

## Remembering Yuval Ne'eman

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Yuval Ne'eman and the author in 2003 in the Hargittais' home in Budapest,  
by Magdolna Hargittai

In my semi-autobiographic book, *Mosaic of a Scientific Life*, I refer to Yuval Ne'eman as "Soldier, Scientist, Politician."<sup>1</sup> My first visit to Israel was in 1992 at the Ben-Gurion University of the Negev in Beer Sheva. I taught molecular structure in an intensive course as we had to cover the material for a whole term in 1 month. The lectures were in English followed by a consultation in Russian for new arrivals from the former Soviet Union. Every Israeli university invited me for a talk during that first visit. When I thought these adventures could not be topped, I received a lunch invitation to Jerusalem from Yuval Ne'eman, the minister of energy who also held the portfolio of the minister of science and technology. My hosts in Beer Sheva were quite surprised because the minister could have not been aware of every visiting professor in Israel let alone invited them for lunch. I understood that the invitation was not due to me as one of the many visitors in science, but to our shared interest in symmetry. I hasten to add that the two of us did not represent the same weight in symmetry

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<sup>1</sup> Istvan Hargittai, *Mosaic of a Scientific Life*. Springer Nature Switzerland AG, 2020, Chapter 32, "Yuval Ne'eman," pp 117–118.

studies. The theoretical physicist Ne'eman was a giant who made great discoveries in the symmetries of fundamental particles. This was our first meeting in person followed by other encounters over the following years. He visited us in Budapest, and we met in Stockholm when he was one of the principal lecturers in the “Symmetry 2000” meeting. I recorded a long conversation with him in Stockholm, which appeared in the *Candid Science* series.<sup>2</sup>

Yuval Ne'eman (1925–2006) was born in Tel Aviv and died there. His life could be the subject of a movie and probably will be some day. He attended the Technion—the Israel Institute of Technology—and graduated as an engineer and physicist. He earned his doctorate from Imperial College while, as a diplomat, he was representing his country in London and a few other European capitals. Few have achieved so much as Ne'eman in physics, and he could only devote half of his time to science. He held high-level functions in the Israel armed forces, especially in strategic planning. Toward the end of his career, he was much involved in domestic politics, founded a party quite on the right of the Israeli political spectrum. His role in politics was pregnant with contradiction. As it is well known, the religious parties are on the extreme right in Israel, and Ne'eman was an atheist. Their alliance was based on political expediency.

Ne'eman was no longer alive when the Higgs particle was finally observed whose existence had been predicted. Upon the appearance of experimental proofs, the theoreticians, Peter Higgs and François Englert, were awarded the Nobel Prize in 2013. When this happened, I remembered what Ne'eman told me about his own predictions in which he anticipated the mass of the then not yet discovered Higgs particle. He stressed this because he thought when the particle would finally be observed, his prediction might be forgotten. So, I felt it my duty to remind the physicists of Ne'eman's early contribution, which was most significant. I did this not because anything might have come out of it for the late Ne'eman—there is no posthumous Nobel Prize. I wrote to Steven Weinberg (1933–2021) as he was probably the foremost theoretician in the world in this area of physics at the time. I felt happy when I understood that I did tell Weinberg something he had not been aware of. Of course, Ne'eman's predictions and his conclusions following from his predictions had been properly recorded in bona fide publications.

There was another Nobel Prize many years before in which Ne'eman could have had a share. In 1969, Murray Gell-Mann (1929–2019) received it for developing the system of elementary particles and their interactions. The motivation for the Nobel Prize was carefully formulated because Gell-Mann was not the only discoverer. Independent of him, Ne'eman had also made related discoveries, and nobody would have been surprised had Ne'eman been a co-recipient. In total, Gell-Mann made more discoveries than Ne'eman, but this was not or should not have been a reason for omitting Ne'eman. What may have counted more was that Gell-Mann had a special gift for coining attractive, easy to remember, and easy to pronounce names for his discoveries, whereas Ne'eman's names were precise and scientific and, accordingly, dull and difficult that would not roll off one's tongue easily.

There was a third component of the difference between these two scientists. Gell-Mann was a physicist who did physics only, all his life. Ne'eman could devote only half of his time to physics in any given period of his life. The other half was taken up by Israeli politics and defense, as well as science policy and administration. Such a multitasking approach to one's activities might make a person hurried and exhausted, but my personal experience with

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<sup>2</sup> Magdolna Hargittai, Balazs Hargittai, Istvan Hargittai, *Candid Science: Conversations with Famous Scientists* Vols I–VI. Imperial College Press, London, 2000–2006.

Ne'eman showed the opposite. He was patient and always ready for a detailed explanation. There were university aspects of his life when he founded a department at Tel Aviv University, and he served the school as rector (president) for some time. It was easy to picture him as a pedagogue.

In his life, science, defense, and politics came together in unison. This found reflection in his view of history, too. When we discussed the Jewish anti-Nazi resistance, he counted among its cases not only the Warsaw Ghetto uprising, Hanna Szenes's heroism, or other armed actions but also the participation of Jewish physicists in the Manhattan Project, the development of radar, and other war-related research activities during World War II.

**Our Conversation  
in Stockholm during the “Symmetry 2000” Symposium, September 13–16<sup>3</sup>**



Yuval Ne'eman in 2000 in Stockholm, by Istvan Hargittai

*Would you please single out one or two of your scientific achievements?*

First chronologically – and in importance too, in my view - I should put the SU(3) Octet Model (1961).<sup>1</sup> This is the classification of the hadrons, namely the strongly-interacting “elementary” particles. As I shall explain, this was a matter of reading a pattern; while my

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<sup>3</sup> Magdolna Hargittai, Istvan Hargittai, *Candid Science IV: Conversations with Famous Physicists*. Imperial College Press, London, 2004, Chapter 3, “Yuval Ne'eman,” pp 32–63.

second key contribution<sup>ii</sup> provided the first glimpse at the structural explanation of this pattern (1962), namely the existence of a further layer, deeper down in the “onion” of matter (later to be known as “quarks”). Returning to SU(3), this work is often compared to the work of Mendeleev, who classified the chemical elements. Here in Sweden, the one-hundred-crown bill carries the picture of Linnaeus, who classified the plant and animal kingdom. It is the same mode of operation. My tool was Group Theory. I did this work during the last months of 1960 and it was published in 1961. At the time this model was not taken very seriously, because other models were favored by the physicists. The most popular one grew out of a basic idea of Fermi and Yang in the late forties. With the discovery of the pi-mesons, Fermi and Yang suggested that the proton and neutron and their antiparticles should be taken as the fundamental particles and that the pions are made out of them: the positively charged pion would then correspond to a proton bound to an antineutron, the negatively charged pion to a neutron bound to an antiproton, etc. This was then augmented in the so-called “Sakata model” by adding the  $\Lambda^0$  (carrying one unit of negative “strangeness”) and its antiparticle. Sakata was a Japanese physicist at Nagoya University who strongly believed in Marxist dialectical materialism [see my excerpts<sup>iii</sup> from his writings and from those of his school]. According to this dogma, there had to be, at the bottom of it all, some little hard basic “bricks” and this was the role they expected the proton, neutron and lambda (with their three antiparticles) to fulfill. Around the same time when I was working on my model (summer 1960), the Sakata team at Nagoya University was visited by Yukawa, who advised them to use Group Theory. The Nagoya school then identified SU(3) as their classification group, defined by the assignment of the Sakata model [p, n,  $\Lambda^0$ ] to be the defining representation. Note that I had heard about the model, but not about their use of Group Theory. My own approach was phenomenological, without any preconceived notions about which of the particles is more elementary. Returning to my application of Groups, I read about Lie Groups and looked at the rank-2 Lie groups, as I could see that the Strong Interactions appeared to conserve only two linear (additive) charges, or in other words, all interactions allowed by Isospin and strangeness conservation indeed occur. There were five such Lie algebras: A(2), the algebra of traceless 3 x 3 matrices, B(2) and D(2) which correspond to orthogonal transformations in 5 and 4 dimensions respectively, C(2) to symplectic (i.e. orthogonal, but with an antisymmetric metric) transformations in four dimensions, and G(2). When I constructed the root-diagram for G(2), it turned out to be a Star of David. Had I been a believer in miracles, I might have regarded this as some heavenly revelation and G(2) would have been suggested as “it” -- except for the fact that the fit with experimentation was rather lacking and the Sakata SU(3) remained as the main competitors to my octet until 1964 and the  $\Omega^-$  experiment. Meanwhile, I settled on SU(3) but with a different basic identification: the nucleon iso-doublet I assigned to an octet, together with the iso-singlet  $\Lambda^0$ , the iso-triplet  $\Sigma^+, \Sigma^0, \Sigma^-$ , and the iso-doublet  $\Xi^0, \Xi^-$ . The three  $\Sigma$  were very similar to the  $\Lambda$  and I had decided this meant that they should “dwell” together. The situation with the two  $\Xi$  was less clear, as their spin had not yet been measured with due precision, so that one of the first predictions of the model was that the spin  $J(\Xi) = 1/2$ , which was confirmed within the year. Another conclusion was that the nucleons should be considered as compound structures. I published my first scientific paper along these lines early in 1961. Almost at the same time, the Sakata group published their SU(3) model.

Perhaps I should fill in and explain how I came to be in London at the age of 35 working on this problem in the context of my PhD thesis. My original degrees were from the

Technion (the Israel Institute of Technology at Haifa, founded in 1912), in Mechanical and Electrical Engineering, first a bachelor's degree and after I had submitted a "project" I received a "Diploma", the equivalent of a master's degree. We were organized in the German academic system, and all my professors had indeed come from Germany. As a matter of fact, they did not speak Hebrew yet and read their lectures from a prepared text with the Hebrew written in Gothic characters. This was happening in 1941-45 and at the same time I was active in the Haganah (Jewish defense underground militia) and involved in lots of activities. Among other things, I specialized in light-weapons training and as such was busy training instructors or sometimes training particular individuals, such as the parachutists that were dropped in German-occupied Europe in collaboration with the British. For the British, they were doing liaison missions to the various underground organizations; while for the Haganah, they were collecting information on the status of the Jews in each country, on their safety and on Nazi crimes. This is how we started hearing about the Holocaust, very gradually. I trained Hannah Szenes, who was dropped over Hungary, was caught by the Germans and executed, a real heroine. In 1945 I also attended the Haganah Officers' School, which was then commanded by Yadin, the archeologist (Yadin, Dayan, and Allon, the three most brilliant future generals, got their training in Palestine in 1936-39 under Captain Orde Wingate – the future Allied commander in Ethiopia and in Burma). The officers' course I was attending included two-sided exercises and when my turn came, I managed to achieve complete victory (over two forces, each equal to mine – the only such result among 120 trainees), by inventing a new technique of preconceived plans based on an analysis of the terrain. The school umpire attributed the victory to luck. The years 1946-47 were spent mostly in Haganah operations, in a struggle for Immigration and Settlement (against British decisions).

I had meanwhile decided I would go into science. I had gone to the Technion out of a feeling of family responsibility – my grandfather had founded a Pumps Factory in Jaffa in 1900, my father had taken over in 1939 and some day I would have to. During the Technion years, however, I had reached the decision to go into science – perhaps combining this with my engineering responsibilities. I was not sure whether it should be mathematics or physics, but meanwhile tensions mounted and after working for a few months designing pumps in the family factory, I was fully mobilized in mid-1946. In 1947 the United Nations decided on the partition of Mandatory Palestine into a Jewish and an Arab State; the Jews agreed, but the Arab side refused and attacked the Jewish cities and settlements, in an attempt to conquer the entire territory and nullify the UN's decision. Prospects were very dim. Lord Attlee, the British Prime-Minister in 1947-49 has written in an article in the (London) Observer in 1958<sup>iv</sup> that when his government decided in 1947 to evacuate Palestine, he, Attlee, was doing it under the assumption that the Arabs would win and conquer [and exterminate?] us. He had been presented with this evaluation by General Montgomery, the Chief of the Imperial General Staff at the time and in 1958 he thus criticizes Montgomery's strategic thinking. I found myself commanding a unit in the field, first in the defense against the Palestinian Arabs, commanded by volunteer Bosnian and other officers who had served on the Russian front in 1943-45 in the Muslim division recruited for Hitler by the Grand Mufti of Jerusalem all over the Balkans and in some Arab countries (especially Iraq, where in 1941-42 the Dictator Rashid Ali el-Khilani's regime fought on Hitler's side, and Syria, which the Germans took over from Vichy France in 1940-41). After very difficult times in early 1948, we started having the upper hand – and then in May 1948, six Arab countries invaded Palestine in a last attempt to forestall the creation of the Jewish state. In the first stage of the 1947-49 War, I fought some tough battles and went through awful experiences, which I should better leave for other times, otherwise we shall never get to my scientific career. On one occasion – countering an attack by a large Arab force on one of our very isolated outposts (“the JNF building at Beit-Dagon”). I did have the satisfaction of full success, resulting from some

imaginative tactics on my part – as in the Officers' School exercise. In the second phase of that war, I commanded units on the Egyptian Front and was responsible for some of the more successful strategic or operational war-plans, especially our October 1948 counter-offensive. I have a nice testimonial to my role in Ben-Gurion's 1952 diary: the Chief of Staff, recommending me for the position of Defense Planner, refers to my having been “the brains” behind the successes on the Egyptian Front. In the last phase I was deputy commander of a brigade group, when I was transferred to the General Staff in the beginning of 1950. I served within the Operations Section, headed by General Rabin, both as his Deputy and as head of the Operations sub-section. It was then that I organized the Israeli Mobilization System, inspired by the Swiss. In 1951 I asked for leave to study physics in France (I was thinking of working with de Broglie) but I gave in to the entreaties of Generals Yadin (the archeologist, my commander at the Officers' school, now the Chief of Staff) and his deputy (General Maklev) and instead, I was sent to the French “Ecole d'Etat-Major” – a branch of the “Ecole Supérieure de Guerre” in Paris. I returned after a year and was appointed Head of Defense Planning. This position proved to represent a tremendous intellectual challenge, because it covered every aspect from Contingency War Plans – to designing the country – selecting the sites for future ports, cities, forests etc. I have told some of this in my evening lecture at the VIIth Marcel Grossmann Conference on General Relativity (Stanford, 1994) and it appears in volume 2 of the proceedings. I was transferred to the Intelligence Branch as Deputy Director General in 1955 and in this capacity in 1956 I dealt with the secret alliance with France and with the collusion with the French and English in the 1956 Suez-Sinai War. After that war there was a relaxation in tension and in the immediateness of the dangers to the country and I decided to go into science. It was my old dream, and I felt this might be my last chance, considering my age (I was 32). In addition, I had learned that Nathan Rosen, a former coworker of Einstein's, had joined the Technion and had created a Department of Physics in it. Now I had taught myself General Relativity and was captivated by the aesthetical aspect, due to symmetry. Here was a chance to work specifically in this area! I went down one floor, to see General Moshe Dayan, the Chief of Staff, whose office was just under mine and told him that I would like to take a two-years leave from the Army and try my hand (or rather my brain) at research in physics at the Haifa Technion. Dayan thought it over and came up the next day with a counter-suggestion. He was then in the process of selecting a Defense Attaché of Israel in London and his idea was for me to do it and combine these tasks with my studies. I accepted – I had heard of Bondi, Gold, and Hoyle and their Steady-State Cosmology and that Bondi was teaching in London. The attaché appointment included accreditation to our Embassies in Denmark, Norway, Sweden and Finland, in addition to the position at our Embassy to the UK in London. Also, I was Military, Naval and Air Attaché (in all 5 countries). Throughout my 3–4 years in this position, I made about 4–5 trips per year to Scandinavia.

*Did it work out, to do your studies parallel to your job?*

It went well in the beginning, i.e., in the first semester of 1958. Originally, I had intended to work on General Relativity with Bondi at King's College, but it was too far from the Embassy, with the whole of London traffic in between. However, I discovered Imperial College at a five minutes' walking distance. The catalogue cited a Professor Brockman in theoretical physics. I went to see him and told him I was interested in Einstein's Unified Field Theory. He reacted “I do not know about the Unified Field Theory, but if you want to learn

about Field Theory, go see Abdus Salam<sup>v</sup> in the old Huxley building”, which is how I got to Salam and to Group Theory.



Yuval Ne'eman in 1972 (courtesy of Yuval Ne'eman)

Salam laughed when I showed him my letter of introduction from Moshe Dayan, but he admitted me “on trial” and I became his graduate student. Whenever I could, I attended lectures. For the first time in my life, I was the oldest student in my group. Note that I used to be a “wunderkind,” having graduated from high school at 15, the youngest ever in Tel-Aviv. I made friends among the other students, Ray Streeter among them, and when I had to miss a lecture, I would copy Streeter’s notes – we had a copying machine in my office at the Embassy. Everything worked well in the spring of 1958, but things went wrong in the summer.

In July 1958, the Iraqis assassinated their king and prime minister, and the first dictatorship (General Kassem) followed in Iraq. In Egypt, the monarchy had been replaced in 1952 by a dictatorship, first under General Naguib, then under Gamal Abdel Nasser. The latter was conducting a Pan-Arab agitation all over the Arab world, endangering the traditional regimes in the Middle East. The Americans — worried about a possible “domino effect” reaching Saudi Arabia and Kuwait — landed in Lebanon, in an attempt at stabilization. The British wanted to drop two battalions of parachutists in Jordan, to protect King Hussein’s regime. To do it, they had to overfly Israel — and I found myself partaking in a negotiation in which we stressed that the new threat was even more a threat to Israel’s existence, and we requested (as a condition for the overflying) that we be given access to needed weaponry. The result was that we were allowed to purchase two submarines (our first) and fifty Centurion tanks (heavier than anything we had till then). This meant that come 1959, I found I could do no physics at all. I studied how the British trained their submarine crews, and I organized an adaptation to our conditions, namely training all levels in parallel, as we had never possessed submarines before. I also had to deal with the fifty Centurion crews. There was no more any

time left for physics. I complained – this was not the deal I had agreed to in my “negotiation” with Dayan. In May 1960, my replacement arrived (the new attaché) and I was granted a full year at Imperial College, now free of any other duties, courtesy of the Israeli Ministry of Defense (they would later recover the investment, by sending their bill to the Israeli AEC). As to the contents, Salam suggested a problem in quantum field theory, namely *the acquisition of mass by the vector-mesons in a Yang-Mills gauge theory* – a problem that was solved by Peter Higgs in 1965. I believe I have in fact given it another jump ahead in 1979-1990 with my SU(2/1) “Internal Supersymmetry”<sup>vi</sup> based on applying ideas in non-commutative Geometry (long before this discipline was invented as such...). However, by the time I was free to devote myself entirely to Physics I had also made my own choice of problem. I knew I wanted to work on the classification (and symmetries) of the “elementary” particles. By Emmy Noether’s theorems, symmetry also implies conserved charges, at least some of which would be dynamical and provide some understanding of the forces. With an understanding of the manner in which the electric charge is “situated” within this complex of charges, one might also be able to calculate electromagnetic mass-differences within a multiplet, magnetic moments, etc. By mid-1960, there were about a hundred “elementary” particles (mostly hadrons, with the new ones coming up mostly as resonance). I studied Salam’s lectures on Group Theory and started applying to the classification issue the groups he had presented in his course. I conceived various such ideas and would go see Salam each time there seemed to be a new way. On each such occasion he would listen to my new idea and react with “This has been tried by Schwinger in 1957; its weakness was ...” or “This has been done by Tiomno in 1958” etc. Salam was getting a bit impatient, and he kept reminding me of the problem he had suggested – rather than wasting my time on the classification. My own reaction was the opposite: if I was thus repeating history, it meant that I was at least neither stupid nor uninformed, since the best people in the trade had followed this path. It was encouraging, at least. When Salam saw that I was indeed determined to pursue this problem, he gave in, after warning me “You are embarking on a highly speculative project, without the security of the typical thesis topics – and you might fail to find something good within your allotted year!” But if you persist, go deeper into group theory, learn more than the little I taught – which is what I know”. He gave me some references, wished me good luck and left for the USA for the summer (of 1960).

When he returned in October, I showed him my SU(3) octet model. He was interested but also related that at a conference he had attended at Rochester, a Japanese group had reported work on the Sakata model, in which they were using the same SU(3) group, though in a completely different context. He had brought back a preprint, which he showed me. He told me to write up my theory and said he would add an idea he had had about “gauging” their SU(3) and getting an octet of vector-mesons – in this case these would be the same as the ones I had derived in my model as one of my predictions. [Note: all eight mesons were indeed discovered in 1961]. He would write up this bit and add it to my paper as a comment in a joint publication. He later (after I had waited for a month) changed his mind and told me to go ahead on my own and publish my model. One unfortunate result of my inexperience was that although I had worked out a nice notation (for the basis matrices, etc.) I changed to the Nagoya notation (thinking this was the rule, once they had issued their preprint), which was very ugly. Anyhow, I reedited the October manuscript and submitted it to the journal *Nuclear Physics*. Then, one day, Salam announced excitedly “Gell-Mann has just issued a preprint with the same model as yours!”

I immediately sent a copy of my manuscript to Gell-Mann. After a few days, my manuscript came back from *Nuclear Physics* with an angry letter, because it was not typed double spaced, and requiring me to do it again. I retyped it and added that I had learned that Gell-Mann had the same idea. My paper<sup>i</sup> carries a received date in February 1961; Gell-

Mann then submitted his to the *Physical Review* in March 1961. In June, Salam went to a meeting in La Jolla and came back with the news that experiments seemed to support the Sakata model, rather than the octet. Gell-Mann was also present at La Jolla and, therefore, in June he withdrew his paper. Later on, in September 1961, he submitted another manuscript, in which he described both the Sakata model and our own octet model, but did not commit himself to either. Gell-Mann's original manuscript was never published in a journal but only appeared three years later in a book *The Eightfold Way*, a collection of reprints, which we published together, after the model had been proven when I was at Caltech in 1964. This book was republished in December 2000.

When I felt confident about my model, I filled out all the forms for my doctorate. Before that I had only registered at Imperial College, but not at London University for a doctorate, as at the beginning I was not sure I would succeed in my work. Sometime after I had sent in the former, I was notified that the Board of Physics of London University had determined that I could work for my doctorate in electrical engineering but not in physics, considering my background at the Technion. This was already after the publication of my first paper, just as my new results were coming in. Salam called the Registrar of London University and told him about my work. The Registrar invited me for an interview and explained to me that they could not look into the affairs of each of their five thousand students. He invited me to resubmit my application and suggested to indicate "quantum theory" instead of "elementary particles" as my subject. In this case it could go to the Board of Mathematics instead of the Board of Physics, in order to avoid asking the physicists to go back on their word. Note that the Ph.D. title is in fact "in Science" and does not mention the precise discipline. This is how I ended up with Ph.D. under the aegis of Mathematics from London University.

My first publication thus proved to be important, although at the beginning only a few people believed in it. The Sakata model was very popular. For instance, I discussed my model with Victor Weisskopf, who visited Israel after I had returned home. Weisskopf thought it was nonsense. In his autobiography<sup>vii</sup> he mentions our meeting, but he does not mention our discussion of SU(3). He only tells a story I told him when we were driving and passing Mount Carmel, the biblical story of Elijah the prophet proving the superiority of his God when the prophets of Baal are destroyed by a sudden fire. I had commented that perhaps Elijah was using a hidden lens to ignite that fire. To Weisskopf, according to his comments, this revealed my bias for science... In any case, he avoids mention of our discussion re SU(3).

My second important contribution was the following. If you compare my first contribution with the works of Linneaus and Mendeleev – let's take the Periodic Table, for instance – it took more than four decades to explain correctly the foundations of the Periodic Table, namely the electronic structure of the atoms of any chemical element. The full explanation and understanding came as late as 1932, after both Pauli's Exclusion Principle and the discovery of the neutron. As regards my classification of the hadrons, I worried about the explanation from the very beginning; I wanted to understand the underlying principles of my model. It also met strong opposition based on the lack of a structural model. Even Eugene Wigner criticized me for not considering the proton to be a fundamental elementary particle.



Yuval Ne'eman (first row, first from the left) in a group of physicists attending the Eighth Nobel Symposium in Göteborg, 1968. Abdus Salam (1926–1996) is second row, third from the left and Murray Gell-Mann is second row, first from the right (courtesy of Yuval Ne'eman).

I was looking for another level of fundamental particles indeed, and I was working out its mathematical foundations. I arrived at a triplet, but I also found that it would have to have *fractional charges*. These particles we now call “quarks”. The proton would then already be a 3-quark composite. I developed my structural scheme in a paper. The first issue of *Nuovo Cimento* in 1963 contains a paper<sup>ii</sup> by me with H. Goldberg, dated February 1962. It took a long time to appear because at one point the editors lost my manuscript.

The *Nuovo Cimento* paper was submitted from Israel as I had returned home in the summer of 1961 and became the Scientific Director of one of the Atomic Energy Laboratories, which was at the reactor south of Tel Aviv on a campus close to the Weizmann Institute. I was still on leave from the Army. In 1962, I finally became a civilian.

Haim Goldberg came to work with me. He had a good preparation in group theory from G. Racah. I had come across Racah when I was the defense planner of Israel between 1952 and 1955. As such I represented Defense on the Atomic Energy Commission. In preparation for the development of Israel’ nuclear infrastructure, six people had been sent to good schools – e.g. to Zurich to work with Pauli and Weisskopf, and so to other places. They had all completed their master’s degree with Racah in Jerusalem. The only one who was not a former Racah student was Lipkin, who had immigrated from America to work in a kibbutz but then joined the project. Out of the six, five returned to Israel to work on the nuclear project. Originally the Israeli nuclear project was an extra motivation for me to become a physicist, on top of my original interest in the subject. In high school my main interest was mathematics, and my interest shifted to physics only after I finished high school. A series of lectures by Sambursky had an important impact. He was the first physics professor in Israel. He came in 1924 after his doctorate with Theodor Kaluza who is much talked about nowadays because of the Kaluza-Klein approach in string theory or in supergravity.

The other influence pushing me towards physics was a series of lectures at the Technion by Franz Olendorf who had just come from Germany. His lectures were on wave mechanics, and they were beautiful.

*When did you become aware of what was going on in Europe during WWII, what is now being referred to as the Holocaust?*

During the war I had no idea of what was really going on in the extermination camps. But we were trying to find out and this was also why we prepared and dropped parachutists like Hanna Szenes behind the German lines.

*There was the Auschwitz Reports.*

In America they knew but Roosevelt did not let anything like that be published. The BBC too got orders not to mention a word about it. Apparently, they were not very sorry about Jews being exterminated. They did not want it to interfere with their efforts and they did not care. I squarely believe that this was the case and I can illustrate my point with Attlee's article which I quoted earlier.<sup>iv</sup> When I was the Israeli Defense Attaché in England, in 1958, General Montgomery published his memoirs. In his book he criticizes Ernest Bevin, who was the Foreign Minister when the British left Palestine in 1948 – and Israel was fighting the War of Independence. About a week after the British forces' evacuation of Palestine, Montgomery, the Chief of the Imperial General Staff (CIGS) at the time, got a phone call from Bevin asking him to return troops to Palestine because the Jews had just taken Jaffa and that was against the British plans. Montgomery did not comply, explaining that they had left Palestine as planned and they could not reverse such things out of the blue. Some time later, in the London *Observer*, Clement Attlee, the British Prime Minister at the time of the events I just referred to, published a long review of Montgomery's book. The first page is full of praise for Montgomery. On the second page, however, he criticizes Montgomery's strategic abilities, citing as an example that when the British left Palestine, Montgomery had estimated that the Arabs would liquidate the Jews. Attlee says, "and we know what really happened", exposing Montgomery as having given him a wrong estimate. It is thus explicit that the British left Palestine on the assumption that we would be conquered and exterminated by the Arabs – or at least that there was a high probability for such a "happy end." And this is not Germany.

This is why I have no illusions about the motivations of suppressing the information about Auschwitz during WWII. There has been documentation about Roosevelt in America and it is now well known. In Britain it is less clear who gave the orders to the BBC and Foreign Office to suppress all information during the war.

*During the war the concentration camps were not bombed, neither were the railway lines. I recorded an interview with Joshua Lederberg, Nobel laureate, a man of broad activities and one who professes his Jewishness conspicuously. When I asked him about this issue of not bombing the concentration camps and railway lines, he defended and explained the non-action of the allies, saying, "It was not an optimum use of U. S. air power."*

It was criminal.

*Even though the American Jewry did not do much and could not do much then, it appears difficult even more than fifty years later to face history.*

It is a shame. We should also be more aware of Jewish resistance as for example, the uprising of the Warsaw Ghetto and the Vilna Ghetto. To me, the preparation for the Manhattan Project was also an act of Jewish resistance. When you read about the “refugees from Central Europe”, the year is 1938, and in 1938 only Jews were refugees, and Szilard works his way to the U.S.A. President through the Jewish lobby. When in August 1939 Einstein signs his famous letter, Europe is still not at war. In Britain, Peierls and Frisch follow the same scenario. All this is part of Jewish history.

*The sadder it is when great scientists are afraid of admitting errors of the past.*

Dick Feynman was a genius, but he fled from his Jewishness.

*Let's return to your story.*

I started telling you about Haim Goldberg joining me in the Atomic Energy Lab. I had continued to think about the existence of more fundamental structures underlying the hadron list. I found that mathematically we could have something like the Sakata model, but the particles would have to have fractional charges. In order to make an octet from triplets you need three triplets. You need three such quanta to make a nucleon. I did not give them names, but I explained that they had a baryon charge of  $1/3$  and how all the hadrons could be made of them. This was in my 1963 paper, and it was very mathematically presented, as I had no idea about the forces acting between the triplets, to make baryons. I only saw that structurally it would be a way of starting from a fundamental field. I sent out an Atomic Energy preprint to Gell-Mann and everybody else.

*Not giving names to what you discovered may have been a severe omission. How do you view this in hindsight?*

In general, I did not give “popular” names anyhow. I called the octet, octet and the symmetry “SU(3)”, and I talked about a Sakata-like triplet model.

*Could you be sure that what you found to be the fundamental particles would indeed be the last level?*

I only said that the present level could be explained by such a level underneath. It would be a fundamental field, yielding a three-quanta realization of the particles. The mathematics is all

there, the physics is discussed very briefly because I had no model of what would hold them together and how.

Gell-Mann's story is that about a year later, in the summer of 1963 he gave a talk at Columbia University. Robert Serber was in the audience. Gell-Mann talked about the octet and Serber asked him whether the octet could be made of something more fundamental. Gell-Mann agreed that there must be something like that and then went to work on his model. Lipkin has published a review in *Physics Reports* called "Quarks for Pedestrians,"<sup>viii</sup> a review of the whole quark model — in which he starts with what we did at the time, Goldberg and I, when very few people believed in the octet. According to Lipkin, had I stressed at that early stage that in the basis of my model there are particles with fractional charges, it would have been considered as a crazy notion.

*Did Gell-Mann quote your paper?*

He did not. He told me he had read it, but it did not "sink in". Only after Serber's question did he really think about these triplets. The first analysis of the birth of the quark model was done by Lipkin, in that 1974 review. Many years later there is a chapter to this effect in John and Mary Gribbin's biography of Feynman.<sup>ix</sup> They study the papers in depth and even end up criticizing the Nobel Foundation for disregarding my contributions.

There was also George Zweig at CERN who rediscovered my idea, although he thought of the quarks as actual particles. The Gribbins say that Gell-Mann chose to go in between the two approaches – or with both: like me he considers quarks as "a mathematical model" and "a field theory" but like George Zweig he also allows for the possibility of quarks as observable particles. Luckily, his paper appeared just when the results of the  $\Omega^-$  experiment were announced – and this attracted physicists. Here I'll have to open a parenthesis.

In the summer of 1962, about a year after my return to Israel, I attended the next high energy conference in Geneva, at CERN. I had intended to present experimental evidence for the octet and against the Sakata model, but the organizers of that session considered the octet to be wrong and did not allow me to. However, in the experimental section there was a report from Berkeley by the Goldhaber (Gerson and Sulamith) couple about K-meson scattering on nucleons – they had expected to find resonances but there were none in that channel. They were very disappointed but to me that was an indication about the assignment of the SU(3) representation particles produced in meson-baryon scattering. If you take an octet of baryons and you scatter on them an octet of mesons, they can go into a certain set of representations  $8 \otimes 8 \rightarrow [8_F \oplus 10 \oplus 10^8]_{as} \oplus [8_D \oplus 27]_{sym}$ . The "oldest" resonance of that type was Fermi's "3-3" (spin 3/2, isospin 3/2) and such an assignment exists both in "10" and in "27". The lack of a positive strangeness (from the K meson) resonance in the Berkeley experiment was now pointing unambiguously to a 10, and thus indicated the existence of the " $\Omega^-$ " particle (the one empty box in the 10 at that time) – again a name given by Gell-Mann... When I was 60, there was a *Festschrift* for me<sup>x</sup> and in it Gerson Goldhaber wrote a little article entitled "The Encounter in the Bus," which tells the story of what followed in 1962. I had heard that the Goldhabers had studied in Israel. When I took the bus from the hotel to CERN I noticed a couple in the bus. There were very few ladies in particle physics, so I took the chance, said "Shalom" – and indeed, these were the Goldhabers. I told them that they should not be sad about the missing resonance in their experiment. I gave them in writing the properties of the

missing particle. In the Plenary Session the next day, the scattering experiments were being reviewed, and I raised my hand. The chair, Professor Bogolyubov looked at me and said, “Professor Gell-Mann.” It turned out that Gell-Mann was sitting right behind me and he also wanted to speak, and the chair recognized him. Gell-Mann explained exactly what I had explained to the Goldhabers. The Goldhabers asked if I had told him, but this was not the case; it was just that Gell-Mann knew the theory as I did. That was when I met Gell-Mann, we had lunch, and this is when our association started. Gell-Mann at once suggested that I should come to Caltech and I did in September 1963, first as a postdoc but within one year they changed my appointment into a Visiting Professor. In 1964 the  $\Omega^-$  was indeed discovered at Brookhaven, and their official announcement mentioned our predictions.

*Can we then summarize that you did the classification of the elementary particles and the prediction of a fundamental particle,  $\Omega^-$ ?*

Yes, but also the first glimpse at the structure, quarks. In the concluding part of Luis Alvarez’s Nobel lecture in 1968 he talks about us, the theoreticians who identified the pattern, mentions the latter’s “beauty” - and assumes we shall soon be there, so that he does not have to explain it, since we can do it best. The next year, in 1969, Gell-Mann indeed got the Nobel Prize (there is no lecture by him in the Annals of the Nobel lectures, although he gave that lecture, because he never submitted his manuscript for publication). However, there is the presentation speech by Ivar Waller and we can read why they did not comply fully with Alvarez’s recommendation.

*Were you present?*

No. He did not invite me although, for example, Alvarez invited his whole group in 1968. This was different, however, and I would not have come, anyhow. Gell-Mann too may have felt bad about me not sharing the prize – I do not know. I stayed with him for two years at Caltech and we were treated there as equally responsible for these discoveries. . There was an hour-long BBC film about us and the discovery of  $\Omega^-$ , with Feynman as the narrator.<sup>xi</sup>

In 1968 there was a conference on elementary particles organized by the Nobel Foundation. I was there and Gell-Mann and Salam were there. At some point Ivar Waller of the Nobel Committee for Physics came to see me, but he was completely uninterested in what I had done. All he wanted to know was whether Salam had anything to do with it or not. Then he wrote in his laudatio about what Gell-Mann did and added that this was also done by Ne’eman “somewhat later”. This is not true. Even Gell-Mann’s biographer George Johnson<sup>xii</sup> writes that when Murray asked someone at Caltech about Lie groups (his first step on the way to SU(3)), I had already done my paper. Besides, his paper was finally never published, except in our joint book in 1964.<sup>xiii</sup>

In 1969, Isidor Rabi – who seemed to have some information about that Nobel affair – told me that the Nobel Prize for Gell-Mann alone was a way out for the Nobel people who were having pressure exerted on them by the British, who were strongly for Salam and either uninterested or even antagonistic in my case. I also got some direct indications of this dislike in 1980, when I was nominated by the USA and Israel for the vice-presidency of IUPAP and the British vetoed it. I believe this may have changed since.

I would like to mention one more area of my scientific activities. In 1979, I decided to go into politics because I found Begin's territorial surrender policies dangerous for the security of Israel. At the same time, I had a new idea about a certain type of symmetry. It is a supersymmetry using a superalgebra. That means that you mix commutators and anticommutators. Ordinary supersymmetry relates bosons to fermions or fermions to bosons. This symmetry  $SU(2/1)$  came to me intuitively because of certain work I had done before that. I called it an "internal supersymmetry". It was a completely different thing. There were no transitions between bosons and fermions instead it goes between left and right chiralities; and yet it works with a superalgebra. About a month after me, David Fairlie in Durham, England had the same idea, though coming from a completely different direction. He published his paper two issues after mine in *Physics Letters*. Both appeared in 1979.<sup>vi</sup> I was puzzled by my own work because it was a completely new subject mathematically and yet it gave important predictions. It predicted, for instance, the mass of the Higgs meson, which the Weinberg-Salam model does not predict. People had been looking for the Higgs meson all the way from 1 GeV and it is not there up to 50 or 60 GeV. It has not been found yet.<sup>xiv</sup> They are waiting for the new accelerator, the LHC, which will be completed in 2005. My model predicts that the mass of the Higgs is twice the mass of the W, which is 85 GeV, so it will be 170 GeV. However, there is a renormalization correction because at high energy the mass is a function of energy. The energy at which this Pythagorean result holds is a higher energy. We calculated the mass of the Higgs at lower energy, and it comes out as  $130 \pm 10$  GeV. My prediction is the only prediction in the field. No other theory says anything about the Higgs – except for ordinary supersymmetry, which then requires the existence of lots of new particles

I worked a lot with a French student I had, Jean Thierry-Mieg and with Shlomo Sternberg, a mathematician at Harvard, on understanding the new concept behind that superalgebra, which produced such a completely new type of symmetry. It was like M. Jourdan one of Moliere's characters who was "talking prose" all his life without being aware of it... It turned out that I "applied" non-commutative geometry ten years before it was invented. In 1991, two physicists, Coquereaux and Scheck, showed that in non-commutative geometry, if you derive the Weinberg-Salam model, you also get my algebra. I had constructed an algebra that is now fully understood in terms of non-commutative geometry. This was one of the two mathematical theories of which my theory of 1979 was a precursor. The other was the so-called "theory of the superconnection" worked out by the mathematician D. Quillen in 1985.

If and when the Higgs will be found and its mass measured, I would now like to advertise my theory and people to know that I had predicted it. I have suggested to my co-inventor, David Fairlie, that we should collect our reprints in a volume, for example, or a review in *Physics Reports*. David is still worried about some things and wants to calculate some quantities to make it easier to understand our approach. The name of the supergroup is  $SU(2/1)$ . It is now all published material, it is all there, and I only want people to know about it.

*Compared with Gell-Mann and other physicists, what is the fraction of your career that was devoted to physics?*

I only became a physicist at the age of 33. Even then I was also involved in the nuclear project in Israel, as scientific director of a large laboratory. Later I was one of the founders of Tel Aviv University and I founded its Physics Department. I had a large share in the fight for getting Jewish scientists out of the Soviet Union. I organized a world system for that. For

example, Arno Penzias, co-recipient of the Nobel Prize in Physics for 1978, went straight to Moscow from the Nobel ceremonies in Stockholm. He gave the same talk in an apartment seminar in Moscow as he did in Stockholm. These were “Refusenik” Seminars, and I was involved in starting and supporting this activity. There were articles in *Izvestiya* considering me as the arch enemy of the Soviet Union. I had called up Penzias one day (he was then at Bell Labs) and told him about our fight, about Levich and others, and he understood the problem at once and joined me in our efforts. There were others, however, who would not touch this problem. My pioneering intervention is even documented in writing.

While I was at Caltech in 1965, a friend, Ivor Robinson of Dallas, Texas showed me the *New York Times* with a letter signed by Landau and Lieberman. Landau was the famous physicist, Nobel laureate and Lieberman, the famous economist in the Soviet Union. The letter is a Letter to the Editor protesting the accusations that the Soviet Union is not tolerant to the Jews. They state that their own careers constitute proof that Jews can make it to the top in the Soviet Union. They suggest that Americans should rather deal with their own racial discrimination. I knew that Landau had had his accident in 1962 and was in bad shape (he was indeed in a “vegetable” state, but I did not know that) at that point. I believed he would not have signed such a letter, except under threats. I drafted an answer and immediately called various people inviting them to co-sign my letter. My Caltech friends did not want to, Rabi did not want to. The non-Jewish Dyson agreed, Chandrasekhar agreed, and Felix Bloch, who was then the President of the American Physical Society, told me, “Make it tougher,” and he also signed it.

*How do you explain Feynman’s and Gell-Mann’s reticence?*

I have written about Feynman’s weaknesses on his Jewish side for the Israeli paper *Ha’arets* in Hebrew, and it also appeared in the New York *Herald Tribune* in English.<sup>xv</sup> Feynman never visited Israel, for instance.

*Some prominent Hungarian Jews are famous for hiding their Jewish identity.*

But then there are Hungarian Jews like Theodore Herzl, the founder of Zionism and of the State of Israel – although for some time his was also a rather assimilationist Jewish family. Such an attitude of denying one’s roots puzzles me especially when a Nobel laureate does it.

*At what level of recognition and achievement would such a person feel comfortable himself?*

When I was looking for support for Soviet Jewry I learned a lot of lessons in this respect. I had a long conversation with Ernst Chain, the Nobel Laureate in Physiology or Medicine (1945), who received the prize together with Alexander Fleming and Howard Florey for penicillin. Chain told me that he was a Foreign Member of the Soviet Academy of Sciences, so he refused to help. On the other hand, Melvin Calvin signed the letter and helped in our fight. There were examples of both kinds of behavior. Rabi’s justification for not signing the letter was that he was afraid that the Jews in Russia would pay for it. I told him though that I

would not do anything like this without first consulting their own representatives, which I did.

*So what fraction of your career was in physics?*

About half. I have had three or four parallel careers, but my involvement in Physics was continuous from 1960 to the present, whereas other activities came in “phases.” Once I started my scientific career, I never stopped it. However, the other main “career” was my continuous involvement in the defense of Israel – which was also my motivation in jumping into Israeli politics. The worst year for my science was when I served as Deputy to the Minister of Defense (Simon Peres). That was in 1974-75. I was President of Tel Aviv University. I went to a committee meeting and Peres was there. He was Minister of Defense. He sent me a note during the meeting, asking me to become his deputy as Minister of Defense. At that time, I was getting more and more involved in university politics and I thought if it should be politics, I would rather be in national politics than in university politics. I resigned from the University and went over to Defense. Once there, I also appointed myself Chief Scientist of Defense when my predecessor in that post left.

*Did you have any political affiliation at that time?*

No.

*Do you still have your party?*

No. The party dissolved itself after the election of 1992.

*How are you being viewed in Israeli politics?*

It is a complicated thing. I believe I am well respected in general. However, not in the extreme left. For instance, I am known to have done a lot for the Israeli nuclear infrastructure project. When the contribution of Mr. Peres to the nuclear project is mentioned, the left is all praise because “he did it for peace”. When I am mentioned in this same context, to the extreme left I am “Professor Strangelove”.

*I would like to ask you about Israeli science.*

Before I answer, I would like just to mention two other results of mine in Physics. I discovered in 1977 the “curved space spinors” (they are infinite-component systems)<sup>xvi</sup> which were believed not to exist. These are representations of the double-covering of

SL(4,R) – which most textbooks used to say does not exist.<sup>xvii</sup> Another important contribution was my 1965 model for quasars<sup>xviii</sup> (also suggested by Igor Novikov). It is a precursor of today's "Eternal Inflation" Cosmology (A. Guth, A. Linde).

Now to the role of science in Israel. In 1983, when I was the first Minister of Science I was invited to the exclusive Elsevier "Economist" Club to give a lecture about Israel's science-based industries. This club meets once a month in Haarlem, Holland. Before me the lecturer was Helmut Schmidt, the former Chancellor of West Germany and the one after me was Henry Kissinger. We had strong science-based industries in 1983 and since then they have further developed well. They are spread all over the country. They started many years ago next to the Weizmann Institute and next to the Technion. Today there is also a large concentration in the Tel Aviv area and in other places. They employ people who left universities, among them scientists who became successful entrepreneurs. As a matter of fact, our key economic strength is in "high tech" ...

*Jewish scientists constitute a large proportion of Nobel laureates, especially in the United States, with Central European background and immigrant parents. Then a few generations down the road, there seems to be no such presence in science. Israel has not produced Nobel laureates so far.*

The graduate schools in America in physics used to be full of Jews and now they are full of Asians. I have my explanation about Jews in science. The Jews were out of society until about 1800 and were allowed only to be peddlers. On the other hand, at least all males could read and write. Then came two revolutions, one was the French Revolution, which started Jewish emancipation, and the other was the Industrial Revolution, which created new types of white-collar jobs, such as engineers, accountants, lawyers, and other new professions. European society was generally traditional, with considerable inertia; the sons often following their fathers in their professions. So, the new professions were not very popular. On the other hand, the Jews were allowed, just at that time, to move from peddling to other professions. They were also better prepared than many others, with their background in education. They jumped at the new opportunities and by 1900, especially in Central Europe, a large proportion of white-collar professionals were Jewish. That still did not mean science, which was still mostly the privilege of the previous order. Even though the impact of religion was gradually waning, many of the Jewish professors when they were moving up the academic ladder had to convert. There are perhaps also other factors. The study of the Talmud prepared the Jewish scientists for abstract thinking. I even have a conjecture about a genetic component. Throughout two thousand years there was pressure to convert. Those who resisted the pressure were those who were more apt than others to create and live in an abstract world of their own. That may have created some selection. There were more Jews in theoretical areas and less in experimental and engineering fields.

A Dutch author has a book on Jews in science, with a different genetic explanation. According to him, the Christian world for many centuries, between Constantine and the Reformation and in Catholic communities even longer, bred itself out of talent for abstract thinking. If there was a son who was more theoretically inclined, he was sent to the Church, and this was in practice a way of getting the genes out. The Jews had the opposite effect. A

rich Jew wanted to marry his daughter to a scholar, and they would live at his table, and this would breed more scholars.

In present-day Israel the computer science groups in industry are very strong. There we have a large proportion as compared to America and Europe.

*Would you say that Israeli science is on a par with their most advanced counterparts in the U. S. and Europe. Israel is small and I am asking about the quality.*

Yes, I would say so, although there are weaknesses. Generally, we produce 1% of world science, although we are 0.1% of the world population. The scientific infrastructure is weak. Theoretical physics is very good, there are excellent people in string theory, for instance. Experimental physics is much weaker because not enough is spent on infrastructure. There are highs and lows. I tried to correct it at the time but now it is the opposite.

The Russian immigration helped our physics. There was a descent in physics graduate students, which was reversed by immigration. This was so for the other sciences as well. Now they tend to go to business, like everybody else.

*A very different question. Do you personally trust any other country besides Israel?*

No, if you mean trusting anyone to guarantee our security

*Not even the United States?*

For one thing, it would be ineffective. The motivation to liberate Kuwait in 1990 was very strong (oil), and yet it took 6 months of preparations. Had it been Israel, we would have been exterminated in the meantime. Definitely, no. For the fate of the Jews? No. I strongly criticized President Bush's hypocrisy during the Gulf War. I was a minister at that time, member of the Cabinet. Our Prime Minister, Mr. Shamir, believed that the safest thing was NOT doing anything rather than doing something. I would come up to him with suggestions for doing something and he would say it was good but not doing it was even better, because not doing it means avoiding mistakes. There was a group of three or four ministers in the cabinet who wanted at least to react to the Iraqi missile showers, but the majority was against. Then, one day, after two Saturdays on which we got plenty of missiles on Tel Aviv, an American general arrived from Schwarzkopf's headquarters. He came for coordination. When he was asked why they were not more successful in destroying the Iraqi missile launchers, he answered, "Sir, I assure you that the Saudis are doing their best". It turned out that for "simplicity's sake", the Americans, who were mainly in the East, south of Kuwait, had charged the Saudis with destroying the Iraqi missile launchers against Israel, which were positioned at the Western end, in the Iraqi Panhandle! You can imagine with what enthusiasm the Saudis were protecting Israel. When this was reported to the Cabinet, I suggested action, including a detailed plan, which was accepted. This time the majority voted with me. Our Minister of Defense, Ahrens then called the U. S. Secretary of Defense Cheney about our intention. Coordination was, of course, important. Cheney informed the President who then

called Shamir, gave him hell, and Shamir cancelled the operation. A few weeks later Bush gave a famous speech in which he called Israel “ungrateful” because American soldiers had defended it... But my distrust goes back to John Kennedy, when I was helping PMs Ben Gurion and Eshkol with their correspondence with the American President about the Nuclear Infrastructure project. We told him that we did not intend to produce weapons, but we did not want to depend on others if someday our enemies were getting them. Kennedy wrote back that this was precisely what the United States could not allow Israel to do!<sup>xix</sup>

*Now I would like to ask you about your family background.*

In the expectation of the Messiah, rabbi Elijah, the “Gaon” (a title given to the “dean” of a rabbinical school, when recognized as an outstanding scholar) of Vilna (around 1790) instructed his students to move to Israel after his death. Our family on my father’s side is said to be descended from the Gaon; at least this is the tradition in our family. My mother’s father’s family derives directly from one of his leading students. They came to present-day Israel in 1807 and settled in Safed (Galilee). They then moved to Jerusalem in 1837 after an earthquake, which destroyed Safed. The first modern press in Jerusalem was founded one hand by one of the ancestors of my mother on her mother’s side. My paternal grandfather was one of the 66 founders of Tel Aviv and of Israeli Industry (he was a self-taught and very talented engineer).

*How do you feel, being an atheist, about the political power of the religious right in Israel?*

In the middle of the 19<sup>th</sup> century there was a big massacre of Christians in Lebanon by the Druzes. It was under the Ottoman Empire - and the Western powers intervened to save the Christians. They forced Turkey to give autonomy to each religious community, this is called the “regime of capitulations”. When the British took over, these religious communities were autonomous, and the British left this system in place. The Jews were happy with it at the time because it gave us self-administration. When the State of Israel was created, it was a fact of life that all civic matters were in the hands of the community’s religious system.

Concerning those small parties, in a democracy small parties always have greater influence than their proportion because the government mostly depends on them to achieve a majority. So, they succeeded in preserving the right of autonomy. It was not created by Israel; it was inherited from previous times.

I, myself, didn’t like this as a person. On the other hand, there are people on the left who say that Zionism is a thing of the past and the Jews and the Arabs are in one common state. My position is that Israel is a Jewish state and the only one after two thousand years of persecution. This state should thus care for the Jews – including those outside Israel as well.

In my political career I allied myself with the religious right because the people who live now in Judea and Samaria are presently the true pioneers, doing what the kibbutz movement did in Palestine during the British times. Most of these people belong to religious youth movements. When I created my political movement I spent a whole night with their leaders, I told them exactly where I stood and that I was an atheist. They were pragmatic and

interested in practical questions. I told them that I would like them to live their life undisturbed, provided that they did not disturb the life of others either.

*How about serving in the Army?*

The ultraorthodox refuse to serve in the Army. Immediately after the War of Independence, Ben Gurion signed a document with the idea that a few brilliant youths would be studying the Torah. Gradually, however, it became a big crowd. It's a shame and I'm waiting for a spiritual leader of the ultraorthodox who will understand that it's a shame not to take part in the defense of Israel. On the other hand, the settlers in Judea and Samaria are mostly of the National Religious Party and all serve in the Army. They make the best units nowadays.

*The Rabin assassination was a big shock.*

I was very close to Rabin historically. At one time I was his deputy in the Army. It was also when his son was born, and he called him Yuval. However, he could be very insensitive politically. The people on the Golan had supported him, but when he started negotiations with Syria, he did very little to explain the situation to them and ask them to be ready to lose their farms for the sake of peace, etc. They were shocked and turned against him. Concerning his assassination, there are always and anywhere some crazy people. However, there are just as crazy people on the left as well. For instance, they demonized Sharon internationally in 1983 after the Sabra- and Shatilah massacres of Palestinian Muslims by Lebanese Christians.

The Israeli security forces made a grave mistake. They could have prevented the assassination. They had an undercover agent who knew everything. He has not been tried yet because the authorities feel very uncomfortable about the whole case. Of course, I condemn the assassination strongly.

*How do you feel about the impact on daily life by the religious forces?*

Maybe I notice it less than others do because I am conditioned by it, and it has decreased considerably. When I was a child, Friday night was a dead night. Now even cinemas stay open.

*Of course, in a modern country you expect complete separation of the state and religion.*

There will have to be more of this separation in the future. It is a gradual process, and we have to remember, if our forefathers had not been so fanatic about their religion we might not exist today. Thus, we must be tolerant. Had I been in Ben Gurion's place or in that of any other Prime Minister, I would have cultivated a more patriotic religious leadership, more devoted to the existence of Israel, for their own good too. The ultraorthodox are in a terrible

economic situation today. They spend their life miserably as Yeshiva students. They have large families and are terribly poor. They should have had a leadership that would open their eyes, tell them to serve in the army and defend Israel. The Bible says nothing about not to fight for Israel. On the contrary.

*How do you view the Jews outside Israel who are not religious?*

The existence of Israel replaces the need of religion for their identity. Non-religious Jews can identify with Israel from a distance. That is what a large portion of American Jewry does. Otherwise, there is a huge amount of intermarriage, although many of the non-Jewish spouses convert to Judaism.

*Your present family?*

My wife is a housewife. We have a daughter and a son. Wherever we went my wife used the opportunity to study. In Princeton, for example, she studied modern Japanese literature. We became both experts because she taught me what she had learned. In Pasadena she took decorative arts. Our daughter studied art history and later business administration. She is in business now. She is married to a surgeon. They have two daughters; both have served in the army. One is studying law and the other Computer Engineering in Jerusalem. Our son is an electronics engineer, he has been in army research and works now for Motorola. He is also married, and they also have two daughters, 12 and 10 years old. The 12-year-old is quite brainy, she may perhaps be the next scientist in our family (three of my cousins are physicists, one a mathematician).

*Who are your heroes?*

When I was young, I was very interested in people like the older Carnot, Lazare. I was torn between science and the army. I tried to join the Haganah when I was 13. I had jumped several classes, and I was in the 10th grade at 13. I was very much interested in mathematics, and I did some things that I may still write up and publish someday. I finished high school at 15 and joined the Haganah. I took part in my first battle with the British in the streets of Tel Aviv in 1946. An immigrant ship had just landed, and we created a bridgehead to let the people come down and the British wanted to prevent that. Although I was increasingly involved with the military, I still wanted to do science. My knowledge of history was always very broad. For my Bar Mitzvah, I had asked my parents for the *Encyclopedia Britannica*. This is how I came across Lazare Carnot (1753-1823). Originally, he organized the armies of the French Revolution and gave them their strategic instructions. He was a geometer, became Napoleon's minister of war and of education (he founded Ecole Polytechnique, etc.), but left politics for science in 1807, and did applied mathematics. Then there was a time when Einstein caught my imagination. My heroes have been from different directions.

*What will be your legacy?*

There will be a part in science and a part in the history of Israel. In 1952–53 I was preparing Israel for the eventuality of what later became known (when it happened in 1967) as the Six-Day War. There was an article recently in the newspaper *Ha'aretz* with three photographs showing the Prime Minister, the Head of Opposition, and me. The article said that both of them are strong believers in the doctrine, which I established back at that time for the defense of Israel. I wish I could be certain that this is true, even under pressure.

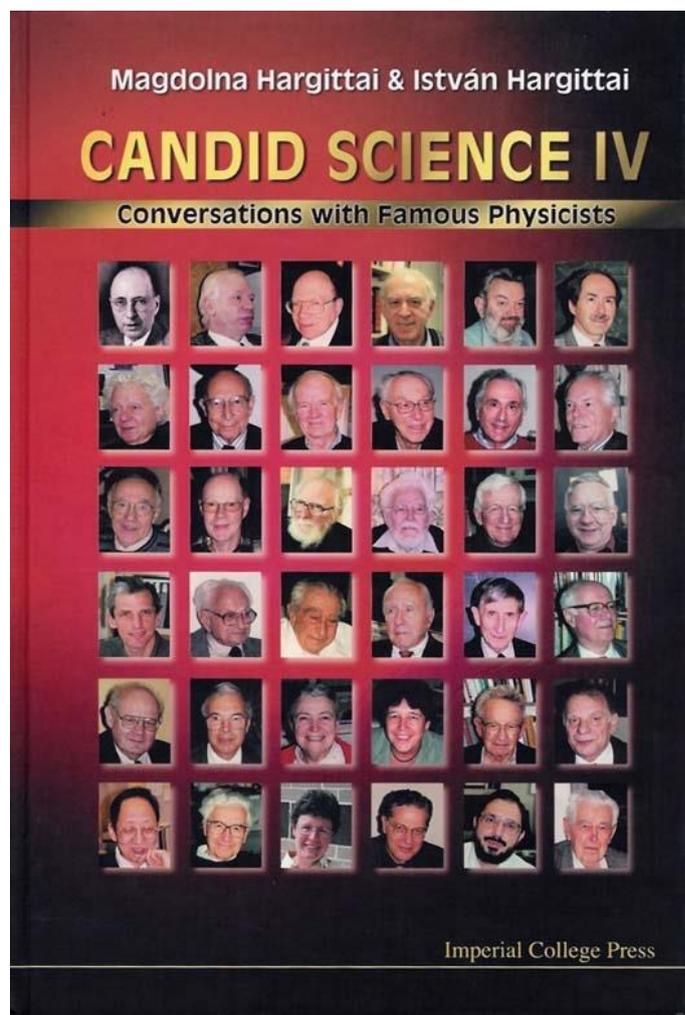
Incidentally, I was appointed head of military planning of Israel by Ben Gurion although he knew that I had voted Mapam (left of the Labor Party). He also knew that when I was in France, I got disillusioned with the left. My stay in France, at the Staff College, coincided with the Slansky show trial in Prague and that disgusted me. I had read Arthur Koestler's *Darkness at Noon*, and I had almost convinced myself that the aims justified the means. After the Slansky trial, however, I felt otherwise.

*What do you do nowadays?*

Lately I have been interested in evolutionary epistemology and just published a book on it in Hebrew. I am preparing an expanded English edition. Its title is something like *Order out of Randomness*. It has nothing to do with chaos theory. I start with cosmological evolution, nucleosynthesis, then biological evolution. I classify and characterize the evolutionary process. I distinguish between active and passive evolution: "active" is when you mutate, by a mistake in copying your DNA, and fit better (or worse) into your environment. "Passive" is when it is the environment which mutates and impacts you, like the catastrophe that extinguished the dinosaurs (or gives you an advantage, as it did for the smaller mammals). I have had two main new ideas. One concerns the evolution of society. Ever since *Homo sapiens* appeared on the scene, he has not evolved much biologically, but society has evolved. Every evolution must have randomness and selection. Where then is randomness? I claim randomness comes through science. Any really important discovery cannot be foreseen. To move science forward, there must be a lot of dynamics, straightforward research programs. The really important discoveries, however, cannot be put into proposals, they will come by surprise. It also means that a society, which tries to regulate its research people and requires them to keep to planned utilitarian targets, is condemned to stagnation. My first point thus concerns the role of science in the evolution of society.<sup>xx</sup> The other point is that ideas themselves also develop in an evolutionary process.<sup>xxi</sup> I give lots of examples for both points. I also discuss other models of epistemology, such as Popper's falsification theory, Thomas Kuhn's paradigms, Lakatos' programs, Feyerabend's "anything goes," and I show how they all correspond to various aspects of my thesis.

### About the author

Istvan Hargittai is a physical chemist and professor emeritus (active) at the Budapest University of Technology and Economics. He is a member of the Hungarian Academy of Sciences and the Academia Europaea (London), and a foreign member of the Norwegian Academy of Science and Letters (Oslo). He is a PhD and DSc, and has honorary doctorates from Lomonosov Moscow State University, the University of North Carolina, and the Russian Academy of Sciences. He has been Founding Editor-in-Chief of the international periodical *Structural Chemistry* (Springer Nature) since 1989. He has published over three hundred research papers and reviews and has published hundreds of other papers, in science dissemination and popularization. He has authored, co-authored and edited and co-edited well over fifty books about structural chemistry, history of science, the nature of scientific discovery, memorials of scientists, conversations with famous scientists, and other topics, many in co-authorship with Magdolna Hargittai, his wife. His books have appeared in English, Hungarian, Russian, German, Swedish, Italian, Japanese, Chinese, and in the Farsi language. His latest book is *Microphone in Hand* (World Scientific 2025).



The cover of *Candid Science IV* in which the Ne'eman conversation appeared. Further conversations with famous physicists have appeared in *Candid Science V and VI*

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<sup>i</sup> Ne'eman, Y. *Nuclear Physics* 1961, 26, 222-229.

<sup>ii</sup> Goldberg, H.; Ne'eman, Y. *Il Nuovo Cimento* 1963, 27, 1.

<sup>iii</sup> Ne'eman, Y. in *The Interaction between Science and Philosophy*, Elkana, Y. ed., Humanities Press, Atlantic Heights, 1971, pp. 94-105.

<sup>iv</sup> *The Observer*, 2 November 1958, p.2-3.

<sup>v</sup> Abdus Salam (1926-1996) was co-recipient of the Nobel Prize in Physics for 1979, together with Sheldon Glashow and Steven Weinberg “for their contributions to the theory of the unified weak and electromagnetic interaction between elementary particles, including, inter alia, the prediction of the weak neutral current.”

<sup>vi</sup> Ne'eman, Y. *Physics Letters* 1979, B81, 190-194; see also Fairlie, D. *ibid.* 1979, B82.

<sup>vii</sup> Weisskopf, V. *The Joy of Insight*, Basic Books 1991, pp. 202-3.

<sup>viii</sup> Lipkin, H. J. *Physics Reports* 1974, 8C, 173-278.

<sup>ix</sup> Gribbin, J. & M. *Richard Feynman, a Life in Science*, Dutton Books, 1997, pp. 192-194.

<sup>x</sup> \* *From SU(3) to Gravity*, Gotsman E.; Tauber, G. eds., Cambridge University Press 1985, pp. 103-106.

<sup>xi</sup> *Strangeness Minus Three*, BBC, Third Program film, 1964.

<sup>xii</sup> Johnson, G. “Strange Beauty,” *Murray Gell-Mann and the Revolution in XXth Century Physics*, Knopf, New York, 1999.

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<sup>xiii</sup> *The Eightfold Way*, W.A. Benjamin, New York, 1964. Republished in 1999 by Perseus Publications.

<sup>xiv</sup> In September 2000, several groups at CERN found 9 events that could be interpreted as a Higgs meson with a mass of 115 GeV. However, it is only a “2-standard deviation” effect as yet.

<sup>xv</sup> Ne’eman, Y. *Ha’aretz/Herald Tribune* joint weekend supplement, 8 October 1999, B7.

<sup>xvi</sup> Ne’eman, Y. *Annales de l’Institut Henri Poincaré*, 1978, 28, 378.

<sup>xvii</sup> Ne’eman, Y.; Sijacki, Dj. *Intern. J. Mod. Phys. A* 1987, 1635-1669.

<sup>xviii</sup> Ne’eman, Y. *Astrophys. J.* 1965, 141, 1303-1305.

<sup>xix</sup> See, Cohen, A. *Israel and the Bomb*, Columbia University Press, New York, 1998.

<sup>xx</sup> Ne’eman, Y. *Acta Scientifica Venezuelana* 1980, 31, 1-3.

<sup>xxi</sup> Kantorovich, A.; Ne’eman, Y. *Studies in the History and Philosophy of Science*, 1989, 20, 505-529.