Mathias' intention was to turn his capital Buda into a university center. A school was created in the Dominican Quadrangle (now visible within the Hotel Budapest Hilton), but the King died unexpectedly, and in 1526 the Ottoman Army invaded Hungary. Islam ruled in Budapest till the 18th century.



In the hope of obtaining help from Europe in the struggle against the expansion of Islam, the western part of the country elected a Habsburg king. The eastern part retained much of its independence while the Catholic Habsburg Empire and the Moslem Ottoman Empire fought for supremacy through two centuries. So in the eastern part of the country the Reformation could take root. Calvinists sent students to the Netherlands, Lutherans to Germany, in order to implant the culture of those developed nations into Hungarian soil. On an occasion Hungarian Calvinists offered temporary shelter to Johannes Kepler (1598) when he got into conflict with religious fundamentalists. The most progressive centers of culture were the Calvinist Colleges founded in the 16th century, based on the spirit of the rational Cartesian philosophy. Jan Amos Comenius, the great educator from Moravia, was the follower of Bacon and taught in a Calvinist College at Sáropatak, in northeast Hungary (1650–1654). There he wrote the main textbook of demonstrative education, *Orbis Sensualium Pictus*, and a handbook of student activity, *Schola Ludus*.³ In the inventory of the Calvinist College in Debrecen magnets and other experimental tools were listed as early as in 1703. (In this context it is worthwhile to recall that according to the history of pedagogy, experimental demonstrations started in Oxford in 1700.) *Johannes Andreas Segner* (inventor of the Segner wheel) taught in Debrecen before obtaining a chair in Göttingen. *István Hatvani* studied in Basel and Leyden, fabricated galvanic cells within a year after Galvani's discovery, while teaching in Debrecen (1748–1786). Due to his demonstrations of electricity in the 18th century, the general public considered him to be a wizard.



²Arthur Koestler: *The Sleepwalkers*, 1959

³The University of Bratislava now is named Comenius University.

In the western part of the country the Catholic university was founded in 1635 (a year before Harvard University). After the expulsion of the Turks from Hungary, this university moved to Budapest (1777).

Reverend *Ányos Jedlik* was born together with the 19th century (1800–1895). To ensure that his electric demonstrations made the maximum impression on his audience he needed high voltage. He tried to improve galvanic batteries. Later on he discovered the concept of the cascade generator: he charged condensers connected in parallel, then discharged them while connected in a series, in order to produce huge sparks. He mailed his description to the *Annalen der Physik und Chemie* but Poggendorf's answer was negative: – “*I am sorry to return your paper. The only new thing is the way of charging the condensers, but the device is overly complicated.*” – Jedlik, the Benedictine monk had enough of the vanities of the world: he never published papers, but continued to show huge sparks to students in the Benedictine College and at Budapest University. When Vienna was staging a world exposition, the aging professor presented 90 cm long lightning sparks (1873). At the recommendation of Siemens, he was awarded the gold medal of the expo, but the Benedictine monk did not show up to receive the medal. As a result, E. Marx from Vienna is generally considered today to be the discoverer of the condenser cascade because he published the concept in the periodica of the Academy of Vienna (1876), but did not refer to Jedlik.⁴

In the meantime Jedlik went on to develop something even more spectacular. To supply electric power for demonstrations he constructed the dynamo (1861), six years before Siemens' work. For the monk-professor the dynamo served as a teaching demonstration, while the Siemens Company developed an electrical industry in Germany.

The Hungarian Academy of Sciences was established from the donation of a count (1825). Its first physicist member was *Ányos Jedlik*. He proposed the election of revolutionary scientists: Faraday (1858), Clausius (1872), Boltzmann (1888) as honorary members. No one can wish for a more speedy recognition of scientific trends!

Jedlik's teachings bore practical fruit later. *Karl Zipernowsky* (1853–1942) constructed electric generators based on the dynamo concept for the Ganz Company in Budapest. The *alternating current* so obtained had the great advantage that its voltage could be easily transformed up or down; thus it offered the possibility of cutting losses by using high voltage (low intensity) current for long-distance transfer – transformed to low volt-

⁴German patent No. 455933

age at the consumers' end to avoid accidents. In order to achieve this, *Max Déry*, *Titus Otto Bláthy*, and *Karl Zipernowsky* constructed and patented the iron-core transformer (1885). At the Budapest Expo (1885), thousand light bulbs were operated with alternating current while the rest of the world continued relying on direct current. Siemens and Edison were reluctant to accept the new technique, perhaps due to their commercial investments in DC ventures. Edison tried to scare people with the alleged dangers of alternating currents. (When Zipernowsky traveled to the United States as the prophet of AC, under the influence of the American electrical industry, the first execution by electric chair was performed with AC, in order to demonstrate its dangers.⁵) The system was first used on a large scale by the Ganz Company in the city of Rome (1885–1892). – *Kálmán Kandó* constructed the first efficient engine for electric trains utilizing AC by changing the single-phase voltage to several-phase voltage, first introduced by him on the Italian railway system (1930). As a result of Zipernowsky's insight AC took over DC worldwide.

– *At the beginning I did not see anything more in the telephone than a kind of telegraph, for transferring news from station to station* – Thomas Alva Edison, the inventor of the telephone, recalled.⁶ – *Phones were meant to replace telegraphs in America because the number of the latter was legally limited due to stock market interests. Theodore Puskás, however, developed plans to make phones available for the public in large. He designed a telephone central, which is able to connect an arbitrary number of subscribers with the assistance of the employees of the central.*

The first telephone central was built by *Theodore Puskás* in Paris (1879). Beside Puskás, there were a few other Hungarians working with Edison. According to legend,⁷ as they were experimenting with the first telephones in the U.S., two assistants were located at the opposite ends of the building. One of them said to the microphone: – “*Hallod?*” – (meaning: “do you hear me?” in Hungarian.) The other answered: – “*Hallom!*” – (meaning: “I am hearing it!”) The short “*bello*” had been taken over by Edison in the American usage to replace lengthy time-wasting formalities. This might be the origin of the international word *ballo/bello*.⁸



⁵Károly Pál Kovács to the author

⁶to Ignác Balla (1912)

⁷Károly Pál Kovács to the author

⁸Another version says that the microphone was called *balló*, “the thing that hears” in one of Puskás' patents, a name taken over by Bell.

5. I. 18.

Hoch verehrter Herr Kollege!

Durch das Ableben von Herrn Prof. Helmert ist die Stelle des Direktors am Potsdamer geodätischen Institut vakant geworden. Es ergibt sich daraus für die Akademiende, die Universität und das Ministerium die verantwortungsvolle Aufgabe, einen Nachfolger zu suchen. Verschiedene Kollegen haben mich nun gebeten, von sachkundiger und nicht unberechtigter Seite ein Gutachten einzuholen. Es scheint mir, dass Sie, hochgeachteter Herr Kollege, der einzige sind, auf dessen Meinung wir in dieser Angelegenheit Gewicht legen sollen; ich bitte Sie daher, mir Ihren Rath zukommen zu lassen.

Ohne Ihrer Aeusserung den geringsten Vorwurf zu wollen, bitte ich Sie doch, in Ihrem Schreiben ^{an die} auf die Herren

Schumann (Wien)

Wiechert (Göttingen)

Kudger

Kohlschütter } (Potsdam)

Schneijder }

irgendwie zu sprechen zu kommen, weil ~~sich~~ die Behörden ~~ganz~~ ~~klar~~ auf diese Männer bereits aufmerksam gemacht worden sind.

Bemerkungen über die wissenschaftliche Bedeutung jedes der drei letztgenannten Herren wären uns auch in dem Falle erwünscht, dass dieselben neben den beiden erstgenannten für den zu besetzenden Posten nicht in Betracht zu ziehen sind.

Ihrer hochgeschätzten Antwort mit grossem Interesse entgegensehend bin ich mit ausgezeichneter Hochachtung

Sie ganz ergebener

H. Carius

Herbenerstr. 5

Berlin - Schöneberg.

When the industrial revolution reached Hungary, several Hungarians went to Germany to begin their scientific careers. *Johannes Andreas Segner*, THEODORE VON KÁRMÁN, JOHN VON NEUMANN, EUGENE P. WIGNER, EDWARD TELLER, *Rudolf Ortway*, *Zoltán Gyulai*, *Béla Pogány*, *Zsolt Bor* worked at the most respected university of Göttingen. PHILIP VON LENARD and ROLAND EÖTVÖS were connected to Heidelberg. München granted Ph.D. to *Rudolf Ortway* and EDWARD TELLER. But Berlin was in the focus of the interests of the young Martians. On Wednesdays, from 5 to 7 o'clock p.m., Laue's Physics Colloquia were attended, among others, by ZOLTAN BAY, DENNIS GABOR, NICHOLAS KURTI, CORNELIUS LANCZOS, JOHN VON NEUMANN, MICHAEL POLANYI, LEO SZILARD, EUGENE P. WIGNER. It is no wonder that German connection further dominated in Budapest. Helmholtz had been elected an honorary member of the Hungarian Academy (1872), his books had been translated into Hungarian.

ROLAND EÖTVÖS, the founding father of professional physics research in Hungary, was the son of the liberal writer and Minister of Culture, *József Eötvös*. He became a professor at the age of 30 at Budapest University (1878), which was named *Roland Eötvös University* in 1950. Eötvös intended to prove Newton's law of gravity by showing that the proportionality of gravitational mass to inertial mass was valid up to 8 decimals, not only to 4 decimals, as was known earlier. For two decades he worked on it carefully, patiently, and successfully in his laboratory. His experimental achievement was acknowledged by the Göttingen Academy with the Beneke Prize (1909). The Eötvös Experiment has become the most quoted empirical foundation of Einstein's Theory of General Relativity.⁹ (The Eötvös gravimeter was also able to measure minute changes of the gravitational acceleration, so it became a popular tool of oil prospecting – in Texas and elsewhere.) Eötvös – like Professors Szily and Fröhlich – was also a Helmholtz-disciple. He was overwhelmed by the exact beauty of classical mechanics. Newton's spirit ruled over the physics institutes in Budapest at the turn of the 19/20th century.¹⁰



Kálmán Szily, professor at the Budapest Institute of Technology launched a popular science monthly for the Hungarian Science Association already in 1869, still running. But it is the merit of ROLAND EÖTVÖS to

⁹Einstein's letter to Eötvös is shown in German in facsimile

¹⁰But at the University of Kolozsvár/Cluj-Napoca Professor *Gyula Farkas* published papers (1906!) and lectured about relativity (1909!).

recognize the full importance of active science in the cultural development of a nation. Eötvös initiated regular meetings of mathematicians and physicists at a dinner table in the Carpatia Restaurant, in the vicinity of the Budapest University. They met on Thursday afternoons, in order to learn about the news in science, to find out about the works of each other, and thereby encourage scientific research (1885). (Thursday afternoon has remained the traditional time for physics colloquia for more than a century.) Eötvös said to his colleagues:

– *We have to raise the flag of science so high that it should be visible beyond our borders. That is our task!*

In 1890 an invitation by Eötvös to a lecture on *Terrestrial Gravitation and its Measurement* was mailed out, but the letter also referred to further goals:

– *Gentlemen! We hope that by meeting here we will take the first step towards assembling again and again with a similar purpose and come into closer contact with each other. Respectfully yours sincerely, Baron Roland Eötvös.*

Eötvös, the first president of the Society, worded the goals of the Society as follows: – *To further the development of science by word of mouth at our meetings, and publish everything that is worth the attention of the experts in a journal: this goal does not seem more than the goal of a self-educating student circle, and still in case we give it the deserved attention, our work will have merit, it will fulfill an important task. If we carry out the task of self-education with dedication and seriousness, it will also have the result that in the future the researchers and developers of science will come from among us. I hereby declare the Mathematical and Physical Society founded.* (1891) – After the death of its founder in 1919, the society was named *Roland Eötvös Mathematical and Physical Society*, or *Eötvös Society* in the short version.

The Society immediately started publishing its own journal, the *Mathematikai és Fizikai Lapok* (1891), serving the aims of the Society since then, with the exception of a few years of collapse following the great wars. In 1950 it restarted as *Fizikai Szemle*, printed now in 2000 copies. (The mathematicians edited another journal.) The monthly *Fizikai Szemle* is like *Physics World* or *Physikalische Blätter* or *Physics Today*; it has also a certain interplanetary character because it has published regularly the papers of Martians like Zoltan Bay, John Harsanyi, Nicholas Kurti, John von Neumann, George Olah, Edward Teller, Eugene Wigner, and many others; it did so even in the cold years of the Iron Curtain. Eugene P. Wigner regularly reacted to specific papers published in the *Fizikai Szemle* [facsimile].

1973 február 4

A Fizikai Szemle Szerkesztő Bizottságának
Budapest V, Szabadság tér 17

Nagyon köszönöm a Szerkesztő Bizottság jókívánásait az immár jelen őrre és leendő jövőre vonatkozó üdvözléseit. Viszonyom ezeket nagyon melegen. Meg szeretném észlelni ragadni ezt az alkalmat, hogy kifejezzem csodálatomat a Szemle tartalma iránt. Alig tudok oly füzetet említeni, amit legalább egy cikk olvasása nélkül továbbadtam volna. Mindig örülök, amikor egy új füzet kezeimbe kerül.

Kiváló tisztelettel
Wigner Jenő

To the Editorial Board of the Fizikai Szemle 4 February 1973.
I thank you very much for the greetings of the Editorial Board. I wish warmly the best to you. I would like to use the opportunity for expressing my admiration for the Fizikai Szemle. I hardly remember any issue that I have put off without reading at least one of the papers. I am always happy when a new issue arrives. With respectful greetings
Wigner Jenő

Kedves Kolléga!

Most olvastam el cikkeit a Fizikai Szemle augusztusi számában és meg kell írnom, mily érdeklődést és örömet váltott ki bennem elmefuttatásai. Én is úgy érzem, ideje nekem a kozmikus kérdéseken gondolkodni. De Ön többet tett: érdekesítően adta elő meggondolását. Sokszor köszönöm és gratulálok!

Üdvözli

Wigner Jenő

és boldog és vig
harárcsújt. kévan.

Dear Colleague! I have just read your paper in the Fizikai Szemle. I have to write you that your thoughts provoked deep interest and happiness in me. I also feel that it is now appropriate to think about these cosmic problems. But you have done something more: you have presented your ideas in an exciting way. Many thanks and congratulations,

Wigner Jenő

Let us quote here an other Martian reader reacting to the same paper. DENNIS GABOR wrote to the author [in Hungarian, facsimile on the next page, in shortened translation]:

My Dear Friend, the British Association and the American Association for the Advancement of Science organized a brainstorming about Science and the Future. We discussed with Edward U. Condon, among others, the possibilities of interstellar flights. To my surprise it turned out that he did not know your paper "Can we Reach the Stars?" which I know from the Fizikai Szemle. Where

Boulder, Colorado, 1968 április 13

Kedves Berétné,

A British Association is
an American Association for the Advancement of Science
rendeltek itt egy kis csehtörténeti díszharmadát a jövőre,
(Science and the Future.) Dr. telethonos Edward
U. Condon-al is beszélgetünk a csillagokból való
kutatásokról. Meglepősen keveset tudunk arról,
tudott a te munkáidról "Együttérzés-e a csillag-
okig" amelyet én is csak a Fizikai Szemleiben ismerlek.
De bizonyos megjelent már más nyelven is? Legy
szíves megmutatni nekem

Prof. Edward U. Condon

Dept. of Physics

The University, Boulder, Colorado.

Condon az tudományos életünkben fejeződik, mint
a volt az elnöke annak a Committee-nek amelyet
az amerikai akadémia megkérte hogy vizsgálja
meg az "UFO"-t, az "Unidentified Flying
Objects"-ek léteiről. Reméljük talán majd hogy
még is lesznek beszámolóik.

Erre magyarázatot is szeretnék, de becsúszott
hullott volna, mert hívták hogy legyen az
etminél híre az UFO-kban, -mint minden
fennsíkunkon meggyőződésünkben!

Örömmel emlékezem a Pest-i telethon-
csinálásra!

Berétné üdvözléssel

János Dienes

was it published in other language? Please, send him a reprint. Condon is especially interested because he chaired the Committee of the U.S. National Academy to investigate the case of Unidentified Flying Objects. Evidently they concluded that there are no definite evidences. I remember our meetings in Pest!

With friendly greetings

Gábor Dénes

Member Number One of the Society had been *Ányos Jedlik*. Between the two World Wars EUGENE WIGNER was the owner of the No. 1 membership card. Members of the Society numbered 400 in the early years. Lectures were dominated by mathematics, but, for example, X-rays were already demonstrated on 16 January 1896, shortly after Röntgen's discovery (9th November 1895), even prior to Röntgen's public announcement in Würzburg (23 January 1896). GEORGE DE HEVESY reported his discoveries (radioactive tracing, discovery of the element Hafnium) within weeks.

Eötvös was a professional experimentalist, a great science politician (president of the Academy, rector of the University, minister of education in certain periods). But he was sticking to the ideal of the "action at a distance" throughout his whole life. He had first class assistants (like Philipp von Lenard and Viktor Zemplén), but after a while they left for other universities because became interested in more up-to-date research.

Viktor Zemplén moved to the Budapest Institute of Technology where he was allowed to lecture on Maxwellian electrodynamics and perform research on shock waves. He wrote the chapter on shock waves in the *Encyclopedia Physica*, forerunner of the *Handbuch der Physik*.

PHILIPP VON LENARD attended secondary school in Pozsony/Bratislava/Pressburg (then Hungary, now capital of Slovakia). The Nobel Prize winners' biography wrote,¹¹ – *Lenard carried out studies in collaboration with Virgil Klatt, who had been his first physics teacher in his native town, at the Modern College of Pressburg. They studied the so-called self-luminous substances such as calcium-sulphide on which Klatt had been working for some years. Together they found that calcium sulphide, after previous illumination, exerts light in the dark, but only if it contains at least some traces of heavy metals on which the color and the intensity and duration of the luminosity depends. If it is quite pure, it is not luminous. This work with Klatt was the beginning of work in the field which occupied Lenard for the next 18 years.* – Lenard quoted this joint 1904 paper also in his Nobel lecture. – The very first

¹¹Elsevier 1967

paper (1897) of Lenard explained why air near a waterfall is negatively charged while the water is positively charged, through the spraying and bursting of water drops. From here, his road led him to study the photo-effect. Lenard left for Kiel, Germany, then to Heidelberg. The Physics Nobel Commission nominated Röntgen and Lenard together for the very first Physics Nobel Prize, but according to the decision of the Royal Swedish Academy of Sciences Röntgen received the Nobel Prize in 1901, Lenard in 1905. When he was elected to honorary member of the Hungarian Academy, he thanked [in Hungarian, facsimile, on the next page]:

Dear Sir President, I have received the honorary membership, the highest honor of the Hungarian Academy of Sciences, with great pleasure. In order to express my gratitude, I shall appear at the sessions of the Academy with my works. I ask you, to transfer my thanks to the Academy for this honor. With patriotic greetings

Lenard Fülöp

Eötvös preferred patient observers, who were ready to record the readings of his gravimeter without preconceptions through thousands of hours. The problem was that his diligent assistants disliked Maxwell, Planck, or Einstein. When they became professors, discouraged their students to study them in the first two decades of the 20th century. Arnold Sommerfeld visited Budapest in the 1920s, and turned to Professor Isidor Fröhlich (a protégé of Eötvös), asking: – *Mr. Professor, what do you think about the new theories?* – meaning relativity and quantum theory. The Hungarian professor answered: – *I am sure Maxwell has been wrong.*

After World War I Szeged – a town rich with blossoming trees – obtained a university, which carried the torch of progress in the 1920s and 1930s. *Frederic Riesz* planted modern mathematics, *Rudolf Ortway* quantum mechanics, *Zoltan Bay* atomic physics, *Albert Szent-Györgyi* exact biology, *László Kalmár* computer science to fertile Hungarian soil.¹²

Later on, after the departure of Eötvös epigons, Ortway was called to *Budapest University*, Bay to the *Budapest Institute of Technology*. They turned the arms of the clock of physics ahead by two hundred years in the capital city as well. Thanks to them, in the 1930s modern *theoretical physics* blossomed in Budapest. In 1929 Professor Ortway (1885–1945), a disciple of Sommerfeld, initiated the *Ortway Colloquium*, held on Thursday afternoons. He gave top priority to quantum mechanics, with lecturers like

¹²Cornelius Lanczos obtained his Ph.D. degree from Szeged University (at Professor Rudolf Ortway)

Heidelberg 1907. máj. 4-én.

Magyar Művelődési Elnök Ur!.

A Magyar Tud. Akadémiának
legnagyobb kitüntetését, tisztelteti
tagja körében megvalósításomat
nagy örömmel vettem tudomásul.

E megtisztetés után igyekszem
fogak H. M. Tud. Akadémia iránt
írték háleimnak olyképen kifejezését
adni, hogy idénkem, az ülésen,
dolgozataimmal fogak megjelenni.

Tisztelettel kérem magyartudóságot,
hogy kedvük a tekintetes Akadémiának
e megtisztelő kitüntetésért háleis
köszönetemmel köszönetet mondjak.

Hazafias üdvözléssel
Leuard Fülöp.

himself and some E.T.-s like CORNELIUS LANCZOS, JOHN VON NEUMANN, EDWARD TELLER, LÁSZLÓ TISZA, EUGENE WIGNER. At Ortvy's Colloquium also secondary school teachers were present; they were given a chance to talk about their research in electronics, materials science, quantum electrodynamics. Ortvy invited not only the top Hungarians working abroad to speak, but Debye, Dirac, Heisenberg, Planck, Sommerfeld as well. (The 50th birthday celebration of the Dirac equation happened in Budapest with a huge birthday cake given to Dirac, with 50 candles on it.) LÁSZLÓ TISZA was Ortvy's graduate student, who made his name respected later as the initiator of the two-liquids model of superfluid helium. Ortvy's regular correspondence with GEORGE DE HEVESY, JOHN VON NEUMANN, EUGENE P. WIGNER, and others was an intellectual bridge keeping Budapest aware of the progress in science even in the cold years to come. They are unique witnesses of the "Hungarian conspiracy" (an expression used by Tuve) and golden documents of the history of physics.¹³ The school of modern theoretical physics survived Ortvy's departure: *Karl F. Novobátzky*, protege of Ortvy and inheritor of his cathedra, taught and developed quantum field theory and relativity in spite of the attacks of Marxist hardliners, thus Budapest University has become the leading center in basic theory. The present physics competition of university students, organized by the Eötvös Society, is most appropriately named *Ortvy Competition*.

In the meantime *experimental physics* radiated from the circle of *Károly Tangl* (1869–1939), the most progressive student of Eötvös. His disciples, *Zoltán Gyulai* and *Sándor Szalay* created a center for crystal physics and nuclear physics at the *Debrecen University*, educating a sequence of genuine experimentalists in this theory-dominated country. The ATOMKI (Atomic Research Institute) established a cyclotron under *Dénes Berényi*.

The *Budapest Institute of Technology* was the first niche of modern physics in Budapest: *Viktor Zemlén* in the 1910s, *Zoltan Bay* in the 1940s, *Paul Gombás* in the 1950s attracted bright students for topics more intimately related to technology. Thanks to *Béla Pogány* (1887–1943), *Rudolf Schmied* created a school of spectroscopy and *Zoltán Gyulai* (1888–1968) developed a school of solid state physics. The Budapest Institute of Technology still dominates in materials science.

Applied physics reached world standards in northern Budapest, where the *Tungsram Company* was created (1896). The name of this light bulb factory originates from tungsten (wolfram), the heat resistant metal which was here patented by *Sándor Just* and *Ferenc Hanaman* (1903), as the

¹³published in the *Fizikai Szemle*

glowing fiber in light bulbs, instead of Edison's fragile coal fibers. The tungsten (and Tungstram) made electric incandescent lamps long-lasting, so that the light bulb could become an everyday item.¹⁴ *Lipót Aschner*, director-general of Tungstram, recognized the importance of research and development. MICHAEL POLANYI and EGON OROWAN developed here the theory of crystal dislocations as the carriers of plasticity (1934). As Orowan said, – *Slowly I realized that dislocations were important enough to warrant publication, and I wrote to Polanyi, with whom I discussed them several times, suggesting a joint paper. He replied that it was my bird and I should publish it. Finally we agreed that we would send separate papers to the "Zeitschrift für Physik", and ask to print them side by side. This he did.* – Imre Bródy, Egon Orowan, and Michael Polányi cooperated in realizing the most economic incandescent lamp, the krypton bulb (1934), and the mass production of krypton [facsimile]. ZOLTAN BAY pioneered radio astronomy, Paul Selényi pioneered photocopying. For a short time even EDWARD TELLER worked in Tungstram.

DENNIS GABOR, EGON OROWAN, and MICHAEL POLANYI later became members of the Royal Society. Experimental science relied strongly on the English connection. GEORGE DE HEVESY and *Sándor Szalay* worked under Ernest Rutherford. Egon Orowan also worked in Cambridge. ALBERT SZENT-GYÖRGYI brought modern experimental biology from the Cavendish Laboratory (Cambridge). Dennis Gabor and Michael Polanyi learned to know industrial application of physics at the Thomson-Houston company. Visits of NICHOLAS KURTI from the Clarendon Laboratory (Oxford) and DENNIS GABOR from the Imperial College (London) strengthened the respect of the pragmatic British approach in otherwise theory-oriented Hungary.

When official institutions were restricted by politics, the Roland Eötvös Mathematical and Physical Society played an important role in enabling scientific life in Hungary. As the motto for this chapter we quoted from the talk given by the president of the Society at the general assembly in 1937. Physics professors tried to connect JOHN VON NEUMANN formally to Hungary, but the proposals were rejected at Szeged University and Budapest University, and at the Hungarian Academy as well by the leading representatives sticking to the government's policy. Only the Eötvös Society elected Neumann (a person of Jewish origin and working in America) to an honorary member. [Facsimile.]

¹⁴General Electric started to use tungsten, but Tungstram went to court and won concerning patent rights.

Budapest, 1938. május 30.

Nagyságos

Dr. Neumann János Úrnak

Budapest.

Mélyentisztelt Tagtárs Ur!

Az Eötvös Loránd Matematikai és Fizikai Társulat Választmányának megbízásából van szerencsém, értesíteni ^{Magyságot} Magyságot, hogy Társulatunk f. év május 21.-én tartott közgyűlésén önt tiszteleti taggá választotta. Kérem engedje meg, hogy mind a Társulat választmánya és titkara, mind a magam nevében es alkalommal is legmelegebb szerencsekívánataimat tolmácsoljam Önnek további sikeres munkájához.

Tisztelő hiva


mleg. ty. r. tanár
u. v. titkár.

To Dr. Neumann János, Budapest.

Dear Society Member! In the name of the Council of the Roland Eötvös Mathematical and Physical Society, I have the pleasure to inform you that the General Assembly elected you honorary member on 21 May 1938. Please, let me express the warmest congratulations in in the name of the Council and the Presidium of the Society, and our wishes for the future success of your work.

Yours sincerely, Prof. Pogány Béla, secretary of the Society

Sub pondere crescit palma. Trees grow under weight. The most intense periods of the Eötvös Society were the war years, when personal contacts to abroad were cut, and government organizations had other priorities. During World War I *Viktor Zemplén* served as excellent secretary till his death on the Italian front. During World War II this was the merit of *Rudolf Ortway* as secretary. This phenomenon of vitality replayed itself later, during the chilly decades of the Cold War.

◇

The turmoil following World War I in 1919 resulted in heavy losses for Hungarian culture: GEORGE DE HEVESY, THEODORE VON KÁRMÁN, ARTHUR KOESTLER, MICHAEL POLANYI, LEO SZILARD were forced to emigrate for fear of right-extremists. The losses were continued in the 1920s: NICHOLAS KURTI, ALEXANDER KORDA, CORNELIUS LANCZOS, JOHN VON NEUMANN, EDWARD TELLER, EUGENE WIGNER went into exile, due to the spreading anti-Semitism.

The collapse and political turmoil following World War II decapitated Hungarian science once again. *Béla Pogány* died during the war, *Imre Bródy* became the victim of the Holocaust, *Rudolf Ortway* committed suicide, *Rudolf Schmied* died in Russian prison camp. The laboratory-creating efforts of ZOLTAN BAY (at Tungsram), GEORGE BÉKÉSY (at Budapest University), ALBERT SZENT-GYÖRGYI (at Szeged University) survived World War II, they began enthusiastically rebuilding scientific life in a democratic republic (1946), but were soon forced into exile by the new extreme-left rulers. Soon a new toll was taken by the military suppression of the Hungarian revolt (1956), which made ANDREW GROVE and GEORGE OLAH to leave the country, among others. But some of the Martians chose the adventure of staying at home in Hungary.

Fortunately everything was not lost. The Society – like a phoenix – was reborn from its ashes: the *Roland Eötvös Physical Society* and the *János Bolyai Mathematical Society* were established in 1949.¹⁵ The Eötvös Society launched its monthly *Fizikai Szemle* (1950) with the optimistic words of *Karl F. Novobátzky*:

– Physics develops with enormous speed, this is the most important science of the world, its importance is unsurpassable by anything else. It was not without reason that Einstein called physics the fifth superpower. Experimental physics reaches for the innermost secrets of matter by extremely sophisticated and expensive methods, while theoretical physics explores the possibilities of logically structuring the phenomena of Nature. In Hungary, the impatient desire to catch up with what we missed for centuries turns into action in physics as well.

The Eötvös Society rapidly extended its reach to the whole country, organizing local groups in each part of Hungary, with meetings moving around since 1951. By social means it created a live scientific forum; it

¹⁵*János Bolyai* (1802–1860) was an army officer at a far-eastern garrison in Hungary, and there created the non-Euclidean geometry in 1825. The 21-year old lieutenant wrote his father: – *Out of nothing I have created a new, different world.* – C.B. Halsted (University of Texas) published an English translation of *János Bolyai's* paper, written originally in Latin, in 1831.

built up a result-oriented order of values, quantum tunneling through the Iron Curtain even during the chilliest decades of the Cold War. Its presidents were *Paul Gombás* (leader of the school in atomic theory), *Karl F. Novobátzky* (creator of a school in field theory), *Zoltán Gyulay* (leader of a school in experimental solid state physics), *George Szigeti* (former co-worker of Bay in applied physics), *George Marx* (a student of Novobátzky, initiating particle physics in Budapest), *Gyula Csikai* (a student of Szalay, developing a neutron lab in Debrecen in close cooperation with the International Atomic Energy Agency), *Norbert Kroó* (a materials scientist, encouraging young talents to work in practical research), *Dezső Kiss* (a student of Jánossy, for a while the director general of the Joint Institute of Nuclear Research in Dubna, in the Soviet Union). The Eötvös Society has about 2000 members, and it has become perhaps the most important organizer of international physics conferences in Eastern Europe since the 1960s. (It hosted several conferences of the European Physical Society, International Union for Pure and Applied Physics, International Astronomical Union, International Atomic Energy Agency, UNESCO.) On the lakeside alley in Balatonfüred lime trees planted by Paul A.M. Dirac, Richard Feynman, JOHN C. HARSANYI, NICHOLAS KURTI, Benoit Mandelbrot, Sir Nevil Mott, Rudolf Mössbauer, GEORGE OLAH, Bruno Pontecorvo, Jurij V. Prohorov, EDWARD TELLER, and EUGENE P. WIGNER preserve the memories of their visits and lectures at the Balaton conferences.

Hungary (*George Szigeti*) has been one of the founding members of the European Physical Society; its past president was *Norbert Kroó* (Budapest). The International Union for Pure and Applied Physics had Hungarian vice-presidents (*Lénard Pál*, *George Marx*). The Academia Europea and the International Astronautical Academy (created by KÁRMÁN) have about a dozen Hungarian physicist members, general assemblies were held also in Budapest. The Association of Hungarian Physics Students initiated the formation of the International Association of Physics Students; its first president was *Patroklos Budai* (a student at Eötvös University in Budapest). At the millennium of the Hungarian school Hungary hosted the World Conference of Physics Students (1996).

One important mission of the Eötvös Society had been to keep contact with Hungarians working abroad, on the other side of the Iron Curtain. After JOHN VON NEUMANN the Eötvös Society elected honorary members like CORNELIUS LANCZOS, JOHN G. KEMENY [facsimile] (these were their only acknowledgements from their mother country while they lived), as well as ZOLTAN BAY, JOHN C. HARSANYI, NICHOLAS KURTI, VALENTINE TELEGGI, EDWARD TELLER, LÁSZLÓ TISZA, EUGENE P. WIGNER (they are also honorary members at the Hungarian Academy). The hon-

John G. Kemeny
P.O. Box 293
Etna, N.H. 03750

December 5, 1991

Dear Dr. Marx:

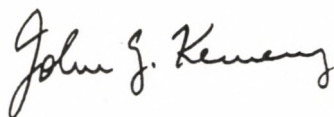
I am deeply honored to have been elected to the Roland Eötvös Physical Society. Thank you very much.

Let me explain why my response is so late. Last summer I retired completely. I sent out changes of address to have my mail sent to my home. So I only go into the College once a month to pick up mail -- which is almost all junk. When I went in this week, I was deeply disturbed to find your fax amongst a lot of junk-mail.

While a trip to Hungary in the near future is not possible, my wife and I would both like very much to visit Budapest one more time. Please hold on to my medal -- it will give me one more incentive to come!

Again, my deepest thanks, and warmest regards,

Sincerely,



or coming from their native country were appreciated. Let's quote from two longer letters [facsimiles].

Dear György! Your letter of 27 October 1977 has just arrived. Thank you very much. I am proud of the membership in the Eötvös Loránd Physical Society. I have received a questionnaire from the International Biographical Center; one of the questions is relat-

1977 november 5

Kedves György!

Most jött meg október 27-i leveled és nagyon köszönöm. Bízok benne az Eötvös Loránd Fizikai Társulat tagságára. Most jött, szintén, az International Biographical Center hírdőve; az egyik kérdésük az, milyen megtezteltetéseket kaptam. Oda beírom az Eötvös Loránd tagságot!

Kedves sorokat még egyszer köszönöm és jókívánságokat viszonozva üdvözlöm
Magukat

Wigner Jenő

ed to my honors I have obtained. I enlist my membership in the Eötvös Society! Thank you once again for your kind letter, reciprocating your good wishes,

Wigner Jenő

Dear Professor! Thank you very much the congratulations at the occasion of the Nobel Prize. I thank you for the book "The Voice of the Martians." Thank you for writing about me in the Fizikai Szemle. I shall consider to be a great honor to become a honorary member of the Eötvös Society. Till the coming meeting,

cordial greetings from Dr. Harsányi János

There are also other prominent honoraries from overseas, from Europe, and from neighboring countries, speaking Hungarian. Their visiting lectures are attended by hundreds of students and physicists, helping to keep the community of the Hungarian speaking physicists together.



Walter A. Haas School of Business

350 Barrows Hall
Berkeley, California 94720

1995. február 13.

Narr György Professor Úrnak,
Az Eötvös Loránd Fizikai Társulat Elnökének.

Kedves Professor Úr!

Nagyon köszönöm a gratulációt. Köszönöm a Professor Úr "Voice of the Martians" c. könyvét is. Köszönöm a rólam szóló cikket is a Fizikai Szemle-ben.

Nagy megtiszteltetésnek fogom tekinteni, ha a Társulat t.b. tagjává választ meg.

A budapesti programomat Havasi Miklós úr, az MTE SZ elnöke állítja össze. Ha van hely erre a programomban, akkor szívesen előadnék a Társulat tagjainak. De persze el akarom kerülni, hogy ugyanazt az előadást különböző tudományos intézményekben újra és újra meg kelljen ismételnem.

A magam részéről szívesen belegyeznék abba, hogy a Nobel előadásomat a Társulat lapja magamról közölhesse.

A közeli viszontlátásig

szívveljes üdvözléssel

Ötörényi János.

There are more Hungarian-born physics professors working actively abroad, most of them in the United States, than within Hungary. Our present intensive American connections are mainly due to their influence. It is a mission of the Eötvös Society to make use of the expertise and knowledge of the Martians, happy and successful far away, in order to strengthen physics at home as well.

We expect that the Hungarian society will gradually grow up to respect its talents. In the 1990s this may become our ticket for re-entrance to the European Community.

The visitors from
 Mars included all
 kinds of outstanding
 people like Zora
 Gabor. Their alien
 accent would give
 them away therefore
 they chose to pretend
 to be Hungarians.
 Unfortunately one of
 them, Theodore von

Koening gave the secret
 away

Not all the Hungarians left
 Hungary. Those who,
 like myself, came to
 America made con-
 siderable contributions in starting
 the atomic age. Those
 who stayed in Hungary
 built one of the best
 sets of nuclear reac-
 tors.

Edward Teller

Epilogue

by Edward Teller

The visitors from Mars included all kinds of outstanding people like Zsa Zsa Gábor. Their alien accent would give them away therefore they chose to pretend to be Hungarians. All this was a well-kept secret. Unfortunately one of them, Theodore von Kármán gave the secret away.

Not all the Martians left Hungary. Those, who – like myself – came to America, made contributions in starting the atomic age. Those, who stayed in Hungary, built one of the best set of nuclear reactors.

The fear of nuclear reactors in general has practically stopped the development of nuclear reactors in the United States and has greatly reduced its beneficial applications throughout the world. A most significant question is whether we shall recover in a collective sense from the strongly negative effects in this field. I believe we shall. Reasonable use of reactors, as in the case in France, is apt to have a decisive influence throughout the world.

In my experience, Hungarians have in general retained the positive approach to technical developments. That, together with the good record of the reactors in Paks, gives some justification to the belief that the Hungarians will continue their leadership in nuclear energy and will be among the first to develop the full economic benefit of the reactors.

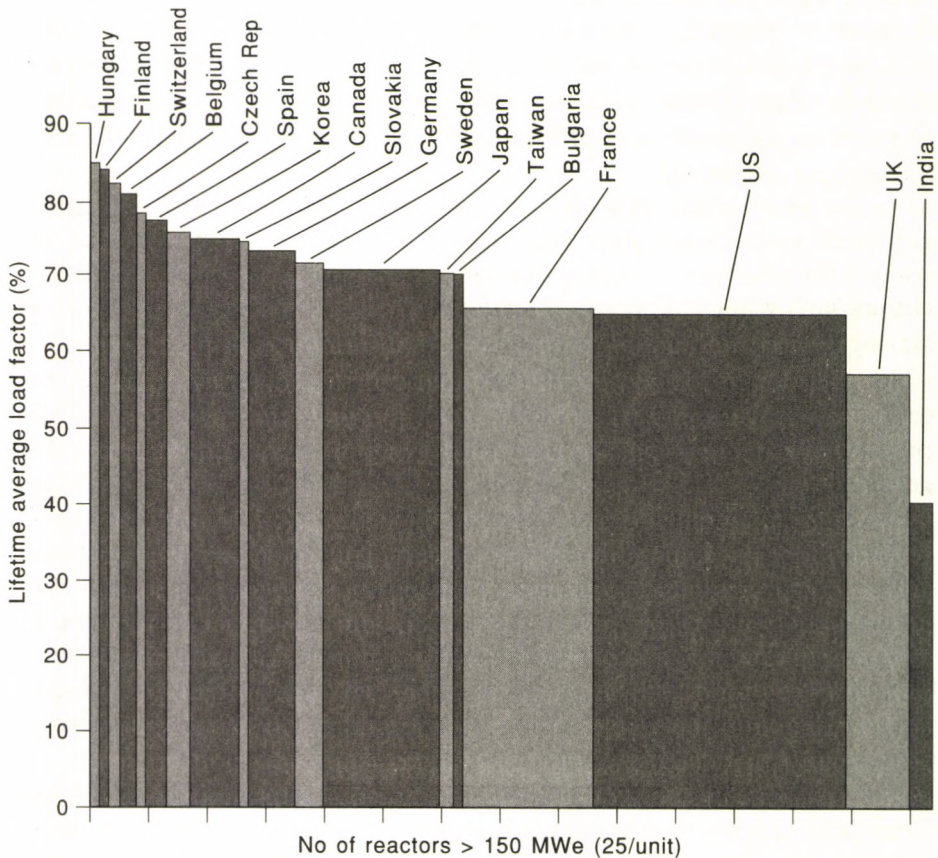
In particular, Hungary now has ample opportunity to use the so-called “nuclear waste” in whatever fashion they choose. I dream of the possibility that Hungary may lead the world in recognizing that what is generally called “waste” is actually a valuable by-product. Of course, these by-products have to be handled with care. But it is not so difficult to handle them because radioactivity can be detected many thousand times sooner than when their concentration becomes dangerous. Becoming the first in a re-birth in the nuclear age could be a great help in the process of achieving practical economic success. The result would be not only plentiful energy, but also the use of radioactivity in medicine, food conservation, cleaning up of sludge, and a great variety of industrial uses.

I should not stop here. The contagion of fear spreading from the nuclear field into many other areas has prevented prompt utilization of the great contemporary achievements in biochemistry. Work with recombinant DNA has lifted the age-old art of the breeding of domesticated farm products into the new and effective potentialities of rapid scientific de-

velopment. Yet worldwide fear and propaganda have counteracted, maybe even have stopped, this fantastic beneficial development. Nuclear technique, biochemistry, and many other fields of progress are interconnected. I suspect that such developments may succeed together or fail together.

I believe that the Martians using the Hungarian tongue, the only one they can speak without an accent, will liberate Hungary, not only from foreign oppression, but also from the hardships that usually occur when we try to adapt ourselves to a set of thoroughly new circumstances.

We all desire to find ourselves overnight in a world that is new and better. Such a change may take a million nights. Perhaps for the Martians, one thousand and one nights may suffice. [Facsimile.]



Source: Nuclear Engineering International, June 1996

Biodata of the Martians

BALOGH TAMÁS – LORD BALOGH (1906 Budapest – 1981 London) attended the Minta Gymnasium, then studied economics. He became professor at Balliol College and was made Lord by the Queen (1970).

BÁRÁNY RÓBERT – ROBERT BÁRÁNY (1876 Vienna, Austria – 1936 Uppsala, Sweden) spoke both German and Hungarian. (His father was born in Várpalota, Hungary, and went to Vienna in 1855, becoming an Austrian citizen in 1877.) He worked in medicine at the university of Vienna, later became professor in Uppsala. Politzer Prize of International Otological Congress, Boston (1912). Guyot Prize of the University of Groningen (1914). 1914 *Nobel Prize in physiology* “for his work on the physiology and pathology of the vestibular apparatus.” Buried in Stockholm.

BAUER ERVIN – ERWIN BAUER (1890 Lőcse–Levoce – 1942 Gulag, Soviet Union) studied medicine in Budapest and Göttingen, received Ph.D. (1914), then came back to Hungary. His brother was Béla Balázs, the avant garde movie director. His wife was the celebrated Hungarian poet Margit Kaffka, second wife was Stephanie Szilard (Leo Szilard’s sister). He left Hungary after the rightist takeover (1919), worked at the universities of Vienna, Göttingen, Prague, Berlin. In 1925 he moved to the Soviet Union, to Moscow University, later became head of the Biology Institute in Leningrad. Imprisoned under Stalin’s purges (1937), died probably of hunger in prison camp.

BAY ZOLTÁN – ZOLTAN BAY (1900 Gyula, Hungary – 1992 Washington, U.S.) studied in the Calvinist Gymnasium in Debrecen, at Budapest University and in Berlin. He was professor at Szeged University, then at the Budapest Institute of Technology, left Hungary in 1948, became professor at George Washington University, then at the American University in the U.S., received the *Boydén Premium* of the Franklin Institute “for overview on the topics of speed of light and based upon it, for his contribution to metrology” (U.S.). Member of the Hungarian Academy of Sciences, honorary member of the Eötvös Society, honorary Ph.Ds from Hungarian universities. He revisited Hungary several times. Buried in Gyula (Hungary).

BÉKÉSY GYÖRGY – GEORGE VON BÉKÉSY (1899 Budapest – 1972 Honolulu, U.S.) studied mainly abroad. Ph.D. at Budapest University (1923). Professor at Budapest University (1939). Left Hungary (1946), professor at Harvard University (1947). Member of the Hungarian Academy of Sciences (1939), U.S. National Academy of Sciences, American Academy of Arts and Sciences. Honorary doctor of the Medical School at Budapest (1969). 1961 *Nobel Prize in physiology* “for his discoveries concerning the physical mechanism of stimulation within the cochlea.” Buried in Hawaii (U.S.).

BÁRÓ VÁSÁROSNAMÉNYI EÖTVÖS LORÁND – ROLAND EÖTVÖS (1848 Budapest – 1919 Budapest) founder of Eötvös Society (1891), president of the Hungarian Academy of Sciences (1889–1905), rector of Budapest University (1891–1892), minister of education (1894). *Beneke Prize* of the Göttingen Academy (1909). Nominated for Nobel Prize among others by P.A. Lenard. Buried in Budapest.

ERDŐS PÁL – PAUL ERDŐS (1913 Budapest – 1996 Warsaw, Poland) left Hungary in 1930 but since 1948 he spent part of his time in Budapest. He was a citizen of Hungary through his whole life, spoke Hungarian, German, English equally well. Member of the American Academy of Arts and Sciences, Australian Academy, Royal Dutch Academy, Hungarian Academy of Sciences, Indian Academy of Sciences, New-York Academy of Sciences, Polish Academy of Sciences, Royal Society, U.S. National Academy of Sciences; honorary doctor at 15 universities, including the Eötvös University in Budapest. *Wolf Prize* (1984). Buried in Budapest.

GÁBOR DÉNES – DENNIS GABOR (1900 Budapest – 1979 London) attended the Toldy Realgymnasium, studied engineering in Budapest and Berlin, Ph.D. there (1927), worked at Siemens in Germany till 1933, at Tungsram in Hungary till 1934, left for England, worked at Thomson–Houston electric company, professor at the Imperial College (1958). Fellow of the Royal Society (1956), honorary member of the Hungarian Academy of Sciences (1964), foreign associate of the U.S. National Academy of Sciences (1973). Michelson Medal of the Franklin Institute (1968), Rumford Medal of the Royal Society (1968), Commander of the Order of the British Empire (1970), Holweck Prize of the French Physical Society (1971), honorary Ph.D. at seven universities. 1971 *Nobel Prize in physics* “for his invention and development of the holographic method”. He revisited Hungary several times. Buried in London. There is an international Dennis Gabor Medal, donated for inventions in optics (Buda-

pest). The street leading to the Institute of Medical Optics at the Medical School in Munich is named Gaborstrasse (memorial plaque in the Institute). In Nottingham, Gabor Street crosses Nobel Avenue.

CARLETON D. GAJDUSEK (1923 Yonkers, N.Y., U.S. –). His (Slovakian) father, Karl Gajdusek was born in Senica (then Hungary, now Slovakia), emigrated to the U.S. before World War I, there he married Ottilia Dobroczi whose (Hungarian) parents were born in Debrecen, Hungary. Gajdusek spent time in his childhood in Hungary. He enjoyed mathematics and science at the University of Rochester, then studied at Harvard Medical School. He studied the virology of tropical diseases on different continents. He revisited Hungary and Slovakia several times. 1976 *Nobel Prize in physiology and medicine* “for discoveries concerning new mechanisms for the origin and dissemination of infectious disease.” He visited Hungary and Slovakia several times.

GRÓF ANDRÁS ISTVÁN – ANDREW S. GROVE (1938 Budapest –) graduated in Madách Gymnasium (1955), enrolled at the Budapest Institute of Technology. Left Hungary (1956), studied in New York, Ph.D. in chemistry at the University of California in Los Angeles. Leader of development at Fairchild, then one of the founders (1968), president (1979), chief executive (1987) and director of the board (1997) at Intel, world's largest microprocessor producer. Honorary Ph.D. at City College, New York. Honorary Dr. Ing. at the Worcester Institute of Technology (Washington). Member of the American Academy of Arts and Sciences, fellow of the National Academy of Engineering (U.S.) Awarded by the Neumann Medal of the Hungarian Society of Computer Science (1995). He lives with his wife in Los Angeles.

GROSSMANN MARCEL – MARCEL GROSSMANN (1878 Budapest – 1936 Zürich) was the son of Jules Grossmann, who owned a factory in Budapest. Marcel's mother tongue was German, but studied in Hungarian, attended primary school and gymnasium in Budapest (Markó utca) as his brothers did. The whole family moved to Switzerland in 1893, there Marcel finished his gymnasium studies (1896), studied at the Eidgenössische Technische Hochschule in Zürich with Albert Einstein (diploma 1900), worked in Frauenfeld (1901) and Basel (1907), then at ETH in Zürich (1907) where he became professor. Einstein elaborated the mathematical aspects of general relativity with Grossmann. The international biannual conference on general relativity is called Marcel Grossmann Meeting.

HARSÁNYI JÁNOS– JOHN C. HARSANYI (1920 Budapest –) attended the Lutheran Gymnasium in Budapest, won the National Student Competition in mathematics, studied at the universities of Budapest, Ph.D. in philosophy at Budapest University, left Hungary (1950), emigrated to Australia. Ph.D. in mathematics at Stanford University. Professor in Berkeley (1964). Member of the U.S. National Academy of Sciences (1992), the American Academy of Arts and Sciences (1984), honorary member of the Hungarian Academy of Sciences (1995). Honorary Ph.D. from University of Sydney, Northwestern University, and Budapest School of Economics (1995). Honorary member of the Eötvös Society (1995). 1994 *Nobel Prize in economics* “for his pioneering analysis of equilibrium in non-cooperative games.” Revisited Hungary recently.

HEVESI HEVESY GYÖRGY – GEORGE DE HEVESY (1885 Budapest – 1966 Freiburg, Germany) studied at the Gymnasium of the Piarist Order in Budapest, left Hungary (1920). Member of 15 academies including Academia dei Lincei, International Academy of Astronautics, Royal Society, Danish, Pontifical, Swedish Academies. Honorary member of the Hungarian Academy of Sciences (1945). Honorary professor of Medical and Technical Universities in Budapest, and 11 other universities. Faraday Medal (1950), *Atoms for Peace Award* (1959). Niels Bohr Medal (1961). 1943 *Nobel Prize in chemistry* “for his work on the use of isotopes as tracers in the study of chemical processes,” received in 1944. Citizen of Hungary till 1944, then Swedish citizen. Buried in Freiburg. (Hevesy Award and Hevesy Lecture of the International Association of Nuclear Medicine. Hevesy Medal of the Hungarian Society of Nuclear Medicine.)

KÁLDOR MIKLÓS – LORD KALDOR (1908 Budapest – 1984 London) studied at the Minta Gymnasium in Budapest and after finishing the last grade in three months, at age 17 studied economics in Germany. He became professor at the London School of Economics, later at Kings College in Cambridge. He was advisor of Prime Minister Harold Wilson on taxation, made Lord by the Queen of England.

SZŐLLŐSKISLAKI KÁRMÁN TÓDOR – THEODORE VON KÁRMÁN (1881 Budapest – 1963 Aachen, Germany) studied at the Minta Gymnasium in Budapest, won the Eötvös Competition, diploma at the Budapest Institute of Technology, left Hungary (1919). Professor at the University of Aachen, left for the U.S. (1933), founder of the Jet Propulsion Laboratory in Pasadena, U.S. (1944). After World War II he revisited Hungary twice. Fellow of Royal Society. U.S. Freedom Medal (1956). First *National*

Award of Science from President Kennedy (1959). Gauss Medal, Watt International Medal. Honorary Ph.D. at the Budapest Institute of Technology (1962) and at 28 other universities. Founder of the International Astronautical Academy. Buried in Hollywood (U.S.).

KEMÉNY JÁNOS GYÖRGY – JOHN G. KEMENY (1926 Budapest – 1992 North Hampshire, U.S.) studied in the Berzsenyi Gymnasium in Budapest, left Hungary (1940), Ph.D. in Princeton, U.S. citizenship (1945). Professor and president of Dartmouth College. He received the prize of the New York Academy; first *Robinson Prize* of IBM (1991). Member of the American Academy of Arts and Sciences, honorary member of the Eötvös Society. Honorary Ph.Ds at 19 universities. Buried in Hanover, New-Hampshire (U.S.).

KLEIN GYÖRGY – GEORGE KLEIN (1925 Budapest –) studied in the Berzsenyi Gymnasium, survived the Holocaust by hiding in Budapest, then studied medicine at the universities of Szeged and Budapest, emigrated to Stockholm (1947), became head of the Department of Tumor Biology at the Karolinska Institute, member of the Hungarian Academy of Sciences, the Swedish Royal Academy, and the Nobel Committee in Physiology and Medicine. Winner of the Letterstedt Prize (Stockholm).

KLEIN OSZKÁR – OSCAR KLEIN (1894 Stockholm – 1977 Stockholm). His father, Gottlieb Klein (1852–1914) was born in Homonna, now Humenne (Hungary, now Slovakia), attended school in Hungary, studied in Heidelberg and Berlin, became a rabbi, moved to Stockholm (1883), lectured at Uppsala University as honorary professor (1897) and is buried in Stockholm. His son, Oscar Klein became professor of theoretical physics at Stockholm University (1930–1962), worked with Niels Bohr in Copenhagen on quantum mechanics: Klein–Gordon-equation, Klein–Nishina formula for scattering light on electron, Klein paradox, Jordan–Klein quantum field theory, and a geometrical interpretation of gravitational and electromagnetic field in five dimensional space-time. Member of the Danish and Swedish Academies, Max Planck Medal. Gottlieb and Oscar Klein are buried under the same tomb in Stockholm. (The Royal Swedish Academy issued a Klein Medal and organizes Klein Lecture every year.)

KORDA SÁNDOR – SIR ALEXANDER KORDA (1893 Pusztaturpásztó–Hungary – 1956 London) attended school in Mezőtúr, then in the Commerce School in the Mester utca, Budapest. In the 1920s editor of the first Hungarian movie magazines. As a consequence of his political ac-

tivities he had to leave Hungary (1919) to Germany, Hollywood, then settled in London as film producer and director. Knighted in 1941.

KÖSZTLER ARTUR – ARTHUR KOESTLER (1905 Budapest – 1983 London) was born “in the year of the birth of the theory of relativity,” as he said. (His father, Köszler Henrik came from Miskolc.) Arthur studied in the Kemény Zsigmond Realgymnasium in Budapest. Left Hungary (1919), studied at the Technical University in Vienna, but “thought in Hungarian” till 1929. (Till 1940 in German, than in English.) He traveled with Hungarian passport till 1939. Later he possessed English passport and lived in Oxford. Revisited Hungary repeatedly. Fellow of Royal Society for Literature and the Royal Astronomical Society. *Sonning Prize* of the Copenhagen Academy (1968).

KÜRTI MIKLÓS – NICHOLAS KURTI (1908 Budapest –) studied in the Minta Gymnasium in Budapest, left Hungary (1929), citizen of Hungary till 1939, then British citizen, professor of Oxford University. Fellow of Royal Society, member of Hungarian Academy of Sciences, Academia Europaea. Honorary member of the Eötvös Society. Professor emeritus of the University of Oxford. First recipient of the *Fritz London Award* of the International Union for Pure and Applied Physics (1958). He lives in Oxford, visits Hungary frequently.

LÁNCZOS KORNÉL – CORNELIUS LANCZOS (1893 Székesfehérvár, Hungary – 1974 Budapest) studied at the Gymnasium of the Cistercian Order in Székesfehérvár, at the Budapest University, assistant at the Budapest Institute of Technology, Ph.D. at Rudolf Ortway at Szeged University (1921). Left Hungary for Germany (1921), then to the U.S. (1931), professor at Purdue University, U.S. citizen (1938). Moved to the Institute for Advanced Studies in Ireland (1954). He revisited Hungary twice. Honorary Ph.D. at Trinity College (Cambridge, U.K.), National University (Dublin), University of Frankfurt (Germany). Member of the Irish Academy of Sciences. Honorary member of the Eötvös Society. Chauvenet Prize of the American Mathematical Society (1960). Buried in Budapest.

LAX PÉTER – PETER LAX (1926 Budapest –) studied in Minta Gymnasium, left Hungary (1941), U.S. citizen (1944). Past director of the Courant Institute of Mathematics at New York University. Member of the American Academy of Arts and Sciences, Russian Academy, Hungarian Academy. Chauvenet Prize (1974) of the American Mathematical Society, Semmelweiss Medal (1975), Wiener Prize (1975), U.S. National Medal of Science (1986), *Wolf Prize* (1987). He visits Hungary frequently.

LENARD FÜLÖP – PHILIPP EDUARD ANTON VON LENARD (1862 Pozsony–Hungary, now Bratislava–Slovakia – 1947 Messelhausen–Germany.) From a family of Austrian origin he was born a citizen of Hungary, spoke German and Hungarian. Studied in the Royal Hungarian Catholic Realgymnasium in Pozsony–Bratislava, at the universities of Budapest, Heidelberg, Berlin, Ph.D. in Heidelberg (1886). Assistant at the Universities of Budapest (1886–1887), Heidelberg (1887–1888), Bonn (1890–1893). Professor in Heidelberg (1896–1931). Member of the Hungarian Academy of Sciences, for which a precondition is Hungarian citizenship (1897). Later German citizen. Baumgartner Prize (Vienna, 1896), Rumford Prize (Royal Society). 1905 *Nobel Prize in physics* “for his work on cathode rays.” Buried in Messelhausen (Germany).

MEZEI FERENC – FERENC MEZEI (1942 Budapest –) studied in the Rákóczi Gymnasium, won the Eötvös Competition, studied at Budapest University. Member of the Hungarian Academy of Sciences and the Academia Europaea. Past chairman of the Scientific Council of the Hahn–Meitner Institute in Berlin. *Hewlett-Packard Prize* of the European Physical Society (1984). Szilard Award of the Hungarian Nuclear Society (1994). European Cathedra at Eötvös University in Budapest (1994).

MARGITTAI NEUMANN JÁNOS – JOHN VON NEUMANN (1903 Budapest – 1957 Washington D.C., U.S.) studied at the Lutheran Gymnasium in Budapest, left Hungary (1923), studied chemical engineering in Zürich (1923–1926), Ph.D. in mathematics in Budapest (1926), assistant in Göttingen (Germany). Professor at the Princeton University (1930). U.S. citizen (1937). Member of the U.S. Atomic Energy Commission (1954), U.S. National Academy of Science, American Academy of Arts and Sciences, Academia dei Lincei, Royal Dutch Academy, etc. Honorary member of the Eötvös Society (1940). *Fermi Award* (1956), the Order of Merit, U.S. Freedom Medal from Dwight Eisenhower (1956). Buried in Princeton (U.S.).

NEUMANN MARINA – MARINA VON NEUMANN WHITMAN (1935 Princeton –) was born in the U.S. but her father (John von Neumann) and mother (Marietta Kövesi) were born in Budapest. She graduated from Ratcliffe College (1956), Ph.D. at Columbia University (1962). Chief economist at General Motors, senior staff economist of the Executive Office of President Nixon (1970–1973), member of the President’s Advisory Committee on trade policy (1987–1993). *Columbia Medal for excellence* (1973). Member of the American Academy of Arts and Sciences.

OLÁH GYÖRGY – GEORGE OLAH (1927 Budapest –) studied in the Gymnasium of the Piarist Order in Budapest, at the Budapest Institute of Technology, Ph.D. there (1949) and became professor. He left Hungary in 1956, moved to London, then to Canada, then to the U.S. (1965), became professor at Case-Western University, then at the University of Southern California. Michelson–Morley Prize (1988), Roger Adams Prize (1989). Member of the U.S. National Academy of Science (1976), Italian National Academy (1982), European Academy of Arts and Sciences (1989), honorary member of the Hungarian Academy of Sciences (1990). Honorary Ph.D. at the universities of Durham, Munich, Crete, and the Budapest Institute of Technology (1989). 1994 *Nobel Prize in chemistry* “for his contribution to the chemistry of carbocations.”

OROWÁN EGON – EGON OROWAN (1902 Budapest – 1989 Cambridge, Massachusetts, U.S.) attended high school in Budapest, left Hungary for University in Vienna (1920). Diploma (1928), Ph.D. (1932), later assistant at the Technical University in Berlin. He worked for Tungstam in Budapest on krypton (with Imre Bródy) and metallic plasticity (with Michael Polányi) in the 1930s, then left for England (Birmingham, Cambridge) (1937–1950). Thomas Hawksley Gold Medal in England (1944), Gauss Medal in Germany (1968) etc. Fellow of the Royal Society, member of the American Arts and Sciences (1951), U.S. National Academy of Sciences (1969), Göttingen Academy of Sciences (1972). From Cambridge (U.K.) he moved to the Massachusetts Institute of Technology (Cambridge, U.S.) (1950), buried there in the Mount Auburn Cemetery.

POLÁNYI JÁNOS – JOHN CHARLES POLANYI (1929 Berlin –) lives in Canada. His parents, Michael Polányi and Magda Kemény were born in Budapest. John studied in Manchester, is professor at Ontario University in Canada (1962). Fellow of the Royal Society of Canada, Royal Society of England, foreign member of the American Arts and Sciences, U.S. National Academy of Sciences. Wolf Prize (1982). 1986 *Nobel Prize in chemistry* “for contribution to the development of a new field of research in chemical reaction dynamics.” He visited Hungary.

POLÁNYI MIHÁLY – MICHAEL POLANYI (1891 Budapest – 1976 Oxford, England) attended the Minta Gymnasium and the Medical School in Budapest. Assistant of George de Hevesy in the Physics Institute of Budapest University. Left Hungary (1919), Ph.D. in Karlsruhe (Germany, 1933), “member for life” of Kaiser Wilhelm Institute for Physical Chemis-

try in Berlin. Professor of chemistry (1933), later philosophy (1988) at the Victoria University in Manchester. Fellow of the Royal Society. E.P. Wigner was his Ph.D. student.

IFJ. SIMONYI KÁROLY – CHARLES SIMONYI (1948 Budapest –) attended the Rákóczi Gymnasium, left Hungary (1966). Ph.D. at Stanford University. Joins MICROSOFT (1981), *chief architect* at this largest software producer.

SOROS GYÖRGY – GEORGE SOROS (1930 Budapest –) studied in the Berzsényi Gymnasium, left Hungary for London (1947), graduated at London School of Economics (1952), moved to the U.S. (1956), U.S. citizen (1961). Billionaire; philanthropist on world scale. Honorary Ph.D. at Budapest School of Economics (1994).

NAGYRÁPOLTI SZENT-GYÖRGYI ALBERT – ALBERT VON SZENT-GYÖRGYI (1893 Budapest – 1986 Woods Hole MA, U.S.) studied at the Calvinist Gymnasium and the School of Medicine in Budapest, professor at Szeged University. Corresponding member (1937), later ordinary member (1938) of the Hungarian Academy of Sciences, U.S. National Academy of Sciences. 1937 *Nobel Prize in physiology* “for his discoveries in connection with the biological combustion processes, with special reference to vitamin C and the catalysis of fumaric acid.” He left Hungary (1948). U.S. citizen (1954). Revisited Hungary several times. Buried in Woods Hole, MA, U.S.

SZILÁRD LEÓ – LEO SZILARD (1898 Budapest – 1964 La Jolla, U.S.) attended the Kemény Zsigmond Realgymnasium in Budapest, won the Eötvös Competition, enrolled at the Budapest Institute of Technology. Left Hungary (1919), Ph.D. at Max von Laue in Berlin. Citizen of Hungary until 1943, then citizen of the U.S. Einstein Award (1958). *Atoms for Peace Award* (1959). Member of the U.S. National Academy of Sciences (1961). Buried in La Jolla, California, U.S. (Szilard Award at the American Physical Society for services in physics and society interrelations. Szilard Prize of the Hungarian Nuclear Society for achievements in nuclear technology and in spreading nuclear culture.)

TELEGDI BÁLINT – VALENTINE TELEGDI (1922 Budapest –) left Hungary (1923), studied chemical engineering in Lausanne. Professor in Chicago and Zürich, worked at Fermilab, Argonne, and CERN. Member of the U.S. National Academy of Sciences, American Academy of Arts and

Sciences, Hungarian Academy of Sciences, Italian academies. Honorary member of the Eötvös Society. Honorary Ph.D. of Eötvös University. Enrico Fermi Distinguished Service Professor in Chicago. *Wolf Prize* (1991). He lives in Geneva, Switzerland, visits Hungary frequently.

TELLER EDE – EDWARD TELLER (1908 Budapest –) studied in the Minta Gymnasium, won the Eötvös Competition, enrolled at the Budapest Institute of Technology. Left Hungary (1928). Studied in Karlsruhe, Ph.D. at Heisenberg in Leipzig. Citizen of the U.S. (1941) and Hungary. U.S. Einstein Prize (1958). *Fermi Award* from J.F. Kennedy (1962). *National Award of Science* from President Reagan (1986). Honorary member of Hungarian Academy of Sciences (1991) and Eötvös Society. Honorary Ph.D. at the Budapest Institute of Technology (1991), Debrecen University (1996) and Veszprém University (1997). Honorary professor of Eötvös University. Szilard Award of the Hungarian Nuclear Society (1993). He lives in California, visits Hungary frequently since 1990.

TISZA LÁSZLÓ – LASZLO TISZA (1907 Budapest –) studied at the Werbőczy Gymnasium and Mathias Gymnasium, won Eötvös competition. Studies, later assistant, Ph.D. at Budapest University (1932). Left Hungary (1930). Worked with Landau at Charkov University, U.S.S.R. (1935–1937). College de France (1937–1940). Moved to the U.S. (1941), now professor emeritus at MIT, lives in Cambridge, Massachusetts. His 90th birthday was celebrated at M.I.T. Honorary member of the Eötvös Society, visits to Hungary.

WIESEL ELIÉZER – ELIE WIESEL (1928 “Sziget”, Sighetul Marmatiei, Romania, former Máramarossziget –) mother tongue Yiddish, speaks also Hungarian. Gymnasium graduation in Debrecen (Hungary), taken to Buchenwald Concentration Camp from Máramarossziget (then Hungary), lost all his family in the Holocaust, only he survived (1944). University studies in Paris and U.S., U.S. citizen (1963). Now professor at Boston University, received the Medal of the Congress from President Reagan, became chairman of “The Presidential Commission of the Holocaust.” 1986 *Nobel Prize for peace*: “*His message is one of peace, atonement, and human dignity. His belief that the forces fighting evil in the world can be victorious is a hard-won belief.*” Revisited Romania and Hungary.

WIGNER JENŐ PÁL – EUGENE P. WIGNER (1902 Budapest – 1995 Princeton) studied at the Lutheran Gymnasium, left Hungary (1921), Ph.D. in Berlin, moved to the U.S. (1930), professor at Princeton University. U.S.

citizen (1937). Revisited Hungary several times since 1976. Honorary member of the Eötvös Society (1977). Honorary Ph.D. at Eötvös University (1987). Member of the U.S. National Academy of Science, Hungarian Academy of Sciences. U.S. Medal of Merit (1946), *Fermi Award* (1958). *Atoms for Peace Award* (1960), Franklin Medal, Max Planck Medal (1961). Szilard Award of the Hungarian Nuclear Society (1992). Hungarian Order of Merit with Rubins (1994) "as acknowledgement of his scientific carrier and of his outstanding achievements in the enrichment of human values." President of American Physical Society (1956). 1963 *Nobel Prize in physics* "for his contributions to the theory of the atomic nucleus and elementary particles, particularly through the discovery and application of fundamental symmetry principles." Buried in Princeton, U.S.

ZSIGMONDY RICHÁRD – RICHARD ADOLF ZSIGMONDY (1865 Vienna, Austria – 1929 Göttingen, Germany) spoke both German and Hungarian. His parents were born in Hungary, his mother was Szakmáry Irma from Martonvásár. School in Vienna, then studied and worked in Göttingen. Ph.D. in Munich (1890). Berlin, Graz, Jena, then professor in Göttingen (1908). Member of the Austrian Academy. 1925 *Nobel Prize in chemistry* "for his demonstration of the heterogeneous nature of colloid solutions and for the methods he used, which have since then become fundamental in modern colloid chemistry." Buried in Göttingen (Germany).

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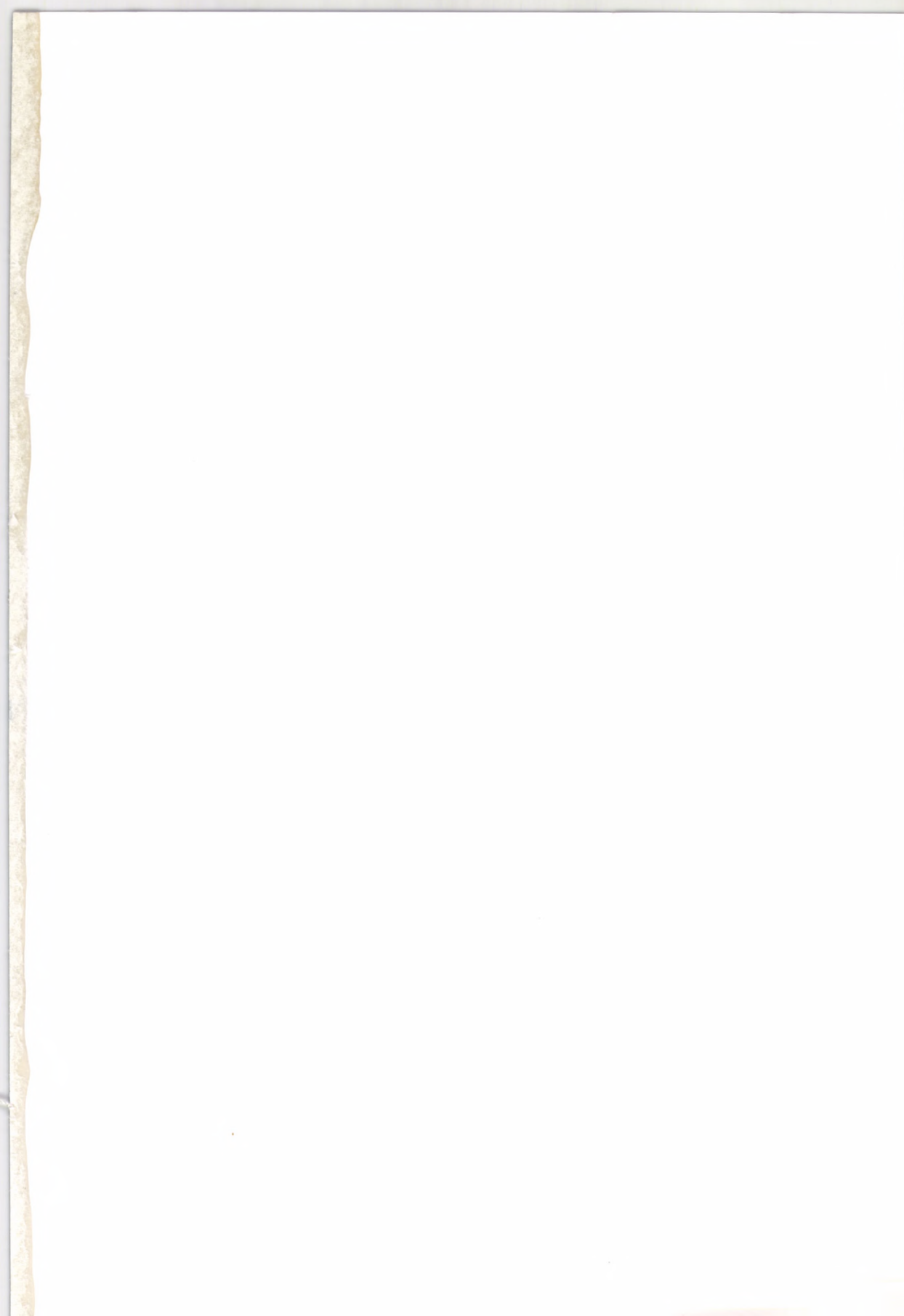
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“Budapest, in the period of the two decades around World War I, proved to be an exceptionally fertile breeding ground for scientific talent. It is left for historians of science to discover and explain the conditions that catalyzed the emergence of so many brilliant individuals”– Stanislaw Ulam has written, himself a member of the Manhattan Project to make the atomic bomb. Fritz Houtermans, who first recognized the nuclear origin of stellar power, has offered an *explanation*:

“The galaxy of scientific minds, that worked on the liberation of nuclear power, were really visitors from Mars. They found it difficult to speak English without an alien accent, which would give them away, and therefore they chose to pretend to be Hungarian, whose inability to speak any language but Hungarian without a foreign accent is well known. It would be hard to check the above statement, because Hungary is so far away.”

In the 1990s the world commemorated the fiftieth anniversary of the first man-made chain reaction in Chicago, the fiftieth anniversary of the explosion in Hiroshima, and of the fiftieth anniversary of the electronic computer. The “story of the atomic bomb” was told repeatedly by citizens of various nations. Leo Szilard, author of *The Voice of Dolphins* once said: – “I am going to write down all that is going in the Uranium Project, not for anyone to read, just for God.” – Hans Bethe then asked, – “Don’t you think God knows the facts?” – whereupon Szilard replied, – “Maybe he does, but he does not know my version of the facts.”

Well, this is a Hungarian version of the human quest of nuclear power, for fast information processing, for a scientific understanding of life, based mostly on interviews with the participants involved. The author knew most of these men and interviewed them personally; he journeyed to Chicago and Los Alamos, to Alamogordo and Chernobyl, to Hiroshima and Nagasaki. It will be left to historians in the future to judge the facts and myths, intentions and consequences.

