CHEMICAL HERITAGE FOUNDATION

GÁBOR SOMORJAI

Transcript of an Interview
Conducted by

Hilary Domush

at

University of California, Berkeley
Berkeley, California

on

30 and 31 January 2014

(With Subsequent Corrections and Additions)

CHEMICAL HERITAGE FOUNDATION
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Chemical Heritage Foundation
Center for Oral History
315 Chestnut Street
Philadelphia, Pennsylvania 19106

GÁBOR SOMORJAI

1935	Born in Budapest, Hungary on May 4

Education

1956	BS, Technical University, Budapest, Hungary, Chemical Engineering
1960	PhD, University of California, Berkeley, Chemistry

Professional Experience

	International Business Machines (IBM)
1960-1964	Research Staff
	Lawrence Berkeley National Laboratory
1964-present	Faculty Senior Scientist
	University of California, Berkeley
1964-1967	Assistant Professor of Chemistry
1967-1972	Associate Professor of Chemistry
1972-present	Professor of Chemistry

Honors

1969	Guggenheim Fellowship
	Visiting Fellow, Emmanuel College, United Kingdom
1972	Unilever Visiting Professor, University of Bristol, United Kingdom
1976	Kokes Award, Johns Hopkins University, Baltimore, Maryland
	Elected Fellow, American Physical Society
1977	Emmett Award, American Catalysis Society
1978	Miller Professorship, University of California, Berkeley
1979	Member, National Academy of Sciences
1981	Colloid and Surface Chemistry Award, American Chemical Society
1982	Fellow, American Association for the Advancement of Science
	Distinguished Scholar for Exchange with China
1983	Member, American Academy of Arts and Sciences
1986	Henry Albert Palladium Medal
1989	Peter Debye Award in Physical Chemistry, American Chemical Society

	Senior Distinguished Scientist Award, Alexander von Humboldt Foundation
	E.W. Mueller Award, University of Wisconsin
1990	Honorary Membership in Hungarian Academy of Sciences
1994	Adamson Award in Surface Chemistry, American Chemical Society
1995	Chemical Pioneer, American Institute of Chemists
1997	Von Hippel Award, Materials Research Society
1998	Wolf Prize in Chemistry
2000	American Chemical Society Award for Creative Research in Homogeneous or Heterogeneous Catalysis
	Linus Pauling Medal for Outstanding Accomplishment in Chemistry, American Chemical Society, Puget Sound, Portland and Oregon Section
2002	National Medal of Science
2003	Cotton Medal, Texas A&M University
2006	Remsen Award from the Maryland Section of the ACS
	Honorary Fellow, Cardiff University
2007	Langmuir Prize from the American Physical Society
2008	Priestley Medal from the American Chemical Society
2009	Senior Miller Fellow, Miller Institute, University of California, Berkeley
	Japanese Society for the Promotion of Science Award
	Excellence in Surface Science Award from the Surfaces in Biointerfaces Foundation
	Fellow of the American Chemical Society
	Honorary Membership, Chemical Society of Japan
2011	Honda Prize
	ENI New Frontiers of Hydrocarbons Prize
	BBVA Foundation Frontiers of Knowledge Award in Basic Sciences
2013	National Academy of Sciences Award in Chemical Sciences
2015	William H. Nichols Medal of the New York Section of the American Chemical Society
	Honorary Fellowship of the Royal Society of Chemistry
2017	Richard Award, Harvard University

ABSTRACT

Gábor Somorjai was born in Budapest, Hungary, during World War II and lived an comfortable, integrated life until Anti-Semitic laws impacted the family. His paternal grandfather had converted to Judaism. His mother's family was in the shoe business. Anti-Semitic laws cost Somorjai's father, a math genius, his bank job, whence he was conscripted and sent to the Russian front. The elder Somorjai was interned eventually in Mauthausen concentration camp and returned with typhoid. Like many Hungarians, the Somorjais were rescued by Raoul Wallenberg and eventually returned to their home, but the Russian occupation forbade school, so Gábor played chess and read history until he eventually matriculated in Minta Gimnázium. From there his basketball coach got him into Budapest University of Technology and Economics, where he studied chemical engineering, interested in polymers and catalysis. When the Russian tanks rolled into Budapest, Somorjai and his girlfriend, later his wife, escaped to Austria. In Vienna he met Cornelius Tobias and learned about Charles Tobias at the University of California, Berkeley. The two immigrated to the United States, eventually accepted, provisionally, by Berkeley. At Berkeley Somorjai switched to chemistry, working with Richard Powell on his long-lived dream of catalysis. During this time he also married.

PhD in hand and dream in heart, Somorjai accepted a job at International Business Machines (IBM). He built an instrument for his research into low-energy electron diffraction (LEED), and observed that catalytic reactions take place on surfaces. His interest in surfaces extended from electrical to chemical reactions, and he began to study platinum and then oxide-metallic interfaces. This led to the study of nanotechnology and the development of the scanning tunneling microscope. Interesting even to laymen are his explanation of why ice is slippery and his discussion of contact lenses, which he points out are polymers; both have their effectiveness on the surface. He is called the father of surface science. Moving at last to catalysis, he began consulting on catalytic converters for General Motors Company. Though he says that instruments magically appear when needed, in fact he has developed most of his own. There are three types of catalysis: heterogeneous, homogeneous, and enzyme. Somorjai is working on heterogenizing homogeneous catalysis to yield hybrid catalysis, and attempting to figure out how to do enzyme catalysis in a hybrid model with heterogeneous catalysis, and then working out how multiple catalysts work. He maintains that the "discovery of [his] life" is that catalytic reactions are controlled by the size and shape of nanoparticles; when two-dimensional they form a Langmuir-Blodgett film, and when three-dimensional they are useful to industry.

Somorjai explains how he brought his parents to the United States while he was at IBM. He talks about Amos Elon's *The Pity of It All*. He wants to do science as long as he can, he says, stressing the importance and explosive increase of science in United States and the change of science research from industry to academia. Somorjai says that finding and placing students is important; he always looked for those with the dream and attempts to place them in the best possible situations. Somorjai has published many articles and books and won many, many awards. He and his wife have established at Berkeley the Somorjai Award and the Somorjai Professorship.

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INTERVIEWER: **Hilary Domush**

LOCATION: **University of California, Berkeley**
Berkeley, California

DATE: **30 January 2014**

DOMUSH: Okay. I am Hilary Domush. Today is January 30, and I am in the office of Dr. Gábor Somorjai. Did I say everything correctly?

SOMORJAI: Gábor.

DOMUSH: Gábor?

SOMORJAI: [Yes]. Gábor is Gabriel, you know, the archangel. Gabriella would be the feminine name of the saint. Gábor is the masculine part.

DOMUSH: Okay. As I said, we like to start at the very beginning and hear from people a little bit about their childhood. And I know that you spent your childhood in Budapest, [Hungary].

SOMORJAI: [Yes].

DOMUSH: And I was wondering if you could talk a little bit about what that was like, growing up in Budapest.

SOMORJAI: Well, you know, *American Scientist*, my autobiography, describes all the essential features of my childhood.[1] I was born into a middle-class family, and my grandparents on my father's [Charles Somorjai] side were originally from Austria, and then they moved to Hungary with the road building. My grandfather [Herman Steiner] was a road builder for the Austro-Hungarian Empire, okay? And he fell in love with a Hungarian girl, and it happened—

[1] Gabor A. Somorjai and Mitch Jacoby, *An American Scientist: The Autobiography of Gabor A. Somorjai* (Bloomington, IN: Archway Publishing, 2013).

two things. He converted from Roman Catholic to Jewish, because she was a Jewish family, and then they stayed in Hungary. But he never learned Hungarian. He spoke German, and they had five children, and as usual in those cases, his mother, my grandmother [Fanni Edelstein], died in childbirth.

DOMUSH: [Yes].

SOMORJAI: And so the father alone raised the five children. And on my mother's [Livia Ormos Somorjai] side, the family was Sephardic [Jewish], so originally they were remnants of the Spanish Jews that moved to the Turkish Empire, and to Thessaloniki [Greece]. And so [they lived] there and as the Turkish Empire retreated and collapsed, they went north. They went to, first, what is Transylvania today, it's called Erdély, and there is a big city there called Nagyvarad, and then they moved to Budapest.[2] And they started a business, a shoe business there. And so [. . .] they built a family house in the 1880s. So they were relatively successful with two shoe stores.

And so it was a comfortable middle-class existence, into which my father and mother got married in 1929. There is a picture of the wedding in the book.

DOMUSH: Oh, excellent.

SOMORJAI: Okay. And with the extended family around them. And we lived in the same family house, in the second floor, and my grandparents lived on the first floor. And so it was comfortable. I was born in 1935. Whatever I remember, it was a very comfortable childhood, until the anti-Semitic laws came into Hungary.[3] Then my father, who worked in a bank, an official in the bank, the Hungarian Credit Bank. That was originally a Rothschild bank. And so then the Jewish laws came in. He lost his job. He lost his job, and then he opened a shoe store, just like my grandfather, and my mother and father worked in that store as long as I remember, until my father was inducted into Hungarian army in 1940, I believe, '39 or '40.

And then my **<T: 05 min>** mother ran the shop again. But our childhood did not change much as far as I can see, except I had a German tante.[4] So I spoke German fluently, but then the Jews couldn't have helpers of German origin, so it went away. But these are minor distractions from a lovely childhood, until I was I would say eight or so.

DOMUSH: Now was—

[2] Nagyvárad is the Hungarian name for Oradea, the capital city of Bihor County in Romania.
[3] Nuremburg Laws, 1938.
[4] German word for "aunt," meaning "nanny" in this circumstance.

SOMORJAI: Okay. Do you mind that I will not host you for lunch?

DOMUSH: Not at all. I was going to ask when you were young, perhaps before the anti-Semitic laws really came into effect, was going to temple and celebrating some of the Jewish traditions a large part of your childhood?

SOMORJAI: The Hungarian middle class that originated were not very religious, and we were much more Hungarian or just like the German Jews. In fact, that was the demise of them, because when [Adolf] Eichmann came and tried to put all the Jews in concentration camps, there were warning signs from the Polish Jews who came through and tried to escape and came through Hungary. But the Hungarian Jews never believed that anybody would touch them, because they were so upright and embedded into the culture. Of course, they were wrong, very wrong.

But there were a class distinction in many ways. Not only that, but there were layers of Jews, Sephardic was one, and my grandfather was on that side, and just normal, you know, services. We got together Friday evening for a meal with the family, and on celebration of holidays. And it was more of a social occasion than a religious occasion. So what's happening is that my father went into the Hungarian army, and immediately he was convert—not immediately, a year later he was converted from a soldier to a cook, laborer, because of the Jewishness. And then he was sent to the Russian front, and he [was forced] to go through minefields; [he survived], he was a very lucky man. At the end [of the war], when [the Germans] were retreating, he was liberated in Mauthausen, which was an Austrian city, by the American troops, and that was the end of the war, 1945. And after a year and a half, he had typhoid disease, and he was very sick.

DOMUSH: Do you mind if I just close this door?

SOMORJAI: Yes. I'll get it.

DOMUSH: Okay.

SOMORJAI: [gets up to shut the door, inaudible conversation] So then—

DOMUSH: I'm sorry. You said that your father at the end of the war when he was liberated—

SOMORJAI: Yes. Typhoid disease—

DOMUSH: —had typhoid—

SOMORJAI: —and so he showed up in Hungary, in Budapest, in very bad shape, but my mother nursed him back to health. And then they re-started the business for two years. And then the communists took over, and they nationalized everything. And if you want to read that, this is described in details in my autobiography. Now—

DOMUSH: May I ask, did the war disrupt—I'm sure it disrupted everything, but were you able to still attend school?

SOMORJAI: Yes.

DOMUSH: Okay.

SOMORJAI: Yes. Yes. The school—they sent me to [was] an English school, a private school, and I had a sister [Marietta], and we both went there. And we stayed in school until it was prohibited for Jews to go to school—I remember everything vividly from that point on. March 19, 1944, the Germans occupied Hungary, because the Hungarian dictator tried to change sides. And of course, the Germans knew it before anybody else. And they occupied Hungary. And at that point Eichmann came in, and they had a full list of all the more prominent Jews. And I remember a day later, when they came in, and the Gestapo was looking for my [maternal] grandfather [Moric Ormos], who fortunately died six months before. And so they couldn't find him. But they didn't have that information.

And that point on, our house was designated as a yellow star house, because it was well-known Jewish ownership. And so we stayed there until we had a break, because Raoul Wallenberg, the Swedish consul, bribed the Germans with probably Swedish merchandise of importance, and he designated a few houses for a Swedish protection. And then we moved to one of those houses, which was in another part of Budapest, and that's where we stayed until the Russians occupied. And the reason why the Jews in Budapest survived is that the Soviet troops surrounded Budapest, and then the Jews in Budapest could not be transported to Auschwitz. Okay. So that was the luck part. So—

DOMUSH: And once you moved into this Swedish home from Wallenberg, did that offer more protection?

SOMORJAI: Well, I mean, it was nominally under Swedish protection. Okay? The Hungarian Nazis and the Germans knew that. But that in every two or three days, a group comes in and lines us up, to take us to the Danube [River], and they were executing everybody. And then miraculously, Wallenberg showed up, and we went back to the house, [waiting] for another episode like that to come. And we survived until finally, the Soviets occupied the core part of Budapest. **<T: 15 min>** And then we moved back to our house, our old house, and life continued.

DOMUSH: Did people seem happy when the Soviets came, that things were better, or—

SOMORJAI: No. No. The Russians were no friends. I mean, they didn't murder, but they took all the male members who were there, and there were some Jews, mostly the Hungarian population, and put them in trucks, and shipped them to Russia.

DOMUSH: [Yes].

SOMORJAI: And of course they raped the women, and that was part of the occupation. But I don't want to go through the details of that. What I vividly remember as a nine-year-old boy is the smell of my grandmother's body, because she died in this house, and we couldn't bury her for a week.

DOMUSH: Oh, wow.

SOMORJAI: Because there was nobody willing to take the body. And then my mother managed to find somebody to take the body. And so as a young childhood experience—this is unforgettable, because I didn't understand the procedure of decomposition.

DOMUSH: Right.

SOMORJAI: As I do now.

DOMUSH: So after the Soviets came, and, you know, as you said, you were going to school—

SOMORJAI: [Yes].

DOMUSH:—did school again kind of change?

SOMORJAI: No. I changed.

DOMUSH: You changed?

SOMORJAI: [Yes]. I changed. I had no interest. During the yellow star period, we couldn't leave the apartment and our house. And there was a lovely old gentleman who was a relative, a distant relative, and he and I played chess every day. That was my morning exercise. We go down and we play chess.

[We had a beautiful] book collection that both my grandparents and I read [. . .]. And. that was lovely. So when I went to school, I had absolutely no interest in school, and my mother was devastated. And she would [. . .] send me to [a] child psychologist [and ask], "What's wrong with him?" And so the guy talked to me, and he found I had a spectacular understanding of literature, and chess. He said, "He may be a historian, but he will never amount to science at all, no mathematics, no science." And so my mother was happy that I was still reasonably sane.

And then slowly, I think it correlated to my father coming back, and suddenly, you know, I came to realize that life goes on, and I became very good, very good in science. I mean, in all the things that a boy of twelve would take. And I went to a famous school [. . .], the Minta [Gimnázium], which was an excellent school [on] a street called Trefort. And this was the place where Edward Teller went.

DOMUSH: Okay.

SOMORJAI: Because this was in Pest [Budapest], where the upper middle class [lived], we had our house there. And so **<T: 20 min>** the talent—of course, that generation of Jews, Teller and [Leo] Szilard and John [von] Neumann, came [from there and they left Hungary] in the 1920's, because of the anti-Semitic laws. They couldn't go to school. It was called "numerus clausus" [and it] closed [the permitted] number of Jews [to attend school], in proportion to their numbers in the population.

DOMUSH: Okay.

SOMORJAI: And the Jewish population were minuscule compared to the ten million Hungarians, and so they would not allow in the numbers who wanted to go to school. That's why my father would never go to the university, but he went to what you would call now a business school.

DOMUSH: Okay.

SOMORJAI: A commercial school. And that's why he went to the bank. He was a genius in math. By the time he got married to my mother, in 1929, he was the director.

DOMUSH: Oh, wow.

SOMORJAI: But that lasted until '38. And then the army came and the rest was history.

DOMUSH: So after your dad came back and you did start to kind of find your interest in school again, and your interest in things in general again, was it just history and chess that remained of interest to you, or did you start to find an interest in some of the sciences, and math as your dad was interested in?

SOMORJAI: A good question. See, I was good at this, math and physics, but I had much more interest in history.

DOMUSH: [Yes].

SOMORJAI: And so I loved history, and I wanted to be a writer, I started writing. And I had some very good teachers who did not discourage that. So I had a superiority complex that I can write better than any of my schoolmates. And I really wanted to go to history, but it was obvious—I mean, many things happened. In 1948, the communists, they took over the government, and they nationalized everything, and the small shops that my parents had was gone. And my father, who was [working in a bank before], got into a small place with an accountant, a small so-called national—it was all state-owned, but it's a small manufacturing place, and he became the accountant.

And so that was our life. The store was closed. And I went to this very good high school. What did you ask which I didn't respond to now?

DOMUSH: I was curious about the interest—if you had interest in science, or if the interest in history was really kind of overwhelming.

SOMORJAI: I had a Rákosi medal. [Mátyás] Rákosi was a Hungarian dictator. And there was a medal for the best student based on examination. So I got that. But I was a good basketball player. That had a lot of interest for me. And I had discovered girls. And so we went out with very little money, but we went out, and I remember a dreadful habit, but it worked, we took a half a cup of melted butter and we drank it before going out, because that coats the intestines. And so the alcohol doesn't absorb so fast. And interestingly enough, much later, anybody who went to the Soviet Union got a briefing from the CIA to take kefir, which is the buttermilk of the Russian side, and **<T: 25 min>** do the same thing. You drink a quart of kefir, which, again, coated the intestines, and if you had vodka, [you would experience] more tolerable results. So this is not just a Hungarian habit, but it appears to show up in various situations.

DOMUSH: So I'm just curious, perhaps it was when you were in the school, the Gimnázium, that you said was so highly esteemed, perhaps you had a teacher in the sciences or the mathematics—

SOMORJAI: Yes. Yes.

DOMUSH: —who was particularly helpful?

SOMORJAI: He was an excellent physics teacher. But I really never thought of myself of going to sciences. I played good basketball, and so my father, through the basketball coach in my high school, got a connection with the basketball coach at the Technical University [Budapest University of Technology and Economics]. And so miraculously, I got admitted, even though I was a class enemy. You know what a class enemy is?

DOMUSH: I don't.

SOMORJAI: You live a sheltered life. A class enemy, in a communist country, is one who is not a farmer, peasant, nor a worker, but everything else.

DOMUSH: Okay.

SOMORJAI: And the class enemy, it means that they don't fit into the regime, and they have to be watched and, you know, submitted to all sorts of hostilities. And so no class enemy, which means the middle class, could be admitted to the university. But somehow through this sport contact, I was admitted. And so I [was] admitted, and I went [to the] chemical engineering [program]. So I listened to my father, and chemical engineering was the field. It was a technology school, like Caltech [California Institute of Technology, Pasadena, California] or MIT [Massachusetts Institute of Technology, Cambridge, Massachusetts]. So the engineering was very strong and I went to chemical engineering.

And of course, it was a planned economy, and so there was a [first five-year] plan where you can graduate fifty engineers, chemical engineers, a year, and no more.[5] But they admitted two hundred. So it was obvious that at the end of the fourth year or the third year, the numbers had to be whittled down to fifty. That was a very competitive situation. And having been a class enemy, I had to be very good at Marxism/Leninism [history], which was the official [philosophy]—[and at a] Russian language course to translate science in Russian. And Marxism/Leninism was the essence of the teaching of the history of the Bolshevik War. And so I had to take an exam, and I have to be very good at that.

And it wasn't that difficult but I had to show that I [was] not as much of a class enemy.

DOMUSH: Right.

SOMORJAI: And my [interest in] science and my engineering [returned]. So, I did [well in] it. Then every summer we went to military service for six weeks, if I remember correctly, and so in various parts of Hungary that was the summer amusement. Then school started.

And then this happened until—I got into the [Technical University of Budapest] in 1953. In 1956, I am in my fourth year, and that's when the revolution broke out.

DOMUSH: Well, before we get to that, I'd like to ask about some of the education experiences at university, especially since you were coming from this very highly esteemed Gimnázium. How did the courses in the university seem? **<T: 30 min>** Were they particularly challenging, or was it more of a challenge to keep proving yourself, that you were going to be one of those top fifty graduates, that you belonged there despite being a class enemy?

SOMORJAI: Both. The first one, I knew that they will not throw me out, because the attrition was enormous. So by the third year, we were down to almost seventy-five from two hundred.

[5] List of economic goals, created by Joseph Stalin, based on policy of Socialism in One Country. Hungary was a satellite country of the Soviet Union.

And so I knew that I would make it, because I had good grades, and I was good at these things. And so that communist side of this sort of brainwashing was unimportant. Every night we go home and we close the windows, and turn on the radio, and listen to BBC [British Broadcasting Corporation] or Voice of America. And everybody did that on the street, because we could see the windows closing. It was nothing secret to those who knew what was happening.

And so I liked the laboratory courses. They were not really challenging. It was a question of deciding what I want to do with myself. And I liked two fields in which neither I knew anything about. This happens very often, and it's very important. One of them was polymers. I found them miraculous, and it was interesting. And the other was catalysis. Again, I didn't know anything about either one, but it looked sort of magical. It caught my imagination.

I knew that I [would] finish, and at that point, I had as much interest in girls as I had in the school, and that's how I met my wife [Judith Kaldor]. She was three years younger than I was. She was a high school student, so we went out, etc., and in a company of young people, and had a good time. Life was in a groove until, you know, [Joseph] Stalin died in '53, and by '56, [Nikita] Khrushchev came out against the Stalinist policies, and the Hungarian communist party became sort of restrained by the new politics.

And so people didn't disappear anymore. The same thing happened [that people have not been imprisoned anymore when] I was a [Alexander von] Humboldt [Foundation, Fritz Haber Institute] senior fellow in Berlin [Germany], in February [1989], when the wall came down [in November], as a result of the same easing of the environment [that I have experienced in Hungary in October, 1956. The Hungarian Revolution broke out in October 1956 as a result of the easing of the strong enforcement of the dictatorship].

DOMUSH: Right.

SOMORJAI: So they don't shoot immediately, and people don't disappear, and life became normal. And then as soon as it happened, the theaters and the night clubs have standup cabaret people and personalities who were making jokes on the regime. And that became almost a daily occurrence, and the jokes came out—you know, I can tell you a few jokes like that. A typical one was that two men were put into prison that were telling, propagandizing that the Russians don't have enough to eat, and ammunition, etc. So then the captain of the guards listened to that, and he said, "All right, I'll teach you a lesson." And he put the two guys up to shoot them, okay? And he said, "Well, **<T: 35 min>** no, I don't shoot you now, but if I hear that, what you're saying again, I will shoot you." And so [they] let go. So they talked to each other; look they don't even have bullets anymore. A typical Hungarian joke. There are many of these.

So the regime started to not clamp down on the resistance. The passive resistance became [a] more active resistance, and by October, 1956, the demonstrations demanded freedom and change of government, and the revolution started. And it was my fourth year. I was to get my diploma in December '56, but of course, I did not until December.

DOMUSH: Right.

SOMORJAI: And then I participated in the revolution. The police disappeared, and so we were guarding the streets during the revolution. And of course, like stupid Hungarians, we do the obvious, put together a list of people who did that. That was the most stupid thing you can do, because as soon as the Russians came back, which was two weeks later, the list was telling them exactly who we were. But it sounded like a typical Austro-Hungarian behavior. [laughter] You know, you can laugh on these things, but it was not a laughing matter.

DOMUSH: No.

SOMORJAI: So [then] my mother got a phone call [from] one of my colleagues at the university, who was also in the National Guard, [that] the police started looking [for people on the list]. Next day, we left. And my parents sent my sister with us, and my girlfriend's parents sent my girlfriend. So the three of us took a train to the Austrian border. And the Hungarian trains were all [on] strike, they were on strike, except [those that] went to Austria.

DOMUSH: Okay.

SOMORJAI: Okay. This was the center. [The only trains not stopped by the strike] were going from Budapest to West, you know. And so we got on this train, and when some point the conductor came, "Next stop, the Russian troops are there, so anybody who doesn't want to [get arrested] off the train." So then at that point, we started walking in western Hungary toward the Austrian border. The ground was muddy and it was raining. [We were] walking during the night, and during the daytime, local farmers took us in. The daytime was spent in a farmhouse, and then at night, we walked [toward the Austrian border] with the help of some of the local farm boys.

DOMUSH: Was it just the three of you walking, or—

SOMORJAI: No. No.

DOMUSH: —there were—

SOMORJAI: No, there were fifty, sixty people walking together—

DOMUSH: [Yes].

SOMORJAI: We broke up, and then separated, and we all put all our money into the hands of these peasant boys [of the farmhouse] to help us.

DOMUSH: Were you able to take much money with you from Budapest when you left?

SOMORJAI: No. No. The Hungarian forint—[has enough for] remuneration for the services—they knew that we cannot take the money to Austria. Austria had schillings, and so we left all of our money as soon as we got to the border, but it was pitch dark, and the border is not straight. It goes like that. And so there was always a chance that we, instead of going through the border, we would go backward.

DOMUSH: Right.

SOMORJAI: And at **<T: 40 min>** that point, [some of] the searchlights were missing, not all of them, but these boys knew exactly which searchlights were off. And so we could come because they knew where it was dark. Anyhow, we managed to come out.

DOMUSH: How many days of walking and train was—

SOMORJAI: Three nights.

DOMUSH: Three nights?

SOMORJAI: Three nights. By the third night, we fortunately reached a Red Cross Austrian [station camp]. We knew that we were in Austria.

DOMUSH: [Yes]. Now when you reached Austria, you had mentioned at one point that at some point you had a German tante.

SOMORJAI: I spoke no German whatsoever.

DOMUSH: You spoke no German? Okay.

SOMORJAI: I refused to speak German. You know, young boys are stupid. And because of all these things happened I just absolutely refused to remember.

DOMUSH: [Yes].

SOMORJAI: And then I forgot German, because I didn’t really know—in ’45, I was ten years old. And when a ten-year-old boy decides to do something stupid, [it] usually happens.

DOMUSH: Was the rest of your schooling in Hungarian, then?

SOMORJAI: [Yes]. [. . .] The school then had eight years of Latin.

DOMUSH: Okay.

SOMORJAI: And then in the last four years, it was also four years of Russian.

DOMUSH: [Okay].

SOMORJAI: And so I had Latin and Russian, okay, as a required subject, and I got good grades, and German was not among them, so it was easy to avoid German.

DOMUSH: Right. So when you reached the Red Cross camp in Austria—

SOMORJAI: Yes.

DOMUSH: —did you know what you were going to do next?

SOMORJAI: Yes. I knew that—you know, when you survive, okay, you start to believe in your judgment, because you survived. And then I made decisions for my sister and for my girlfriend and myself. And my father gave me an [American] twenty dollar bill when we left. And he put it in a [tube of] toothpaste—the tube could be opened from the bottom—and he squeezed out the paste, and then put in a piece of plastic with a twenty dollar bill, and then gave the toothpaste back. And so I had twenty dollars we had converted to [Austrian] schillings. That gave us enough money for the bus to Vienna, [Austria]. I knew that I didn't want to go to a camp, but I wanted to go to Vienna and get out of Austria. And so that twenty dollars got us there. But once we arrived in Vienna, there was another Red Cross station, and then the International Rescue Committee, I—[the] IRC, took over the refugees. That committee also helped Jews from the concentration camp go to Israel.

DOMUSH: Okay.

SOMORJAI: And there were several—that was not a Jewish thing. But there was a Jewish agency [World University Students] who helped us and gave us some money. And the two girls went to—where the nuns go.

DOMUSH: The convent?

SOMORJAI: Convent. Women went to convent, and I was put into the *studentenheim* [youth hostel]. Do you speak German?

DOMUSH: I used to, so some of it's still there.

SOMORJAI: Yes. So [we stayed at] a fraternity building. [. . .] The question was how to go to the US. I decided I want to go to the US.

Then my story started, and the book describes it much better than I can. But one of the professors from [University of California] Berkeley, Cornelius Tobias, was on a sabbatical here in the Karolinska Institute **<T: 45 min>** in [Stockholm] Sweden. And he came to Vienna to see if he could help with Hungarian refugees.

And he had —you know, in the *studentenheim*—let everyone know that anybody who wants to go to the US to talk to Professor Tobias. So I signed up and talked with him, and then he knew that I was in chemical engineering—

DOMUSH: And so close to graduating.

SOMORJAI: —and he said, “Well, I have a brother who was also in the Technical University, and he is now a professor of chemical engineering in Berkeley,” which was Charlie [Charles] Tobias. And if you open the book for a moment, I’ll show you the picture of Charlie. I didn’t put in Cornelius, because he was never the teacher for me. But you see the revolution. Okay. So this is Charlie Tobias, who was a professor here in chemical engineering, of Hungarian origin, and his brother was the one who interviewed us, in Vienna.

DOMUSH: Okay.

SOMORJAI: Okay. Then he gave me the address [of his brother Charlie Tobias, and of] Ken [Kenneth] Pitzer, the Dean of the College [of Chemistry] and we were given a preference quota because we were students. [Dwight D.] Eisenhower and the Senate gave fifty thousand special immigrant status because they felt badly about the Israeli-Egyptian conflict from the same time, but it didn’t do anything for the Hungarian [refugees]. Anyhow, we managed to get on the quota.

DOMUSH: And this is you, your sister, and your girlfriend all managed?

SOMORJAI: No. I had an uncle in Chile.

DOMUSH: In Chile?

SOMORJAI: In Chile. And, you know, girls are treated differently in most Jewish families, I would say, but maybe other families as well the boys. And so they told my sister that if she made it to Vienna, she should make contact with my uncle in Chile and go to him.

DOMUSH: Okay.

SOMORJAI: And so she was directed that way. But I was not, and my girlfriend came with me. And so we decided to go to the US. And so we got into this first preference quota, with the World University Service, WUS. And because we were students, it was easy to get on the first preference quota.

DOMUSH: Once you had this contact with Cornelius Tobias, it seemed like a given that you would come to the United States. But did you have any inkling that perhaps you would go to Great Britain or somewhere else in Europe?

SOMORJAI: I had no interest. I wanted to come to the US.

DOMUSH: Okay.

SOMORJAI: I didn't explore that. But many went to Switzerland, many of the refugees went to Switzerland. Many went to England. And many went to Australia and Canada. A hundred thousand Hungarians escaped.

DOMUSH: Yeah.

SOMORJAI: Just before—the Russians deliberately kept the borders open so the troublemakers would leave. They did the same in 1968 in Czechoslovakia.

DOMUSH: Yes.

SOMORJAI: And then they clamped down the border. So that helped us. But it was a very [short period]. By December 1956, the borders were closed. So we had a window—I think November 25, something like that. November [was] when we crossed the border.

So I had no idea where Berkeley was. I knew nothing about the schools in the United States. I didn't know whether it was an excellent school or not. And so we were put in a separate camp, waiting to get to the States. **<T: 50 min>** We were put up in a nice house. And then we were shipped by bus to an Air Force, US Army camp in Munich, [Germany].

DOMUSH: Okay.

SOMORJAI: And we stayed there a day or two, and then we took a plane, a military plane, to Camp Kilmer, which is in New Jersey, where all the refugees were cleared for green cards.

DOMUSH: [Okay].

SOMORJAI: Okay, what was—

DOMUSH: And did your sister—while you were in Vienna, your sister made contact with your uncle?

SOMORJAI: With my uncle. And then she went to Chile. Well, that's another unpleasant story, but by the time she got there, our uncle was bankrupt.

DOMUSH: Oh.

SOMORJAI: The business [declared] bankruptcy. So it was not a very financially wholesome situation.

DOMUSH: Right.

SOMORJAI: But she was in Chile. And we were in Camp Kilmer [New Jersey].

DOMUSH: Okay. How did you go from Camp Kilmer—how did you make your way then to California?

SOMORJAI: Yes. But in making [the trip] from Vienna to Camp Kilmer, the single people were taken by boat. But we told them we would like to stay together. And they said, "Well, if you want to stay together, why don't you take a walk and come back as a married couple?" [laughter]

That was the advice of the people, and that's exactly what we did. So we were allowed to take the plane—

DOMUSH: Oh, wow.

SOMORJAI: —from Munich. And so we just came by plane and not by boat. [At Camp Kilmer, getting the green card is] called processing, getting green card, there in Camp Kilmer, and then Judith, my wife, now she was put into the New York University [New York City, New York] dormitory, because all the women students were there. And I was put into the—oh, God, I think [its] called an International House—Columbia International [New York City, New York], but I'm not sure of that.

DOMUSH: Okay.

SOMORJAI: The International House [was] where the men were placed. So we were in New York, and I started applying for a job. And I took the [address of] Charlie Tobias's, and I wrote to him. Then [I received] the first letter—have the letters in the book.

DOMUSH: Great.

SOMORJAI: One letter from Charles Tobias, and the other one from Pitzer. Pitzer accepted me on probation in Berkeley as a graduate student, based on my fourth-year status, okay, with one hundred forty dollars a month, which was eight hundred and fifty dollars a semester. That's fantastic amount of money. So it seems that came first. I instantly accepted. Then the World University Service of the IRC [International Rescue Committee] gave us a one-way ticket from New York to San Francisco, [California].

DOMUSH: Wow.

SOMORJAI: And Tobias was waiting for us at the airport. [. . .] I hadn't had the money to pay for housing, but I knew that as of February [1957], this month the semester starts, that I would get money. And so I was in a house with a lady, and a few houses down, my wife who was a high school student in Hungary, got an au pair position with a small room [where she stayed] with a lady. So that was the beginning.

DOMUSH: Wow. What a—

SOMORJAI: But that's why I wrote the autobiography.

DOMUSH: [Yes].

SOMORJAI: Because in **<T: 55 min>** this country, you glorify the upward mobility. But there are reasons for it. And most of the American scientists have a background similar to mine, whether they come from China or they come from a European country or anywhere else. It's a given that I'm good in science. But you need luck, and you have to be healthy. Those are the most important things that you can have. And then you can talk about upward mobility.

DOMUSH: I agree. I mean, after doing many of these interviews with scientists, many of whom have come from—

SOMORJAI: Strange backgrounds.

DOMUSH: —from other countries, some through very straightforward immigration processes, some through less straightforward,—

SOMORJAI: Right.

DOMUSH: — there is a lot of luck involved.

SOMORJAI: Right.

DOMUSH: And there is a lot of making contact with the right people at the right time.

SOMORJAI: Yes. And it's not predictable at all.

DOMUSH: No.

SOMORJAI: But the judgment comes in a big way, okay, and so once you survive and go to a good place, you develop self-confidence in your own judgment, and it extrapolates to science. I know when I [plan to do some important experiment], I keep the dream in mind. The strategy is what most people focus on, and how to get from here to the next step, but if you want to be a first-class scientist, on the very top, it is the dream that gets you there. You have to have a dream, and you want to get there somehow. And it has to be a scientific dream, okay?

And when I interview new faculty, young guys coming in, the question I ask which is the hardest to answer, you ask these guys, "All right, if you have the best students, all the money that you could ever use, the best equipment, what would you do?" [. . .] Most of them cannot answer the question, because the thinking process is sort of simple; how do I get my laboratory, or the students? How do I have the money to do this? [I understand the vision is not there], but the dream has to be.

DOMUSH: Right.

SOMORJAI: Because then whatever happens, you move towards the dream. And that's how we choose faculty. And I can tell you, the best people in the sciences who are geniuses at experiments and write well and teach well, they will never make it to the top, because they have no dreams.

DOMUSH: Interesting.

SOMORJAI: They don't know how to—

DOMUSH: Right.

SOMORJAI: —keep themselves in science. You know, I don't play golf, and science is my [source of] fun. This is my life. And, you know, it's easy for some to become a dean, or a higher administrator, or anything else that it could lead to. There's nothing wrong with this, but the dream is missing, and the searching for something that is not an extrapolation of the science.

DOMUSH: [Yes]. Do you think that when you started at Berkeley, you know, new to the United States, a refugee from Hungary, that you had this dream of upward mobility, that you knww that—

SOMORJAI: No. Absolutely **<T: 60 min>** not.

DOMUSH: Okay.

SOMORJAI: Absolutely not. However, it took a while to develop this, but subconsciously it's there, because I wanted to do catalysis.

DOMUSH: [Yes].

SOMORJAI: I had no idea what catalysis is, but it sounded good. Or polymers. And there was nobody in catalysis or polymers in Berkeley. So I finally found a professor when I was finally accepted after my first semester, because I passed the course, and I was allowed to look for a professor. In inorganic chemistry, Richard Powell was willing to give me a catalysis subject, because he had students who would go to Chevron, and they had catalysts. Then, you know, I have to find out why they collapse or why they change in size, a major effect in the oil technology.

Anyhow, I did it. And then we find out that I was good at building things. I was good at doing experiments that had not been done before. I was comfortable with that. But you have other motivations in life. I never made a penny until that, because I was in school in Hungary, living at home. I left, and I made one hundred forty dollars a month. And by the way, we got married in the summer of ’57.

DOMUSH: Okay.

SOMORJAI: Because we were alone, and it was the only thing to do. And so I never made a penny, and money was most important. So then I figured three years later that I had enough. Not only that, my professor never had any money. Now you have to read the—this is a Berkeley story, and this is the cathedral of science in the US. So what you will see is important. Half of the faculty worked on the Manhattan Project.

DOMUSH: Right.

SOMORJAI: And Berkeley was a centerpiece, [with the likes of J. Robert] Oppenheimer, Teller, [Gilbert N.] Lewis, and the atomic bomb research. The other half refused to get federal money because it [would] destroy the university. The university’s autonomy [would] be destroyed by the federal government. My professor, including several world-famous professors, was like that.

Now of course they disappeared, because they had no money, no students, and those who got federal money were winning out, and nowadays everybody accepts that federal money comes and supports science. But at that time, it was not like this. So I had no money. I got nine months’ salary. Every summer I had to work for three months in industry at the Stauffer Chemical [Company], to get some money. And I was a teaching assistant all three years and every semester, because my professor had no money. And I was sick and tired of teaching. The last thing I ever wanted to do was teach.

And so I went to full industry, and I took the highest-paying job I could. That was IBM [International Business Machines]. And so I went to IBM. I got offers from DuPont [E. I. du

Pont de Nemours and Company], and from all the oil companies, because my thesis was very much oil related. There were opportunities. I have the whole list of all the jobs at home. It's interesting, looking back. I had three offers from DuPont, but I didn't want to **<T: 65 min>** go to Wilmington, [Delaware], which was a company town.

DOMUSH: [Yes].

SOMORJAI: And somehow, it doesn't fit my thinking. And IBM had virtually no catalysts.

DOMUSH: Right.

SOMORJAI: And so I thought, [I would be open to] whatever chemistry I could learn, so I learned solid state science and went into a new field. [. . .] I took the job [in 1960]. It was a fabulous salary of ten thousand dollars a year.

DOMUSH: Now before we talk about IBM, I'm curious. You said that, you know, when you left Hungary, you spoke Hungarian, Latin, and some Russian.

SOMORJAI: No Russian, but I could read Russian.

DOMUSH: Okay. You could read it.

SOMORJAI: Latin I never used.

DOMUSH: Right.

SOMORJAI: It was for cultural benefits.

DOMUSH: How did learning English go?

SOMORJAI: I had an English teacher, a lady, [who] taught very poorly. My wife always half-jokingly said that we have to take English for foreign students. She got an A. I got a C. She will never forget. And so—but you learn. You have to learn. There were much worse things happening. In Hungary, the examinations were all oral.

DOMUSH: [Yes].

SOMORJAI: Now there is a style, there is a way of gaming the examinations. You watch the facial expressions, and the body language, of the professor, and so when you go wrong with your answer, it shows. And so it's easy to change my story according to the body language of the professor. Now when you do written [examinations] in the US, obviously—

DOMUSH: Right.

SOMORJAI: —everything is written. And not only that, but you have to know the theory to apply, because you have to solve problems, so it was a very different ball game. I managed to learn that, but I lost my hair in the process. Not that it didn't start earlier, but I think that definitely lost my hair. It was a tense situation, but I managed.

DOMUSH: Was it difficult to make the scientific transition? You know, all of the chemical engineering that you'd been learning was in Hungarian.

SOMORJAI: Oh, I left chemical engineering.

DOMUSH: Okay.

SOMORJAI: Chemical engineering in Europe is mostly chemistry. Okay, because their manufacturing prowess is not as great as the US. In here, the engineering is all applied mathematics, differential equations, and how to build a reactor. It [did not involve] chemistry. And I had absolutely no interest in, you know, differential equations and how to handle the chemical process of a black box.

DOMUSH: Right.

SOMORJAI: And you just do fluid mechanics and whatever. So I was given a chance of either chemistry or chemical engineering, the two departments of the same College of Chemsitry.

DOMUSH: [Yes].

SOMORJAI: And I immediately went to chemistry as soon as I listened to Leo Brewer, who was teaching thermodynamics, physical chemistry. Brilliant, absolutely brilliant. He was the one in the Manhattan Project who developed the materials to hold all the actinides, including plutonium, all the isotopes, in a crucible made of europium salts. He was an unbelievably good teacher who loved physical chemistry.

And so I decided immediately to go to chemistry, and not chemical engineering. And so after the first semester, when I took unit operations, I knew I did not want to be a chemical engineer. I went to chemistry.

DOMUSH: [Yes]. Did you continue to have much contact with Charles Tobias?

SOMORJAI: Yes. Yes.

DOMUSH: Okay.

SOMORJAI: Over the years it was delightful. But he was a chain smoker, and he died of emphysema. That's one of the worst **<T: 70 min>** ways to die. You suffocate.

DOMUSH: Yeah.

SOMORJAI: And so we were very good friends till the end. We were good friends. But there is a—how should I say? I have a hard time to call him Charlie, due to the age difference, because this is not—

DOMUSH: [Yes].

SOMORJAI: **—**put it in a language of respect.

DOMUSH: Right.

SOMORJAI: I also couldn't call to Dick Powell, my research director, as Dick. So it was always Professor Powell. But within these boundaries we were very good friends, and I've [befriended them for] fantastically long time. Second to none. Working in a way of choosing people who have dreams, that's the important thing.

And so I had four students in those days. At the end, you see all of their names. And I teach them instrumentation, synthesis, reaction studies broadly. Science develops at the boundaries of fields. I should say new science develops at the boundaries of fields. So if my students can do synthesis and reactions, they can put it together and do something unique in science, and the same with instrumentation.

So you teach that you don't stay in a groove, but you look for the edges, the boundaries of the fields. You know, this is my last hurrah, because I'm seventy-eight. So I am absolutely convinced that the three fields of catalysis, heterogeneous, homogeneous, and enzyme, are the same. The same fields. It's just they work [in different] mediums. You know, enzymes work in water. The heterogeneous catalysts usually works in a gas phase, and the homogeneous works in an organic solvents. But they are all nanoparticles. And nanoparticles have very low coordination [that can readily rearrange that is needed] for catalysis, because everything has to be flexible.

DOMUSH: Right.

SOMORJAI: To do the catalysis. And the nanoparticles, the enzyme, your body has [over] three thousand of those, and they work, but under different conditions. And so once you have a dream like that, there will be no question whether you'll get to it, or my students will get to it. And you build up dreams according to what is not known. You never stay in the groove of known science if you ever want to be a leader of science. And then that is history. It taught me a lot, because I see a pattern of success.

DOMUSH: [Okay].

SOMORJAI: Okay? The first fifty years of twentieth century [involved understanding of the] atom, quantum mechanics, hydrogen bomb, atomic bomb, and physics. The second fifty years, where we are now, since '57, Sputnik I would say [we are involved with the evolution of], molecules, making chemicals, environmentally-sound manufacturing, or green chemistry, biology, [and the] medical [evolution of the sciences]. As a result, we had **<T: 75 min>** a twenty-two-year increase in life expectancy. The quality of life is much, much higher than the first fifty years. And after the first fifty years, we were still one of the countries who were reasonably good in science. Now we're world-class. [. . .] Nobody writes books about these fifty years. , except some books like Andy [Andrew] Grove's, and he's my age, and Hungarian, and he got the degree [in Berkeley].[6]

DOMUSH: [Yes].

SOMORJAI: He was found, unfortunately, to have Parkinson's. The Steve Jobs story is fantastic. But he was on the technology side.

DOMUSH: Right.

SOMORJAI: Doing products, science-based, but doing products. And so there are one or two books, but not much. My book is one of the first that focuses on the fifty years of exponential growth of science, which made the US world-class, okay? There is no question that all my people, postdocs, and graduate students just to work for science and take the knowledge that comes with [the engagement of science].

But there is a reason. The reason is, and I wrote this in two places in the book, at the beginning and the end, [that] the American federal money invested in was one hundred fifty million dollars in 1957 when Sputnik [was launched by the Russians]. In 2012, the American investment in science is one hundred fifty billion dollars. So maybe I am very creative, very productive, but I am working in the Renaissance of an exponentially growing funding for science.

DOMUSH: Right.

SOMORJAI: Okay. And that is unbelievably important. Now I understand that my professor didn't want to take federal money, and he was worried about the autonomy, and there is a very good reason for this, but fortunately it worked out fine. And the one hundred fifty billion dollars is not that much money, with the US, with, I don't know, a four-trillion-dollar budget. And the society got used to the idea that science delivers a longer life expectancy, more health, and products.

DOMUSH: Right.

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[6]Andrew S. Grove, *Only the Paranoid Survive: How to Identify and Exploit the Crisis Points that Challenge Every Business*, (New York: Doubleday, Random House, Inc., 1996).

SOMORJAI: And so this also that happened in 1880, in Germany. By distilling coal, typically brown coal, the Germans discovered [the synthesis of] indigo and that the British colonies [were put out of business]. And they didn't bring in more money, and the colonial empire collapsed, except they sold opium [to] the Chinese for a while. But the whole culture changed, and it absorbed the scientific input in Germany and America.

DOMUSH: [Yes].

SOMORJAI: Now we don't talk about it, because there are also some political shenanigans going on. The US population is convinced of the importance of science to their quality of life. And that will not go away, at least not for one hundred years.

DOMUSH: Right.

SOMORJAI: And that historically is a key change. And that was due to this exponential growth. You ought to look at the—well, these are good numbers.

DOMUSH: It was interesting. A couple of minutes ago you were talking about teaching your students and having taught your students to try and pursue new science at the edges, pursue things that are at the boundaries of—

SOMORJAI: Yes. Absolutely.

DOMUSH: —of different fields.

SOMORJAI: Absolutely.

DOMUSH: And, I mean, of course it's interesting, because what you work on is surface science.

SOMORJAI: Yes.

DOMUSH: So you're always looking at the surface—

SOMORJAI: At the boundaries.

DOMUSH: —looking at the boundaries,—

SOMORJAI: [Yes].

DOMUSH: — whether it be in your actual field or on a—

SOMORJAI: Absolutely.

DOMUSH: —on a higher level. I was curious, though, before we talk about IBM, because chronologically, that's where we were, you said that when you were working with Dick Powell, you discovered that you were good at **<T: 80 min>** building instruments, and making kind of reactions work and go. And I was wondering what some of the instrumentation is that you started building.

SOMORJAI: Okay. To be in the cathedral of science, right, you immediately get a feel for the trends, because most people work at the frontier of their discipline. So now he suggested that I work with X-rays, small-angle X-ray scattering, which had a way of detecting the size of platinum particles as they grow during the catalytic industrial process. And he had no money, and so Professor [David] Templeton, who was here and world-known, gave me an X-ray machine to use. But I had to build the small-angle X-ray [machine]. And then I build that up, and nobody has done the small-angle X-ray scattering, which at a low angle would give the size of the particle.

So I put it together, the apparatus, and I had to work between midnight and three o'clock [a.m.], because electricity was not stable, and the signal intensity was changing as the electric lines were going through voltage hiccups. And so I did that with my thesis in three years, and I found out how to see these particles grow. And I had to use a high pressure instrument to [demolish the mesopores to allow the X-rays to scatter from the particles instead of the pores].

DOMUSH: [Yes].

SOMORJAI: So I took a 100,000 atmosphere plunger, high pressure anvil, which Professor Jura provided for me and then I squashed all the holes out of this. And so what gave the contrast is the metal particles. And so this was the idea of using new techniques to get to an important result I was interested in catalysis, because my project was about this field and I saw it [to be useful in engineering].

DOMUSH: [Yes].

SOMORJAI: So [I got my PhD in catalysis] but I learned that the future of physical chemistry is going to the atomic [and molecular] scales, and every new direction in physical chemistry pointed to fact. Infrared spectroscopy, [which was invented and practiced by] George Pimentel, came out after I was at IBM. [At IBM, I was focusing on techniques that gave us atomic information]. This was a time when the DNA was shown by X-ray diffraction.

And the macroscopic properties of surfaces, the surface area, or just the reaction without knowing how it goes, is not the future. So when I went to IBM, I didn't do any catalysis, because I was learning how to make transistors, and I was put in a project to make a cheap computer. This was before the integrated circuits.

DOMUSH: Right.

SOMORJAI: **[**To make a cheap computer, I used] a photoconductor luminescent material. The luminescent material gives the pulses of light, and then the photoconductor responds to that to make a cheap computer, and it worked, but it died. And so they asked me why does that die. And, you know, I went to surfaces, and I found that all **<T: 85 min>** these devices are small because the electron has to go from one end of the device to the other one, and it has to be as short as possible, for the device to be faster.

And surfaces were the key. The reason it died is because the surface, which consists of cadmium sulfide and cadmium selenide, was oxidized in air, and it became cadmium oxide, and it no longer was a photoconductor on the surface layer.

And so I discovered this, and found out that it's easy to repair, because all you have to do is encapsulate it with some glass or polymer or something, and it worked. However, the device was not cheap enough.

DOMUSH: Right.

SOMORJAI: And so it was not an option. So I gained a great deal of reputation within the company, but they decided that the device would not work. Four years later, Fairchild

[Semiconductor International, Inc.] came out with integrated circuitry wherein the transistors hook up together.

DOMUSH: Right.

SOMORJAI: And we have now over millions of transistors in a PC [personal computer]. So it was clear the surfaces were the key, and that device told me that I should do surfaces. There was no catalysis here, but surfaces. And so as luck would have it, in Bell [Laboratories, Murray Hill, New Jersey], in the 1960-62 period, they discovered how to take electrons, and using a television screen, they diffracted from a surface, and they can detect the structure of the surface with low-energy electron diffraction. And that low-energy electron diffraction was discovered in the 1920s, '27 we got a Nobel Prize because electrons diffract.[7] That was the proof of quantum mechanics.

DOMUSH: Right.

SOMORJAI: But it took so long from scattering the electrons on the surface, a day or so, that the surface becomes contaminated. But in the meantime, the space science forced the evolution of vacuum, because space is an ultra-high vacuum, and we needed pumps to create space environments. And you needed it, for transistors, because the surface, as it got smaller, the surface was everything. We needed a way to clean up the transistor, silicon and the germanium.

So the ultra-high vacuum was developed because of the space sciences, and the transistor took over the radio tube as an amplifier.

DOMUSH: [Okay].

SOMORJAI: Now—So I decided I have to work on surfaces, because that's the way that these devices go. And then in IBM, there was a discovery of the solid-state laser. You know when you have a—what is the case, green—

DOMUSH: Like a laser pointer?

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[7] Louis de Broglie was awarded The Nobel Prize in Physics in 1929, for his discovery of the "wave nature of electrons." The de Broglie hypothesis was confirmed at Bell Labs in 1927.

SOMORJAI: Laser pointer, it has a diode laser, okay?

DOMUSH: Right.

SOMORJAI: [. . .] And so it was obvious that these diodes are smaller and smaller. So surfaces—[because the ever increasing surface-to-volume ratio became ever more important]. I went to Bell Lab to find out how they did this television projection of the electron diffraction within a microsecond.

DOMUSH: Do you remember who you talked with?

SOMORJAI: Yes, yes. Germer, Lester Germer. By the way, it is in the book, a description of the—Lester Germer was the original guy who worked with [Clinton J.] Davisson and got the Nobel Prize in 1927.[8] But he stayed at Bell Labs, and he just decided that the television, which now came into understanding [of its] use, **<T: 90 min>** is a nice way of projecting fast the signals. So I saw [how it] commercially became available, and I persuaded IBM to buy the first commercial machine [LEED instrument, made by Varian] to do that. And I thought, this is my future, because it was an atomic level study of the surface. This knowledge was missing from surfaces. Surfaces stayed in the middle ages, because the few atoms on the surface could not be studied with atomic level techniques. And so they studied the absorption and the flow of gases, but these are all macroscopic. They're not molecular.

So this got me, and IBM got me the machine, the first commercially available. And then my manager called in and said, "Well, you're doing fine, and so we promote you to be the manager of crystal [growth] gallium arsenide, here." Sorry. [Phone ringing]

DOMUSH: No problem.

[Interruption]

SOMORJAI: And so I said, "Well, you know, thank you very much, but I want to study surfaces.

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[8] Germer and Davisson proved de Broglie's hypothesis in 1927 at the Bell Labs; Davisson (with George P. Thomson of London University) won the 1937 Nobel Prize in Physics for their experimental discovery of electron diffraction.

DOMUSH: Right.

SOMORJAI: And now we have a machine. And I really think I can do lots of good things." He said, "Thank you very much. You will be the manager as of next week." It was obvious, they wanted to put me in a place that they make more money from my talents, and it's not a bad thing, but it was a shock to me, that I will not do that, and I don't want anybody to tell me what I should do and I had to leave.

DOMUSH: And this promotion it would have been the point where you left the lab, not only—

SOMORJAI: No, not necessarily.

DOMUSH: Okay.

SOMORJAI: But as you might know, from a research lab, the young researcher who is talented, but his talent can be used to make some useful device somewhere else. And so you move into the processing mode, but that was not the issue. [I worked at] a big research laboratory in Yorktown Heights, [New York]. When I went to IBM, within a year they built that laboratory. I started in Poughkeepsie, [New York], and then I moved over there. And by the way, my wife went to [complete her degree in chemistry]. She went to Vassar [College, Poughkeepsie, New York] to finish because I finished before she finished undergraduate. And so when I got the job at Poughkeepsie, she went to Vassar and finished.

DOMUSH: Right.

SOMORJAI: Then she worked at IBM for a while, until [our first child was born]. So it was obvious that I had a career path—that it was an industrial career path. Okay, so I was not about to accept what they wanted me to do, because I wanted to do surface science with the new machine that gave me atomic level view of the surface. So I started to look for a job. And so I got lots of rejections and lots of acceptances.

And among them, Berkeley gave me both an offer in chemical engineering and chemistry, and Caltech, and Davis also gave me offers—Teller had the Davis department there. When I got the offers from Berkeley, I wanted to come back. And so I accepted the job, and I'll come back to Berkeley with my little baby of three weeks old, my daughter. We had two children, my daughter, and then my son, who was two years younger.

But I was not allowed to take the machine with me, so the first thing I did was to get Berkeley to buy me a machine.

DOMUSH: Okay.

SOMORJAI: The **<T: 95 min>** one bought by Berkeley was the only one I bought, and I built another twenty-five machines like that in house, because it was much cheaper. I had a fantastic technician, a Hungarian guy [Emery Kozak] who emigrated after spending three years in a camp in Russia.

DOMUSH: Oh, wow.

SOMORJAI: After the war, he was brought over to the US. But in fact, in recollection, he died recently. And so he built my machines here. And so I started my laboratory and teaching.

DOMUSH: Let's take a quick break before we start talking about your lab.

SOMORJAI: The ladies' room is at the end of the corridor.

DOMUSH: End of the corridor.

[END OF AUDIO, FILE 1.1]

DOMUSH: Okay. Back on after a quick break, and you had just started talking about moving to UC [University of California] Berkeley, moving back to Berkeley.

SOMORJAI: [Yes].

DOMUSH: But I really quickly wanted to ask, you mentioned that when you moved to New York, when you moved to IBM, your wife finished up school at Vassar, and I was just curious. You hadn't been in the United States that long. How was the transition, moving from Berkeley to New York?

SOMORJAI: Easy. Easy. But, you know, [as students] we had absolutely no money. Suddenly, we had money. So IBM paid for my transportation over there. Do I want to do that? And I was ashamed to say that I had absolutely nothing to take with me. So we bought, six months before, [a] 1951 Chevy, used, and it was a lemon. It had no heater, nothing, and when I [drove] higher than forty miles per hour, it broke a piston rod, because it was [ill-shaped]. But I asked IBM, I have a car, and so they transport it there. So they picked up and transported this. So we arrive in Poughkeepsie in the middle of winter, okay, with a car that had no heater. And I didn't know what a snow tire was. So it was really crazy.

We had the car, but IBM gave the transportation cost, put it in the taxes, and all that, in my first month's salary. And so I expected a big check, but I got a tiny check. So I had to go to IBM to borrow some money. But we rented a house, and so it was a different lifestyle, and I had some very valuable colleagues and good friends there. And it was a very stimulating atmosphere for both of us. We lived in a community of professors from the Columbia Teachers College, and they cleaned our driveway. We rented a pre-fab house in the middle of eight acres, and it was nice, including the fact that the field mice made it to the back of the refrigerator, because it was the middle of the woods. I mean, these are interesting adventures of two young people who had no children. And so in 1963, I started to look for a job, and then Judy was pregnant, and so for some reasons she had to stay in bed for a few days, and whenever I was traveling. And the whole thing was adventure. And in the middle of my interview with Caltech, [John F.] Kennedy was assassinated. Okay. So the interview stopped. I had to come back a week later—everything was fine. Everything was going for us, and we were ready to move, because I was unable to let my dream go.

DOMUSH: Right. Were you only applying for academic positions, or were you also looking in industry?

SOMORJAI: I just got, I think, on the reasonable feeling that if I go to industry, then I will always be—if I'm successful, always be subjected to professional career paths which takes me out of research. And I was good at research. I enjoyed the research, and I wanted to stay in surfaces. So I thought that the only way to go is academia. And I was right.

DOMUSH: Was there anyone, perhaps Dick Powell or Charlie Tobias, or somebody else, that you could ask or did ask for advice about making that transition, or perhaps where to apply, or anything like that?

SOMORJAI: No. No, because **<T: 05 min>** I knew that they would say that academia is the way to go anyhow.

DOMUSH: Okay.

SOMORJAI: It was a question of—it's very important to maintain contact by being a recruiter for IBM.

DOMUSH: Okay.

SOMORJAI: On the West Coast, because I came from here, and they sent the people to where they get their PhDs, and so I was the recruiter in Berkeley and one or two other schools on the West Coast. And that helped me maintain contact with the faculty, which is important. So I was not strange to them, and they knew what I was doing. And so there was nobody here in surfaces or new instrumentation. Academia did not discover computers and solid-state science, especially in chemistry. So whatever I did, it was new.

DOMUSH: [Okay].

SOMORJAI: So then we showed up here, in June of 1964. [University of California] Berkeley had money. I mean, the Manhattan Project really—the radiation laboratories, at Berkeley [led it] to be a powerhouse in science. And Brewer was one of the directors of the new direction of the energy department to go into materials instead of nuclear research. And they really decided to go into materials. And basically, when they hired me, I was the first one who brought in new materials to them in chemistry. So I had no room on campus except an office, and so I started in the building on the hill. I still have a building on the hill. It's called Surface Science and Catalysis Laboratory [Lawrence Berkeley National Laboratory], that I [started] about thirty years ago from DOE [Department of Energy] for my research. So I have two offices.

Berkeley's strengths is double loyalty to teaching and research on campus, and the organized research institutes. I don't know how much you know about the history of science in the US. The US science has two roots, English and German. And if you look at my book, in the beginning, I wrote down the scientific genealogy, which tells you—my roots, which was German. And let me just find it. Here. Scientific genealogy, it starts with [Gabriele] Fallopio, you know the fallopian tube. This was in sixteenth century, in Italy. And then it goes from Italy, and goes to Germany, to Jena [in Thuringia, Germany]. This was Germany, and then the German cities, Erfurt, Erlangen, Leina, again, and then it moved to the States. After [Richard] Abegg and [August W. von] Hoffmann, who was an organic chemist, it goes to Eyring, Henry Eyring. And Henry Eyring was a Mormon, and he got his PhD in Berkeley, but he went to Princeton [University, Princeton, New Jersey], okay?

DOMUSH: Right.

SOMORJAI: And then Dick Powell was his student.

DOMUSH: Okay.

SOMORJAI: Okay? And then it was me. So this root is German root. And the German science was made by the children of businessmen. And it had to be useful. So this started with Haber and others, sort of chemistry technology, **<T: 10 min>** which was then moved to the US at MIT and Caltech. The technology side of chemistry. And so this was also a time when you—in order to have a technology, you needed a combination of talents. And so the cooperation, collaborative institutes of several disciplines, added up to making new pharmaceuticals or new materials. So the West Coast was the seat of the Germanic root. Why? Because the Ivy League schools, during the [the Great] Depression, were full of people, and jobs became available in Chicago, [Illinois], and west of the Mississippi [River].

DOMUSH: Right.

SOMORJAI: Okay, but then G.N. Lewis, who came here, was a physical chemist—Michael Polanyi, John Polanyi's father, [also came from German roots and brought physical chemistry to America]. Genius.

DOMUSH: [Okay].

SOMORJAI: G.N. Lewis came from MIT to here [in 1912], and started to build the physical chemistry. Physical chemistry was a subject that is the underpinning of all of chemistry. So the other English root was John Harvard, Cambridge [University] and Oxford [University]. And then they populated the Ivy League schools, Yale [University, New Haven Connecticut], Princeton, etc. And there was an attitude of you don't do science in a collaborative mode. You are alone, and you put your stamp on the future by your own research.

And so all those schools were never [about] fostering interaction between faculty. In fact, junior faculty were instantly fired if they had a paper with a senior faculty. And so that was a totally different way of doing science, and also upper-class people fund their own research.

So these two roots were very visible until I would say twenty-five years ago. The fact that Harvard has institutes of medical research [Harvard Clinical Research Institute] and other things is very new compared to the West Coast.

DOMUSH: Right.

SOMORJAI: So academically, the two coasts are very different. The fact that I was in industry and wanted to go to academia was not looked—viewed in the East Coast with great interest, because it was not in the culture. I got a beautiful letter of rejection from Princeton. Harvard answered me, they wanted me to go to the materials department instead of chemistry. Anyhow, these roots are attitude roots, and it immediately means that the West Coast people are much more likely to do new science which is at the boundaries.

And so it was not that difficult to understand this, because I came from Berkeley. So this obviously helped. So I started with surface science, and I worked with single crystals, but then I had a dilemma. The single crystal work was all semiconductors, and Bell Labs and IBM were working with single crystals because they were physicists, and they looked for laser action and looked for electronic properties. Now they have twenty-five, fifty people working on semiconductors, single crystals. I was not about to be able to compete with them.

But nobody worked with metals. And platinum is the **<T: 15 min>** grandfather of catalysts. And so I thought, "Oh, let's work with platinum single crystals, and let's do platinum structure, and then chemistry." So I decided to go to chemistry, and I was the first one in the country who used metal single crystals in chemistry.

DOMUSH: Now when you were at IBM, were you able to publish or participate in conferences? Was there a mechanism while you were at IBM to be known kind of to a larger world?

SOMORJAI: No, no problem, but it was not viewed as an absolutely essential part of judgment of success, like it is in academia.

DOMUSH: Right.

SOMORJAI: I published twelve papers there, and I was never stopped to do that. Conferences, no problem. But it is not the centerpiece of success.

DOMUSH: Right.

SOMORJAI: Okay. So we came to Berkeley, and I started to work here. I don't want to belabor, but I utilized what I learned at IBM, including low-energy electron diffraction and single crystals.

DOMUSH: [Okay].

SOMORJAI: But left out semiconductors and left out everything that IBM, Bell Labs, and Texas Instruments or whatever, are good at. It was obvious that the physicists knew very little chemistry, and I had a marvelous recognition of my talents in chemistry, and so I always recommend that you go to a field which is not the area of PhD you're from, when you go to industry, for my students. They teach and they offer a lot and so as a result, the promotion ladder is very strong. So again, boundaries, interfaces.

DOMUSH: Right. Now when you started here at Berkeley, did you have any difficulties getting graduate students early on? Or how did that process go?

SOMORJAI: No. Once I became a faculty member, graduate students came. I had three students. One of them—two of them were older than I was. So this was in 1964 and '65, [Hyland Lyon] was thirty-five and [Joe Lester in] '65 was thirty years—I was twenty-nine. Okay. And one of them was a lieutenant in the Air Force. There is a school in Carmel, no, Monterey, [California], which is for Navy pilot schools. And one of those guys was sent to me to get a PhD. And then I got a postdoc [Stig Hagström] from Sweden who knew surfaces, who was my first postdoc. And in fact, he became the chancellor of all Swedish universities.

DOMUSH: Wow.

SOMORJAI: He passed away two years ago. We stayed good friends. The third one was a transfer from an electrical engineering school. And then came the first guy, Joe [Joseph] Lester, who did an academic position, and went to Northwestern [University, Evanston, Illinois] after.

DOMUSH: You mentioned the person who came as a postdoc from Sweden, from [Kai] Siegbahn's laboratory.

SOMORJAI: Yes, Stig Hagström.

DOMUSH: When you decided to focus on surfaces, you know, you had one of these first low-energy electron diffraction instruments. Was there any sort of community of people who were looking at surfaces that you could—

SOMORJAI: Absolutely not.

DOMUSH: Okay.

SOMORJAI: Not at the atomic level.

DOMUSH: Okay.

SOMORJAI: All the surface was macroscopic study for measuring absorption, isotopes and nothing, **<T: 20 min>**—or reaction with microscopic instruments. Nothing on an atomic or molecular level.

DOMUSH: Okay.

SOMORJAI: Okay?

DOMUSH: So even in Europe, though? I mean, as you said, someone came from Siegbahn's laboratory. Even—

SOMORJAI: No. He did [X-Ray] photoelectron spectroscopy and that, at the line, was not surface-related.

DOMUSH: [Yes].

SOMORJAI: But once he started work with me, then it became surface-related. To start a new field in a, you know, discipline, it's very important. It is a scenario of a good career path, no? But you have to do it well. I mean, my first student, Joe Lester, was an excellent experimentalist. In that time, I had no judgment of who should go to which university, which I now obviously have. And so I sent him to the best school that I could find a job for him, because my students deserved the very best. Well, it turned out he was a good instrumentation guy, but he never published anything, and he was not kept in Northwestern. Then he went to a company in Massachusetts, and he had a brilliant career. He did research there.

But then it taught me a lesson. I mean, I have to judge the students, where they should go, and if I don't, they suffer, and it will not work out. So these are learning processes. As luck would have it, the platinum, the first crystal we got led to an immediate discovery, that the structure of surfaces, the first layer [was] very different from the structure of the lower [atomic layers]. And that was known for semiconductors from Bell Labs and IBM, but it was not known for metals. And so my first publication was the restructuring of metals, and that is very important even now, because that is one of the reasons why metals are such good catalysts.[9]

DOMUSH: When you did go to publish that—

SOMORJAI: Yeah.

DOMUSH: —first article, that first discovery, since this was really a new area, did you have any difficulty publishing that?

SOMORJAI: Oh, of course. People didn't believe it. I published it [in *Physical Review Letters*], and they didn't believe it. And I was an unknown factor, and these were physicists that were doing chemistry that were not low-energy electron diffraction. That's why I am called the father of modern surface science.

DOMUSH: Right.

SOMORJAI: So they repeated it at Cornell [University, Ithaca, New York], and especially at Chicago [University, Chicago, Illinois]. And so I may have made a big mistake, but they have not made a big mistake. And so when they found it, of course, it was right. But they did what I published with much more proof or whatever. So that's how the scientific discoveries are validated, okay? This is the normal business.

And what I gained with notoriety, scientific notoriety, is that now they look at it, they find it interesting, and they don't hesitate to reproduce it immediately.

DOMUSH: Right.

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[9] S. Hagström, H.B. Lyon, G.A. Somorjai, "Surface structures on the clean platinum (100) surface," *Physical Review Letters 15*, (1965):

SOMORJAI: Because it's likely to be important. So the validation procedure has not changed, okay? And it's good. It's very good practice.

And then I started to build instruments in addition to low-energy electron diffraction molecular beam scattering from surfaces. New students were coming in. And the funding was so important, and because of the atomic research at the Lawrence Berkeley [National] Laboratory, the funding was really never a problem. Berkeley is a very rich university because of the **<T: 25 min>** impact in the field that the students come and sometimes bring their money, and with funding from the Department of Energy. At that time, it was the [US] Atomic Energy Commission. And so it has been a tremendously facile start. I had no room on campus, because the two or three new buildings were not built. But on the hill, there was a new materials building, and I moved on, and I had a floor.

DOMUSH: Wow.

SOMORJAI: As much as I needed.

DOMUSH: Right.

SOMORJAI: Okay. And so I focused on science on an atomic level. But that's not catalysis. It was surface science. I always tried to move to catalysis, but it took thirty years to do that, because ultra-high vacuum was necessary to clean the surface, to make sure that I do the right thing. And the surface—it's not impurities that I see. No, when I did gold and palladium, rhodium and platinum, it had to be investigated, and the techniques to get composition analysis were discovered only in 1968 for surfaces, Auger spectroscopy. And how did I prove that the restructuring of the platinum was right? Well, because I tried the neighbors, iridium and gold, and they showed also restructuring. So it was not the impurity in platinum, but it was a property of the material, the intrinsic property of the material.

And so then you go on, and I don't know—one of my most popular discoveries is why ice is slippery, okay?[10] It's the same thing. The ice has a layer of water on it, and the ice is slippery because [of] that water layer. And the water layer gets thicker when you move into the temperature range where you ski or ice skate. It's only the thickness of the layer is different, but the surface of ice is water.

And so it took us a while to prove it with more sophisticated [techniques]. What makes surfaces unique is because the structure—composition—behavior are totally different. Now when you go to nanoscience, which we are in the middle of, when you have just a few atoms,

[10] Yimin Li and Gábor A. Somorjai, "Surface Premelting of Ice." *J. Phys. Chem. 27,* (2007): 9631–9637

you can imagine how different those are from the bulk, many atom surroundings. And that's where catalysis is. But to get to nanoscience, it had to be over the year 2000.

DOMUSH: Right.

SOMORJAI: Okay?

DOMUSH: I'm curious. You mentioned that you had this low-energy electron diffraction, this one machine that you bought, and then you—

SOMORJAI: We built the rest.

DOMUSH: [Yes], you and your technician and your students built the rest. Especially when you first got to Berkeley, you know, you get these couple of students, couple of postdocs. How much are you in the lab using the instruments, doing the chemistry, doing the science, versus sitting in the office, thinking about it, talking about it with your students, and having them go out and do it?

SOMORJAI: I see my students every day. I go to them and we—the secret is in the small details, okay? So you cannot play the big man who steps in in order to do this, and then waits until the results come in. That's nonexistent science.

I obviously, as I accumulate knowledge, in the beginning, I had every detail, work along with the students. But then I knew what I was doing, all right? I knew how to clean that material. I knew, you know, **<T: 30 min>** I am performing the whole [experiment] and I learned the technology inside out. And then I didn't join those experiments because I knew how to do it, and I participated in [developing] new techniques and new instrumentation, as one of the major things that we do here. We developed new instrumentation to study surfaces [in vacuums where they could be kept clean, and then we did new instrumentation to go to high pressures, because catalysis doesn't work in ultra-high vacuum. So we had to go through what I call the pressure gap to do catalysis. And so you needed new instrumentation.

Now I'm using the Synchrotron, the light sources, to look at my sample under reaction conditions while they produce chemistry, and see what happens on the surface. And that is a revolution, okay? And we go through these revolutions, and then I deal with the instrumentation that is needed to first understand what I'm doing. And once that happens, and I understand it, I have more trust that the students can do it, because I can pull them out if there's any problem.

DOMUSH: Right.

SOMORJAI: And the professor's major responsibility is to get the student out [graduating with a PhD], in my case, in four years. Never keep a student longer than four years, because time is a very important variable. But that means that if they are in the wrong paths, or I gave him the wrong direction to go, I have to recognize this and then pull them out, okay?

DOMUSH: Right. Quickly.

SOMORJAI: And change the direction. Or if I mismatch the talent of the student with the research that I am suggesting, whatever the reason, I have to pull him out and put him in another direction to be successful. You cannot build students on failure. You have to get them successful. Once they are successful, then that is a self-confidence level, and then everything comes out right.

DOMUSH: Right, because if they have some successes, if they have some self-confidence, then they can start to have those scientific dreams.

SOMORJAI: More understanding what they're doing is, what else can I do with it?

DOMUSH: Right.

SOMORJAI: Okay? And, well, some students get to that point faster than others. Nevertheless, it is the success that pulls them out. And so now I usually have a big enough group [where I can] put the students together with a senior student to learn synthesis, characterization, new instruments, catalytic reactions. But the change of directions of research is a judgment call, and how to use the new equipment that comes in, that you develop, what to do with it, which makes it unique, is a judgment call. We are —

DOMUSH: It's just about 11:30 [a.m.], and I was thinking that perhaps this might actually be a good time—

SOMORJAI: Anything you wish.

DOMUSH: —to stop for today, and then tomorrow, we can talk about the development of your research over the time that you've been here.

SOMORJAI: Right.

DOMUSH: Some of the big accomplishments, some of the things that may have proved more difficult, or some of the revolutions in instrumentation—

SOMORJAI: Right.

DOMUSH: —that you just mentioned.

SOMORJAI: So if I just look at the table of contents, okay—

DOMUSH: Sure.

SOMORJAI: —you might want to read this, it's a good book.

DOMUSH: I'm sure it is.

SOMORJAI: It's not because of me or I have a good story, but Mitch Jacoby is a very good writer. Let me just show you this. So we are here, "Chemistry in the New World," about my [time at] Berkeley [for] graduate school, and then life in Berkeley, industry, okay, and then experiencing faculty life in Berkeley. And so what happened here, in '79, is the fifteen years in Berkeley, from '64 to **<T: 35 min>** '79. [So] in '79, I became a member of the Academy of Sciences. So that was a milestone, to start—

DOMUSH: Yes.

SOMORJAI: —and a milestone to finish. And so that was 1979. So from assistant professor to member of the National Academy of Sciences, okay?

DOMUSH: [Yes].

SOMORJAI: And the surface chemistry at low pressures. It was not really catalysis,

DOMUSH: Right.

SOMORJAI: But just understanding surfaces. And then the next part is the catalysis, but you know, I did many other things.

DOMUSH: Yes.

SOMORJAI: Because once you get to a molecular level of surfaces, there are many molecular level technologies and phenomena that are not known. And so I felt like a child in a, you know, a cookie shop. And so I went to polymer surfaces.

DOMUSH: [Okay].

SOMORJAI: Okay? I went to biointerfaces. And SFG [sum frequency generation vibrational spectroscopy] all described [the surfaces] of these fields. I [was] sampling what was not known, and I could contribute to it. But then you have to make choices. If you do too many things, especially if you're successful, the field is growing [fast], okay, then you have to neglect something else. And to start new things is easy. What is difficult is what to stop. You can start new things, because you are the first one, you have the techniques, and you just play. And learn while you play. And the students go somewhere else and continue the field. There are many fields that I stepped out of, and my students continued.

DOMUSH: Right.

SOMORJAI: Sylvia Ceyer. She's the chair of chemistry at MIT. She is doing molecular beam scattering, which I did in the seventies. So is Steve [Steven] Bernasek, who is at Princeton. But money's finite doesn't mean that I don't have enough money. Rather, I cannot handle more. I cannot handle more than twenty people in the laboratory working day and night.

DOMUSH: Right.

SOMORJAI: Okay. And so the moment I start to have a conflict of what to do, I have to make a decision [about] what to stop. And that is the hardest thing to do, for me. And so I decided when nanoscience came in, I will get out of biointerfaces. One of my best students, Paul Cramer, who is at Penn State [Pennsylvania State University], is a fantastic guy. He does nothing but biological surfaces.

DOMUSH: [Yes].

SOMORJAI: Dave Castner, who runs the [National ESCA and Surface Analysis Center for Biomedical Problems] institute at Seattle, University of Washington. Fantastic. Zhan Chen is the biointerface guy in Ann Arbor, Michigan [University of Michigan] [department of] chemistry. Fantastic guy.

But I had to get out of biointerfaces in order to focus on catalysis, because catalysis got me to nanosciences, and my dream did not suffer by getting out of biointerfaces.

DOMUSH: Right.

SOMORJAI: But I still have a problem with that, because I worked with the Johnson & Johnson Company in contact lenses. The contact lens is a beautiful bio-device that you can take out and put in. Do you have contact lenses?

DOMUSH: No. Just glasses.

SOMORJAI: I will never wear a contact lens in my life. The amazing damage that you can do to the eye, and you always have to wet it.

DOMUSH: [Yes].

SOMORJAI: And you blink to wet it, okay? And then blinking for some reason for some people becomes exceedingly painful.

DOMUSH: [Yes].

SOMORJAI: **<T: 40 min>** Because they are a tight area. Asians have a very tight eyelid.

DOMUSH: Right.

SOMORJAI: Anyhow, so there are marvelous fields of biointerfaces, and it will never stop. But once I decided to get into catalysis, I had to get out to focus on the new science.

DOMUSH: Right. Now is some of the decision—for instance, the decision about focusing on nanoparticles, focusing on catalysis, some of that is, kind of, the dream, the goal from the beginning, of surfaces and catalysis. But is some of it also instrumentation-driven?

SOMORJAI: Yes.

DOMUSH: Okay.

SOMORJAI: But something happens. I think it is God's gift to science, is that when it is obvious that an instrument is necessary to understand something, miraculously, somewhere in the world that instrument appears. And over and over again, I mean, I can show you the instrument that we developed, the nonlinear laser optics. These are new generations [of instruments], doing surface vibrational spectroscopy, only on the surface monolayer, under reaction conditions, you know. I developed that with Ron [Yuen-Ron] Shen, a physics professor. And I have four of those instruments, to look at, under reaction conditions, the surface [phenomena] and what the molecules on the surface are doing.

And so we developed a high-pressure scanning tunneling microscopy, when you can image the surface while the surface is doing catalysis. And what we find, is that when the surface is doing catalysis, you cannot image, because everything is mobile. Everything's moving. The moment you poison the surface, nothing moves. You get beautiful images, but no chemistry.

DOMUSH: Right.

SOMORJAI: Okay? I mean, these are fantastic, interesting phenomena. And then you have an instrument developed, two things: it has to work under the conditions that you want, because the second question is what is this unique for, that other instruments, that already exist, cannot do? And it takes a while until you figure out that what is the unique niche of that instrument that gives you new science. And it doesn't happen overnight. You have to do all the experiments to make sure it works, and then you figure out, now why did I spend so much time and money to do this? What can I do with it which is unique? This may sound strange to you, but this is how the thinking goes.

DOMUSH: Right.

SOMORJAI: When the laser was discovered, I wondered what I was going to do with a laser. We took fifteen years until they found that they could not live without it. Many things—this is how new things work.

DOMUSH: Right. Well, like I said, I think that this is a pretty good time to stop. And tomorrow, we can—

SOMORJAI: Okay. Very good.

DOMUSH: —we can be focused on the changes in instrumentation, the changes in research in your laboratory that brought you through surfaces that brought you through nanoparticles—

SOMORJAI: Absolutely.

DOMUSH: —and catalysis.

SOMORJAI: Take a look at this book, because this is how I apportioned the chapters.

DOMUSH: Excellent.

SOMORJAI: Okay. That's why it took me four years to write.

DOMUSH: Excellent.

SOMORJAI: Very good. Well—

[END OF AUDIO, FILE 1.2]

[END OF INTERVIEW]

INTERVIEWEE: **Gábor Somorjai**

INTERVIEWER: **Hilary Domush**

LOCATION: **University of California, Berkeley**
Berkeley, California

DATE: **31 January 2014**

DOMUSH: Okay. Today is January 31. Again, I'm Hilary Domush, and this is part two of the oral history interview with Dr. Gábor Somorjai. And yesterday, we had made the transition to UC Berkeley, and we'd started talking about your research. But before we get into the way your research progressed, some of the changes you made, you mentioned about at various points having to decide, do you want to pursue certain pathways at the expense of others. I wanted to ask you about some consulting work you did on the catalytic converter. At Chemical Heritage Foundation, we've done some other oral histories related to the catalytic converter, and of course, this September will mark the fortieth anniversary of the catalytic converter, so I wanted to ask you a little bit about the consulting work you did there.

SOMORJAI: That was with General Motors [Company]. General Motors decided, because of political pressures and for no other reason, to go for a catalytic converter, which was not a business direction for them. They were manufacturers, and not improvers of emission. And so it was obviously going to be a surface device with a high surface area on them, so they needed people who understood modern surface chemistry. So they turned to me, and I consulted with them for about seven years or six years.

And the catalytic converter design was in progress. The clear conclusion is that you cannot have a catalytic converter that stays alive as long as you had lead in the gasoline. The decision that had to be made was how to [remove] the lead from the gasoline. And it of course had major repercussions to the gasoline manufacturers, because they couldn't use certain promoters, which lead was, to increase the octane number. But they had to go to a different way of changing that.

But once the decision was made, General Motors just pushed ahead to take the lead out of the gasoline. And so I participated in identifying, in my laboratory by using surface techniques, what does that do. And so it was obvious that lead forms compounds that poisons the precious metal catalyst, which it was platinum and palladium on high-surface-area oxide. So they also engaged other companies, Engelhard Company [Engelhard Corporation, New Jersey], another one to develop—

[Interruption, speaking to another person]

SOMORJAI: So to make it support, we used an oxide support without the use of leaded gasoline that [had] transition metal salt composition, and then we do see the naked platinum being stable, which eliminated leaded gasoline]. And that required a [continuous] surface analysis, and that is what I could provide. Okay. So they hired many of my students and postdocs. At the end of my consulting career, there were eight people who were working in research in General Motors, and that was nice. [L.] Louis Hegedus was one of them.[11]

DOMUSH: [Yes].

SOMORJAI: I got Louis here to Berkeley when he was in Germany, he wrote to me. **<T: 05 min>** He wanted to come to the United States. Of course, he was Hungarian. And I helped him like I was helped before. And so he came here and got a chemical engineering degree here with Professor Petersen. And then I think his first job was at General Motors.

DOMUSH: Yes.

SOMORJAI: And so this was a period that surface science and surface chemistry had a frontal window in the way they had to do research in this catalytic converter era.

And so usually, you had a first generation of catalysts, and then you learned that you can have a second generation which is better in some ways, you know. That was the same thing there. The first generation catalysts were platinum, palladium, and then they found rhodium, the metal that could reduce nitrogen oxide emissions, NOx, in the presence of oxidizing conditions, which removed unburned hydrocarbons and carbon monoxide, okay? So you needed a catalyst that could reduce NOx and oxidize hydrocarbons and CO. This became the three-way catalyst, which was what we have now, but with changed composition, but the same idea. So that was a very important rhodium-platinum catalyst, and we had to develop the sensor, because the oxygen organic ratio had to be such that this three-way chemistry could play out.

DOMUSH: [Yes].

SOMORJAI: And so the sensor technology was part of this thing. The oxygen intake, obviously, it was a delicate balance, and they went for sensors. And so the sensor technology was part of the success of the catalytic converter, three-way catalyst. So that development went

[11] L. Louis Hegedus, interview by Hilary L. Domush and Jacqueline Boytim, 7-8 December 2013 (Philadelphia: Chemical Heritage Foundation, Oral History #0810).

on. The first thing they [did was to] remove the lead and force the gasoline producers to go to another mixture. The second one is to go to the three-way catalyst, and that required sensor technology in the same time that they had the catalytic converter doing its thing.

But then came the problem, is that the ratio of platinum to rhodium was ten to one, ten platinum atoms to one rhodium atom. And the mining ratio in South Africa was different. It was fifteen platinum to one rhodium, because rhodium was an impurity in platinum.

DOMUSH: Oh. [. . .]

[END OF AUDIO, FILE 2.1]

SOMORJAI: That's the point that the ten to one ratio was necessary, and the mining ratio of fifteen platinum to one . . . . So the platinum mines also got the rhodium as an impurity of platinum, but they had to over-mine platinum in order to get enough rhodium that goes to the catalytic converter. So that was a challenge, and you can go two ways, try to live with less rhodium, but that was not easy, or you destroy the platinum price in the world market.

DOMUSH: Right.

SOMORJAI: And so GM did a beautiful job of stabilizing the platinum price, and they didn't disturb the world market. I'm telling you that every chemical decision has a major technological impact, as well as outside science impact in the world of commodities and finances. They succeeded to get a three-way catalyst that works over 75,000 miles, as long as there is no lead. [. . .]

DOMUSH: Right.

SOMORJAI: How do you recover what you have? And so that was a major project, how to leach out the impurities that shouldn't—because leaded gasoline was much cheaper—

DOMUSH: Right.

SOMORJAI: —than unleaded gasoline.

DOMUSH: And so you were working on not only trying to figure out what the lead actually did to the catalysts, but how to deal with the fact that sometimes lead might—

SOMORJAI: Absolutely.

DOMUSH: —might enter the system?

SOMORJAI: Absolutely. And so basically, we had to take sodium ammonium hydroxide and leach it, and that removed the lead. But the young kids were driving leaded gasoline when they shouldn't have. The placement of the catalyst [was intolerable], because it heats up, it heats up. You would be amazed in the Midwest the races in the wheat fields where they were going 150 miles per hour, which really heated up the [emitted gas during the gasoline combustion]. [. . .] Where do you place [the catalytic converter so that it] shouldn't fry the driver, and shouldn't fry next to the driver? However, if there was a choice, you want to fry next to the driver and not the driver. [laughter]

So there were some very interesting strategic manufacturing issues. And so you work on a catalytic converter, but you have to respond to all these. Anyhow, it's very interesting.

The shock was that we had solved the problem, and they had a supply of catalysts, supply of support, but they decided to get out of the business because this was not their business, and sold it to the Engelhard and the Degussa. [They are both German companies.] But Toyota [Motor Company] did not, and Toyota as a result has been the major manufacturer. Just to show how unwise these business decisions are, has come out with another four generations of catalysts. And for example, they solved the problem in Canada, in 20 [degrees Celsius] below, when you turn on the ignition, you have an extra amount of gasoline and not enough air.

DOMUSH: Right.

SOMORJAI: So they [put in] cerium oxide, which actually by its composition keeps the oxygen in the lattice of the catalyst. So for the first instant, the oxygen from the compound, cerium oxide, was **<T: 05 min>** replacing the air input, oxygen. And so this catalytic change was using cerium oxide as an oxidative mask in cold parts of the world.

DOMUSH: Right.

SOMORJAI: Many very interesting new businesses came, which on specialized conditions are very important.

DOMUSH: Now when you were doing this consulting work for GM, and you said, you know, your lab was doing a lot of this research, were they effectively funding some of your graduate students? How—

SOMORJAI: They hired them.

DOMUSH: They hired—

SOMORJAI: They hired them. They paid a minimum amount, and the consulting means that you don't publish in that area, because you never know what is company confidential. And they are very careful for competitive reasons. When I consulted, it was work that I could continue because I did the science before, okay?

DOMUSH: Right.

SOMORJAI: And so I could tell them, well, you know, we do this and this, this should work. I had a higher probability of success.

DOMUSH: Right.

SOMORJAI: Than if I didn't do that work. And so that was the reason. But the fact that they hired my students was the real bonus. And those students of course did the technology, and they could have everything that I knew. And so at some point, there was no reason for me to consult, okay?

DOMUSH: Okay.

SOMORJAI: Moreover, when this decision happened, then some of my students, who were already managers, you know, went along with the flow, because they had no choice. The others left the company. But in fact, because the business decision didn't include catalytic converters, all of my students left. And Louis Hegedus went to W. R. Grace [W.R. Grace and Company, Columbia, Maryland], okay?

DOMUSH: [Yes].

SOMORJAI: And many of the others ultimately went elsewhere. Two went to Australia, one went to Europe. Anyhow, it fell apart. The research fell apart, because they solved the problem, and from that point on, they bought the catalysts.

DOMUSH: Right.

SOMORJAI: Just like the oil companies are buying the technology, and they provide the crude. And they no longer are major players in the catalytic research business. What happened in the US is that industrial research at the frontiers has vanished, because industry found that research is slow compared to the advances of the technology, which they force to meet in order to stay competitive. Did I make sense to you?

DOMUSH: Yes.

SOMORJAI: So what happened is basically when I started in Berkeley as an assistant professor, 1964, there were many industries with tremendous research. Shell [Oil] Laboratories, Standard Oil [Company], Exxon [Mobil Corporation], the Bell Labs, IBM, General Electric [Company]. These laboratories were much better than some of the academic laboratories in the field that they were interested in. Many of the advances in instrumentation could come from industry or academia, but both were real players. But then that vanished. And so over my life period, academia now totally took over basic research. I don't know a single exception to that anymore.

DOMUSH: Right.

SOMORJAI: For a while, the pharmaceutical companies were doing real research. But that was also taken, mostly because like Novartis **<T: 10 min>** and other companies made academic laboratories and funded them. And so they went to a specialized research enterprise to feed them with the science needed to get the next generation of drugs or next generation of technology. Now it was amazing to see the change. Now if there are exceptions, I should mention it to you. The exceptions, maybe, are in the high technology side of integrated circuitry building, to make transistors smaller and smaller, faster and faster, as a result. But I will be hard put to mention whether Intel or some of the smaller venture—some of the smaller companies that look at the technology of fabrication, okay, are on par with the academic arrangement. But it's not known, because they focus on improving one aspect of the technology. And academia sometimes does that, sometimes does not. So there are some [companies that] do research, and the same in the pharmaceutical area, but usually, it is 90 percent academia and 10 percent industrial technology push. But it used to be either fifty-fifty, or in some fields, industry was much more advanced.

DOMUSH: Do you think—you mentioned yesterday that, you know, since 1957, the United States has really been a superstar in world science. And do you think, or from what you've seen, that this shift away from industrial basic research and having the basic research be more in academia, do you think that that is a positive or a negative for science in the United States, or just different?

SOMORJAI: I cannot answer that question, but it didn't hurt the evolution of research.

DOMUSH: Okay.

SOMORJAI: And I'm a researcher. By and large, if I make discoveries, advances in process, chemical process, like ammonia synthesis, that I consulted with ICI [Imperial Chemical Industries, London, United Kingdom] on that, I brought the knowledge based on which the technology could be improved almost immediately. I worked, consulted, for eighteen years with Union Carbide [Corporation]. And the company went from a major research power to zero, because it's owned by the banks, Manufacturers Hanover Trust [Company, New York, New York]. After Bhopal [India], the Indian fiasco, okay, the bankers got frightened of technology, and they sold piece by piece the whole company to the best offer they could get.[12]

And then, there was for a while, a middle management that was superb, because they were used to discovery mode and technology development, based on that. And then they retired, and vanished. [This was the end of] discovery. The company also found financial reasons to veto the new technology because it was too expensive. Okay. [The technology was] too expensive because they wanted instant satisfaction. And in technology, you don't get that. It takes about five to ten years, really, until it pays off, because it's a **<T: 15 min>** learning process, and [requires] understanding.

And so the middle management that was originally fantastic were not going to the upper management, and the upper management made absolutely purely business decisions of whether it gives an important component of next quarter earnings. And when that happened, the obvious decision in the upper management was don't do it. So either by default, or however you bemoan

[12] The Bhopal gas tragedy occurred the night of 2-3 December, 1984, at the Union Carbide India Limited pesticide plant in Bhopal, Madhya Pradesh. The plant leaked methyl isocyanate gas and exposed over 500,000 people.

that, it doesn't matter, but the whole research emphasis shift in this country, shifted to academia. And in fact, everywhere else in the world [has experienced this shift] except we have a technology infrastructure that is much stronger than most other countries.

And so everything I would say now, it would be derogatory to the other countries, and I don't want to say it. But England had [not much chemical] manufacturing left.

DOMUSH: Right.

SOMORJAI: They all do financial manipulations, and money that is processed in London, [United Kingdom]. The Germans are very good in basic research, but they are still recovering from the Second World—the Nazi era, which basically demolished the research infrastructure. And they're doing a good job, but I can tell you the differences between German science and us, and there are major differences. [. . .] If you look at the top one hundred universities of the world, and these are listed, not a single German university among them.

DOMUSH: Right.

SOMORJAI: So they say that, well, the Max Planck Institutes do that. You're right. But the Max Planck Institute structure is top-down, the pyramidal structure. I have, you know, another fifty-five, fifty-eight professors in chemistry, so we all do research. And there are superstars, and there are coming up, but we have a base. And the pyramidal structures allow shifts of faculty from mediocre universities to better ones.

DOMUSH: Right.

SOMORJAI: And then the salaries are not equal. So the competition, it's a competitive system. The German system is not that competitive, but when they have these superstars, they become directors of Max Planck to make sure that they cannot do any more research, because they have management responsibility. And so usually, that gives power, but you take the best researcher, and then you put him in a situation of power that makes it impossible for him to do research. And he has to work with the second echelon team.

DOMUSH: Right.

SOMORJAI: No, I have twenty people. I don't have a lieutenant, okay? This is as much as I can handle by myself. But we don't have the structure of the supervision that goes to the not so good scientist.

DOMUSH: Right.

SOMORJAI: Right? There are many things [that are different in supporting research in other countries]. I can explain all these things. But this is not important. And I just don't want to come through of being critical of places, because Germany is still the best of the lot. And there are other countries, like Italy, which is dysfunctional, for no reason, because they're full of talent.

DOMUSH: Right.

SOMORJAI: Okay? And so you see all the things that are going wrong, and **<T: 20 min>** we try to avoid those things.

DOMUSH: Right.

SOMORJAI: And—but you learn. You learn with this. I know the system works well, and it attracts first-class people, because they can have an upward mobility, okay? South Korea is full of talent, fantastic. There were two superb guys in my laboratory; they [have faculty jobs] in South Korea.

DOMUSH: Interesting.

SOMORJAI: Okay. And you have to go from a given place. In Italy, you cannot change university. You get your PhD, your only chance of getting a professorship then is staying put in Bologna, [Italy], or Ferrara, [Italy], or Florence, [Italy], and so there are few cities with the universities.

DOMUSH: Right.

SOMORJAI: Minimum possibility for a talented person to [exercise their talents]—this is our big strength.

DOMUSH: Well, I mean, you mentioned yesterday multiple times about the ability to train, the ability to move upwards, and that necessitates some ability to simply move and grow, so that you can have those opportunities to dream, to have upward mobility.

SOMORJAI: Absolutely.

DOMUSH: Yeah.

SOMORJAI: Absolutely. And so our advantages are that the best universities have the best professors, and I am [making a simplification], to teach the best way how students can succeed in the future.

DOMUSH: Right.

SOMORJAI: Now we can violate that, and it happens, but this is the idea. And then the salaries are not equal.

DOMUSH: Right.

SOMORJAI: I would say, you know, the salary as a top professor and as a mediocre professor, it's three to one. And in some places, this cannot be true, because they don't have the money, and then the top universities have a structure which is very flexible, to get the best people in, if possible. And many countries, for political reasons, they just don't do that.

DOMUSH: Right. [. . .]

SOMORJAI: You didn't know that?

DOMUSH: I did not.

SOMORJAI: There are many things like this in the world. And our absence of these idiosyncrasies, either historically built or evolved, gives us tremendous strengths.

DOMUSH: Did—

SOMORJAI: When I went to IBM, Leo Esaki was there from Japan. He discovered the tunnel diode, one of the transistors. He had no job in Japan because he was not from the right place at the right time. When he gets the Nobel Prize [Nobel Prize in Physics, 1973], instantly they got him back to Japan, and he became a great man because he succeeded in the US. The same thing now in China. Some of my students now get multimillion dollar offers from China to go back with no expenses spared to have a laboratory, because they succeeded here.

DOMUSH: Right.

SOMORJAI: And that is the way—I don't mind that. But we live on their science, because we don't have these dysfunctional situations. And then the nationalism. Koreans cannot get a job in Japan. No Japanese would ever get a job in Korea. And neither one would get a job in China. Okay. In Europe, there is virtually no mobility, in spite of the European community—what do they call it?

DOMUSH: The Union?

SOMORJAI: Union. The European Union, which allows French to go to Germany, and Spanish to go **<T: 25 min>** to Poland. If you look around, there is no mobility.

DOMUSH: [Yes].

SOMORJAI: It's not obvious, okay? So there are overwhelming traditional forces. It may change. I don't know, maybe another generation or so. But I have not seen a single French professor in Germany, or vice versa.

DOMUSH: But it's slow. Maybe, like you said, in the next generation.

SOMORJAI: Absolutely. Absolutely. Because they could.

DOMUSH: Right.

SOMORJAI: Okay? The rules are, very, very flexible. This is a side—

DOMUSH: That's okay. That's okay. Well, I was curious if now might be a good time to get back to talking about some of your research and, you know, as we've said, how that kind of changed and developed, how instrumentation—

SOMORJAI: Changed?

DOMUSH: — maybe drove some of those —

SOMORJAI: Yes. Right.

DOMUSH: —decisions. And yesterday, we talked about your use of the low-energy electron diffraction. And I was wondering if there was any other instrumentation that you wanted to talk about in particular.

SOMORJAI: Yes. Yes. So low-energy electron diffraction gave the opportunity to see surface atoms if they were ordered, because diffraction requires periodicity. So I use single crystals, which are ordered. And we learned how to clean them, how to order them, various crystal phases, and discovered reconstruction. However, this required a low-pressure environment. You had to go into ultra-high vacuum to clean these crystals, and then you had to stay at low pressures, because the electron had to go in and out, and it couldn't if you increased the pressure of the device environment.

So then the theory had to be developed of this technology, and fortunately, [Sir] John Pendry in Cavendish Laboratory [University of Cambridge], was the major person who developed the theory, which is not like the X-ray diffraction theory. The electron low-energy diffraction was a multiple scattering-theory developed, and so we could solve structures. And then you have pictures of the diffraction pattern, but to understand those pictures, you have to understand the intensities, and where they come from [to solve the surface structure], etc.

So by 1979 or so, we had a theory, and I hired Michel Van Hove, one of my men who was a theorist and worked with John Pendry. And so we could solve the structure of molecules, the monolayer structure of the molecules on surfaces, with many discoveries in the process. [. . .]

DOMUSH: Right.

SOMORJAI: It's understanding surface science. It was important. We solved over fifty structures at a molecular level. Now the catalysis is kinetics. It's motion. It's dynamics of molecules going in and out, and in this process, they do bond-breaking or bond-making chemistry. So I went to molecular beam scattering. Molecular beam scattering, to have a mixture of molecules hitting a surface. And then in that collision, they make bond-breaking and reactions and that was catalysis. However, it was still low pressure. It was to get the molecular beam in and out. You have to keep the surface clean. You cannot go high pressure, because it formed a pillow of gas. It doesn't allow the new molecules to reach.

But it was a very important area to make discoveries in the dynamics, and what are the reasons. And I wrote a few books, okay. The first edition—I gave the Baker Lecture at Cornell University, and the first major book was this **<T: 30 min>** book.

DOMUSH: Okay.

SOMORJAI: Was 1979, and the book came out in '82, I believe. [The book explained] what the surfaces looked like on electronic scale. And then after I went into high pressure in catalysis [inaudible] when I wrote this book, *An Introduction to Surface Chemistry in Catalysis*, the first—[13]

DOMUSH: Right. And this one is about the move to high pressure?

SOMORJAI: [Yes].

DOMUSH: Okay.

SOMORJAI: Yes. Move to high pressure. And the second volume, which came out in 2010.[14] The second edition, really included current nanoscience and everything that we know now.

DOMUSH: Right.

SOMORJAI: Okay? So this one, again, it's a teaching book.

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[13] Gábor A. Somojai, *Introduction to Surface Chemistry and Catalysis*, (New York: Wiley, 1994).
[14] Gábor A. Somorjai and Yimin Li, "*Introduction to Surface Chemistry and Catalysis*", Second Edition, (Hoboken, New Jersey: John Wiley & Sons, Inc: 2010)

DOMUSH: [Okay].

SOMORJAI: But understanding surfaces has improved. And became [on the] atomic, and molecular [scale].

DOMUSH: What instrumentation allowed you, though, to move into high pressure?

SOMORJAI: Of course. Yes.

DOMUSH: Because you said with the molecular beam scattering, you were still at low pressure.

SOMORJAI: The first one—[yes]. So, we could analyze now, at low pressure, the composition of the surface, oxidation state, or the placement of molecules, their motion. The first major change was a nonlinear laser spectroscopy machine. It was called some frequency generational vibrational spectroscopy.

So it turns out that when you scatter light [such as] normal light, infrared or UV or whatever [kind of] light, it penetrates the surface. Because light, unlike electrons, which don't penetrate because they have mass, big mass, and so they could back scatter from the surface. Low-energy electron diffraction was surface sensitive at low pressures, but that was the problem, because if you had high pressure, the electrons would never make it to the surface.

The photons can go in and out, and X-rays go deep. And the surface is almost invisible, because they go ten thousand layers before they turn around. But it turns out that if you take two light beams, okay, an infrared and a visible light beam, and sum it up, so it means they impinge in the same space, spatial and time, in the same time, temporal resolution, then the secondary process is impossible to penetrate. It stays on the surface, and that reflects from the surface only. And so we call it in chemistry, it has [different] selection rules

DOMUSH: Right.

SOMORJAI: —that if you go to the bulk or the gas phase or liquid phase, okay, they cannot penetrate. But if you have a change of symmetry, okay, at the surface, the surface is different from what's on top of it, liquid or gas.

DOMUSH: [Yes].

SOMORJAI: And the surface is different from what's under it, because those are bulk. Those are all very symmetrical things. It has to be non-symmetrical [and the surface is not centrosymmetric]. And then you get a signal, a vibration spectrum, which is only [from the surface], no matter what the conditions, high pressure, solid/liquid interfaces. This was an outgrowth of a laser spectroscopy technique **<T: 35 min>** called second harmonic generation, which got a Nobel Prize in physics in 1982. Along with Siegbahn, who [did] the photoelectron spectroscopy, and [Arthur Leonard] Schawlow, got the Nobel Prize [Physics, 1981]. [. . .] So second harmonic generation basically, what it did, if you take the same laser beam and you double the frequency, then you have the same effect. Double frequency cannot penetrate.

However, what we did here with Professor Ron Shen in physics and myself [. . .] instead of having two light beams of the same frequency which you doubled, we take different light beams, one infrared and one visible, and then you tune one. And that gives you at a sum frequency vibrational spectrum, because you tune the energy of one of the beams, while the [other] beam stays a constant [frequency]. And that was miraculously surface sensitive, vibration spectroscopy, the way we identify molecules, now we could identify molecules on the surface under reaction conditions. And that was a major breakthrough of going to high pressures and do chemistry, identifying the molecular structures as they turn over, and do catalysis.

DOMUSH: Right.

SOMORJAI: And that was one of the first techniques that we discovered. The second was the scanning tunneling microscope. The scanning tunneling microscope was used always in vacuum, because it was discovered that way. But it turned out that you can do scanning tunneling microscopy atom, by atom, with a little tip at high pressures. The tip didn't care. And that was not obvious, but it worked. So we can go with this scanning tunneling microscope at high pressures.

And so we build prototype instruments there, and usually, if you build prototype instruments, you have about five years before anybody catches up.

DOMUSH: Right.

SOMORJAI: Okay? Because that's usually the time scale, even if I helped everybody to get to that, and I did, it takes about five years to catch up. And you have a tremendous scientific advantage, because you can use that new instrument to do new science. So that was the second technique. Now in—I was—

DOMUSH: Now—sorry. When you moved from the scanning tunneling microscope into high pressure, were you able to modify an existing scanning tunneling microscope?

SOMORJAI: No. No.

DOMUSH: You had to kind of start fresh?

SOMORJAI: You have to build, because they were all vacuum.

DOMUSH: Okay.

SOMORJAI: They were all vacuum. First of all, you have to put a vacuum to clean, everything clean. Then you go to high pressures, and then you start the experiment to do catalysis. Okay? And that combination—you see, this is the boundaries of two fields.

DOMUSH: Right.

SOMORJAI: And once you are comfortable with combining A and B, you immediately have a totally new way of doing science, and different problems you can tackle.

DOMUSH: [Yes].

SOMORJAI: So—okay. So it turns out that we could look at the surface atoms at high pressures. And then you ask, you know, so now what? What have you done? What are you doing? And it took me two years to figure out what this can do for us, because we didn't understand why it would be important. We had seen nothing under reaction conditions. You remember, I told you yesterday that when you have a reaction, everything is mobile. [The molecules on the surface are] moving much faster than the tip, okay? And everything is blurred. And you see nothing but the reaction going on. But then we found that if you poison the reaction, [the molecules on the surface stop] and you get beautiful patterns, but no chemistry.

DOMUSH: Yeah.

SOMORJAI: Okay? That was not obvious. When you do this, all you see is nothing. Then my God, why did that happen? So you discover something, and now you understand it. So we found the technique that can identify mobility, and that mobility of molecules on the surface is absolutely necessary for **<T: 05 min>** catalysis on a molecular level, because they have to find a site that they can do chemistry. And you now work at high pressure on a crowded surface. Everything is full of molecules. And if you go to a solid-liquid interface, and there are lots of reactions there, that you have maybe a thousand times greater molecular concentration, so the surface is very crowded [compared to gas]. So you have to somehow do chemistry in a very crowded surface in catalysis.

And so now we understood what some of the ingredients that are absolutely necessary to do catalysis. Mobility on the surface, and these other techniques, [including] defects on the surface. We discovered this; first we did low-energy electron diffraction, and then with the reaction, the [atomic] steps and kinks on the surface are the sites that bonds are broken.

Now you understand the outcome of this in nanoscience, because when you go to nanoparticles, you have lots of mobility, and you have lots of low coordination sites. So these atoms have only few nearest neighbors, okay, and the catalysts are these tiny particles. Every catalyst—empirically they put in and they developed a whole, you know, nanoparticle architecture of catalysts everywhere in the oil industry and in the automobile industry. But they never bothered—they always said, “Oh, we need small particles to minimize the cost of the metal,” or something like that, which was true. You minimize because you use very little. But that was not the reason. The reason was that it wouldn’t work without these low coordination sites, where each atom is surrounded by less [of] nearest neighbors. And if you have lots of nearest neighbors, catalysis doesn’t occur.

So we found that by looking for the mobility and looking at the steps. Everything was small.

DOMUSH: Right.

SOMORJAI: Okay. And low coordination sites. Now—

DOMUSH: Now may I ask, are you still looking—originally, when you first got to Berkeley, you were looking at single crystal platinum surfaces kind of as your model system. Is that still a similar type of thing to what you’re doing, or has it just moved on?

SOMORJAI: Well, yes and no. No if I can help it.

DOMUSH: Okay.

SOMORJAI: But if it turns out I have a hell of a time to image the nanoparticles, because the nanoparticles don't stay put. They move. And the tip is not controlled on the nano scale, so yes and no. I cannot image the nanoparticles at high pressure with the scanning tunneling microscope. I have to do it on a single crystal, because I need a bigger area to get a regular image.

DOMUSH: Right.

SOMORJAI: The vibrational spectra is no problem. I can go to nanoparticles, because they average over a million of them. And so that averaging technique allows us to see even on a small place, nanoparticles.

Now the holy grail right now, if I could find a tip which is so controlled that it had one or three atoms at the end, and only those three atoms would touch the nanoparticles, so it would be imaged—

DOMUSH: Right.

SOMORJAI: But I haven't been able to do that. I'd love to. Now the problem is that technology cannot control the tip geometry. So the STM [scanning tunneling microscopy], I cannot—if I could control the tip geometry, and I can put it in the theory, that I have three atoms, two atoms, whatever, **<T: 10 min>** I could get structures on a single molecule. But I cannot do that, because the tip is uncontrolled. [. . .] Sometimes it gets easily destroyed, because on the atomic scale, you have to be gentle.

DOMUSH: Right.

SOMORJAI: And we just simply don't have the control of the tip structure. But this is a continuous evolution of instrumentation. Maybe if I was forty-five years old, I would spend the next five years to control the tip.

[Yes]. But I choose other problems and hope that somebody else will choose that one, because there are other type of problems. [. . .] The technique, such as STM, work on single crystals, but I went to high pressures [on nanoparticles. But I could use SFG—sum-frequency generation—vibrational spectroscopy under reaction conditions on nanoparticles how reactions occur, how you break bonds or make bonds].

So then we can do many other things, in addition to catalysis. I could look at polymer surfaces with the same techniques. And biointerfaces. I mentioned the contact lens. So these are hydrogels.

DOMUSH: Right.

SOMORJAI: And you can study the surface, and when you take it out, it's dirty. You find out what the dirt is, and if the dirt stops the oxygen diffusion to your eye, then you get red eye syndrome, and it's very painful. So then the water has to diffuse through the eye, and you blink together, and then we see some people cannot blink, and others who can. But in fact, so you can look at biointerface problems, and then you say, "Well, [phone ringing] what are biointerface amino acids, which form peptides, and then will those peptides form proteins." And so you can go into the biointerfaces of how the body does things at the surface. Your body is basically a polymer surface in water.

DOMUSH: Right.

SOMORJAI: With a layer of proteins on it. That's the human body. And so if you look at the polymer in water, and then you absorb amino acids, which you can polymerize the peptides and polymerize the protein, you're onto doing biointerface in the medical sense. Well, that was a major area. And I did that, because I love to find out how to do things with the techniques that I have, and most people didn't. And many of my students are now in the field. That was one field.

What was the polymer—we did oxides. Just to get away from metals, and we did oxides. And it turns out the support, the catalyst support on the catalytic converter, is aluminum oxide.

DOMUSH: Right.

SOMORJAI: And now we put platinum in a film on an oxide, alumina, and we found what happened there. Does the oxide change its chemistry? **<T: 15 min>** The answer is yes. And then we discovered that the oxide-metal interface is a special site. A special site because there is charge flow between the oxide [and a metal] —it's like a Schottky barrier. It's a semiconductor junction.

DOMUSH: Right.

SOMORJAI: The charge flow from the metal to the oxide, or sometimes the other way around. And that charge flow does unique chemistry. So originally, when you do metal chemistry, we call it covalent bond chemistry. But now, when we look at the oxide-metal interface, it is acid base chemistry, because the charge can ionize [the molecules at the metal-oxide interface] to negative or positive. And that is another fundamental way to do catalysis.

So catalysis really occurs with both covalent chemistry and ion chemistry. And the oxide-metal interface turned out to be the [the sites for ion chemistry frequently called acid-base chemistry]. So I was fully into catalysis and fully into polymer and biopolymer surfaces, and it was a no-go, my research [was unfocused].

And both [directions] grew under our hand, which means students got PhDs. And so then I had to make a decision, what to do, and the decision came when nanoscience appeared.

DOMUSH: Okay. And so this is about [the year] 2000?

SOMORJAI: Two thousand. Absolutely. [In] 2000, my God, suddenly we could use colloid technology, okay, to make little particles all the same size, the same shape. Then these are the real catalysts.

DOMUSH: Right.

SOMORJAI: So I decided to take a jump into [the synthetic] chemistry of nanoparticles of metals, because you always thought about doing something new that you can use to extrapolate, like structure, size, and things like that. And so I started with platinum, again. Let’s take platinum nanoparticles and compare them with single crystals.

DOMUSH: Okay.

SOMORJAI: [. . .] Now when you go to a new field, you get the problem. You don’t understand it, and it turns out that when I make nanoparticles, I can make beautiful size, from one to ten nanometers. Same size, same structure, surface structure, because they are crystals. But in order to make it, so that you could put it in a bottle, it had to be kept with an organic cap, because the organic caps have low-energy, and they don’t stick. The metals stick, okay?

DOMUSH: Right.

SOMORJAI: So the cap. All right. So can I do that chemistry through an organic cap? The answer is yes, because the cap had to be porous, and we found out how to make them. And sometimes we make an inorganic cap. We call it the core shell structure. We pour in the metal nanoparticle and the shell around it is oxide, titanium oxide or alumina or silica or something. And that has very different properties.

So you have to take apart the **<T: 20 min>** nanoparticle, okay, to make sure that you look at the metal underneath. And so that was a very interesting structure, in the field of material science.

DOMUSH: Did you have collaborators or people that you were working with outside of the group to help assist you in transitioning to this?

SOMORJAI: Well, yes and no. The people on the outside of the group were going for semiconductor properties, like emission, electron transport, and so catalysis was not their interest. But it was mine. And so I did catalysis, but I used the knowledge that was accumulating in material science to make various nanoparticle structures and alloys and bimetallics, etc.

So you use the same technology, but you focus on catalysis, and not light emission or [electron transport] or something like that. But there's cross-learning. This is why it's so important that my students learn synthesis, because then they can run with it for other fields. And catalysis, because then they can stay in catalysis, etc.

So we now learned how to make catalysts that do every reaction [. . .] from the literature, from the technology. And this was no longer a single crystal face. But we can get sometimes the same reaction on the right nanoparticle structure, sometimes not. So we found a major discovery, of I would say, probably of my life, is that [. . .] catalytic reactions [can be controlled by] the size and shape of the nanoparticle. So you change the size and the shape, to get different products.

DOMUSH: Right.

SOMORJAI: The question is why? Well, it's not obvious. Absolutely not obvious. And so what we find is that when you change the size.

DOMUSH: Oh, we're fine.

SOMORJAI: Okay. [Yes]. When you change the size, [you coordinate] the number of coordination atoms, and how many atoms it has as nearest neighbors changes. And that cluster size changes the electronic structure, the oxidation state, and so just by changing the size, you do different things. And in some reactions, the shape change meaning that one crystal ace from one of these clusters is much more active than another one. So as you change the shape the various crystal faces give you the sum total of what they're willing to do.

DOMUSH: Now as you were understanding this, that the fewest nearest neighbors and the crystal faces and the geometry, were you understanding it to such an extent that you could predict—

SOMORJAI: Yes.

DOMUSH: —what it was going to be? Okay.

SOMORJAI: Absolutely. Absolutely. You know, what we do, we do the same reaction, and we change the size, and we see how it changes. And in some cases, the size beyond a certain size didn't make any difference, but then the shape gave us different results. So now we had a synthesis that we can make nanoparticles in the one to ten nanometer regime easily, and we can make it with any composition such as bimetallic, palladium, rhodium, nickel, copper, and anything that industry uses.

But we can control it with the shape and the size. And then now we can do it in two dimensions or three dimensions. We can now deposit these nanoparticles as **<T: 25 min>** a film, and it's two dimensional. It's called a Langmuir–Blodgett film.[15]

DOMUSH: [Okay].

SOMORJAI: Or you can take a mesoporous oxide where we can control the pore size, but it's a three-dimensional structure, and industry uses three dimensions, because they want to pack lots of catalysts in there.

And then I put my nanoparticles in that catalyst, okay, in the three-dimensional mesopores. And that means we can get very close to what industry does, except we control the size and the shape and the pore size of the mesopores. The mesopore ought to be bigger than the little particle we put in there. Otherwise, it doesn't go in, okay?

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[15] Contains one or more monolayers of an organic material, deposited from the surface of a liquid onto a solid by immersing (or emersing) the solid substrate into (or from) the liquid.

DOMUSH: [Yes].

SOMORJAI: And we can control all that.

DOMUSH: Now as you're doing this, you know, especially as you're moving into the nanoparticle area, I asked you a second ago about if there were people that you were kind of collaborating with, but are there people that you are competing with, even if it's kind of a friendly competition?

SOMORJAI: Very few.

DOMUSH: Okay.

SOMORJAI: But I learned from them. Basically, I have to tell you how I started. [. . .] I hired a postdoc and a visiting scientist, people who were very good at making industrial catalysts, and then I taught them colloid chemistry to control the size. And they knew almost all the technology, except the physical chemistry and how to make the same size or the same shape.

And so I learned from them about how to make the real catalysts. And then we took mesoporous oxides, which were all available in the size of the pores, and so we got the knowledge of the real catalytic technology into making the same size and same shape nanoparticles in three dimensions. So that was a real catalyst. I mean, whatever I'm doing, I do a high-technology catalyst by controlling the pore size, the shape, and the size. And so now I can compare what I have in terms of chemistry with the industrial catalysts. And this is the Holy Grail of what is defined as the product distribution of the catalytic reaction totally changing when you change the pore size, [and the nanoparticle] shape and size.

DOMUSH: Right.

SOMORJAI: But we also discovered a new site, which is at the metal-oxide interface, which is the charge. So this is called Lewis acidity. So this was the boy who was here, who was a PhD—got his PhD at UC Berkeley, focusing on the oxide-metal interface. And that's a unique site. So we can tackle both catalytic mechanisms, the covalent bond mechanism and the charge particle mechanism, which is the oxide-metal interface.

And so now you will revisit an important catalytic technology, and you find surprises, because when you change one of these components such as size, shape or pore size, the products totally change.

DOMUSH: [Okay].

SOMORJAI: Or you put an alloy in there, such as a bimetallic, zirconium and platinum, and the products change immediately, because there is a different chemistry going on. So we reach the atomic level study of catalytic reaction on a metal-oxide interface, the main state of the most heterogeneous catalytic technologies.

So you utilize the advances in instrumentation to do [studies under reaction conditions]. You utilize the pressure **<T: 30 min>** that changes the pictures of a crowded surface to do chemistry. And then you don't lose control of the atomic structure [as you monitor how it changes during the reaction. I call this molecular catalysis].

DOMUSH: Right.

SOMORJAI: —and molecular—the simple molecules you do on the surface. And most catalysts uses a mixture of molecules put together. And I have yet to go there. I want to look at single molecule reactions. That's my stage of understanding.

So now you can dream [a] different way than with a single crystal. Single crystal, you dream to get away from it with the single crystal, you dream to go to high pressures.

DOMUSH: Right.

SOMORJAI: How do you do that without losing the molecular understanding? So now you went to nanoparticles, and this is the real catalytic system, and you understand the low coordination, because that's what makes you change the chemistry as you change the size.

DOMUSH: [Yes].

SOMORJAI: You discover, for example, that when you go below one nanometer—

DOMUSH: I'm sorry, below one?

SOMORJAI: Below one nanometer, one nanometer is forty atoms.

DOMUSH: Okay.

SOMORJAI: If you go below one nanometer, maybe one hundred atoms or so, the metal is no longer an atom. It's an oxide. It has charge. Its electronics structure changes when there is no bulk.

DOMUSH: Right.

SOMORJAI: Okay. These atoms are Pt^{2+} or Pt^{4+}, or Rh^{3+}. Au^{4+}. And so the chemistry changes because of the electronic structure changes. And so now we went through a range of homogeneous catalysis, which is usually in a liquid phase, organic liquid, it's a transition metal ion, a single ion, okay, surrounded by ligands of molecules. And these clusters, these small clusters, forty atoms, are the same ions that the organic chemists, the homogeneous catalyst people used. They were not metal atoms.

So I got together with my colleague in [single ion] homogeneous catalysis, [F.] Dean Toste, and we put these clusters instead of the homogeneous ion. And we did the same reactions on the clusters, and we had no problem, absolutely no problem, to get the same results.

DOMUSH: I'm sorry. Did you say who the colleague was that you—

SOMORJAI: Dean Toste.

DOMUSH: Oh, okay.

SOMORJAI: Dean Toste. A very good organic chemist. He did homogeneous catalysis, and he's open-minded. You have to have—and not all organic chemists are open-minded. So we did that. But the fantastic discovery is that the problem in homogenous catalyst, that the catalyst is small, and it is in the same solution where the product forms, the reactants come in, and they're all mixed up. And it is very difficult to separate the catalyst from the reactant and products. But if you put these clusters on a—we're okay?

[…]

SOMORJAI: Okay. And what we found is that we can put these clusters on a support, a dendrimer, polymer support, and we found the conditions that these particles stay put and don't leach.

DOMUSH: Right.

SOMORJAI: And the [gaseous] reactants fly by, and the [liquid] products flow by. And the catalyst is easily separable from the reactant and products. So this is a major evolution of the pharmaceutical industry, because all the homogeneous catalysts make these complex molecules with structural properties such as size and shape, where the molecules that make the properties **<T: 35 min>** shape and the static properties make it either poisonous or beneficial [medication].

DOMUSH: Right.

SOMORJAI: Okay? And so you can now make complex molecules with the clusters, and easily separate the products and the reactants from the catalysts. And so we have a program, and this is ongoing research.

So then dream, it appears that if you look at all three fields of catalysis, homogeneous, heterogeneous, and enzyme, all the catalysts are nanoparticles. Nanoparticles, except the enzyme catalysts work in water, and we have a protein wrap around the active site. So now we could heterogenize homogeneous catalysis with Dean Toste.

DOMUSH: Right.

SOMORJAI: So can we heterogenize enzyme catalysis?

DOMUSH: Now if you're working, again, to use the phrase you keep using, kind of at the interface of the two fields, the interface of heterogeneous catalysis and homogeneous catalysis, do those labels, what type of catalysis it's been described as, does that label become unimportant?

SOMORJAI: Absolutely.

DOMUSH: Okay.

SOMORJAI: It's a hybrid catalysis. The hybrid catalysis, as long as you get the same products—

DOMUSH: Right.

SOMORJAI: —that you get with one or the other, okay, then you can claim that it works under different conditions, which are more useful in homogeneous catalysis.

DOMUSH: Right. And if you can understand the function and the surfaces and the way that the catalyst is working, the nanoparticle is working, it doesn't necessarily matter how you describe that catalyst?

SOMORJAI: Well, but you have to understand why it does that, that you can heterogenize homogeneous catalysts. It turns out that it was a very simple trick that allowed us to do that. The supported cluster was hydrophilic, and the solvent had to be hydrophobic; benzene and toluene are hydrophobic. As long as the dendrimer support and the nanoparticle that we deposited with the organic cap are hydrophilic, it didn't leach—

DOMUSH: Right.

SOMORJAI: —into the hydrophobic solvent. If we put in water, it leached.

DOMUSH: Right.

SOMORJAI: Okay? Because it was hydrophilic, and the catalyst was hydrophilic. So it was very simple to keep it stable, okay, with this one. But we had to find out, you know, how to do that. And so—

DOMUSH: Right. Simple, of course, once you know.

SOMORJAI: Of course. So that's true. Now this is the key statement of science, taking over every field applications, whether it's biointerfaces or human body or catalytic technology. Once you understand—I mean, I could explain—once we did ammonia synthesis and I had thirty times more turnover rate on my single crystals than ICI [Imperial Chemical Industries] in England. They came to me, said, why do you have a higher—and when I looked at how they did it, and it was very simple. They combined the co-catalysts in a way that they got side reactions, and it was no co-catalysts, but it was a piece of rock. And all they had to do is add the co-catalysts in a different manner, and then they got the same thing that I did.

Sometimes these are very simple things that control this. But the knowledge is the difference. All this knowledge. And this is why academia focuses on knowledge gaining, [and] is taking over fundamental research. **<T: 40 min>** And the technology takes advantage of that by paying for us or having institutes that they attract people to work in like a cancer institute, or diabetes institute. So the science got separated in academia, because we deal with more and more complicated chemistry, and the technology runs ahead.

So right now, I think this is the last real challenge that I'd like to solve, is how to do enzyme catalysis in a hybrid model with heterogeneous catalysts. I have been thinking about that, and there's a huge change in my thinking that must take place to tackle enzymes. If you have a human body, with the enzymes, and there is a fetus, the fetus takes nine months. Very slow, and come out as a human being with very little damage of organs.

DOMUSH: [Yes].

SOMORJAI: So it is tremendously selective, slow, but selective. With my hair, it may not look much, but I have to go to a hair cut in every three weeks. It grows, and I have it cut, and grow, and it's always the same hair, okay?

DOMUSH: [Yes].

SOMORJAI: So enzyme catalysis is slow, but it's very selective. And it is the result of not one catalyst, but a series of catalysts that work in tandem. So whatever reaction intermediate you get here, it moves over to another catalyst, and it does something else, and then it goes to another catalyst. And somehow, which I certainly don't understand, it always does the same thing, slowly, but it always does the same thing.

[. . .] The enzyme catalysis works with a catalytic architecture where homogeneous or heterogeneous catalysis in this model works with a single catalyst. So it's a very different approach. I get a problem, so like high [hexane] isomer products for high octane gasoline, with a single catalysis. It's not obvious that it cannot work with two catalysts or three catalysts, and end up with a different product. But I never tried.

DOMUSH: Right.

SOMORJAI: Because I already got the product. Homogeneous catalysis, we find now all we have to do is change the flow rate in the liquid, and you get a primary product and then a secondary product, which forms much slower. So when you start to slow things down, there are intermediates that can be identified. Now in an enzyme, if you want a baby, you don't stop the intermediates, but you wait nine months and you get to the final product, so it works with a catalytic architecture. How [does one] make that? I don't understand this architectural process at all, because I did that with single catalysts to do relatively simple molecules as compared to a human being.

And so now I am trying to learn enzymes. I have no idea how the enzymes work, but I have some colleagues who can make certain products with enzyme catalysts, and I'm just trying to learn this. [Enzymes make an architecture that makes sequential products.] **<T: 45 min>**

DOMUSH: Right.

SOMORJAI: But that is not an architecture, because the architecture is that you have intermediates that grow an organ, or a [strand of] hair, or a [piece of] skin, and so this one is a challenge to me. It's a very different catalytic chemistry than the simple-minded homogeneous and heterogeneous chemistry. You know, all my scientific life, I always simplified things. I went to the single crystal, not a particle, because I could understand a single crystal. And then a single crystal was all one, one, one faces, and it did absolutely no chemistry. Absolutely nothing. And then I [damaged] the crystal and got [atomic steps], or a kink. It suddenly started to do H_2/D_2 exchange chemistry. So you go from a blank passive surface that should be doing that, and it doesn't, okay, and try to find out how to go forward.

And I finally ended up with nanoparticles, because it's all over the [technology to make simple reactions with] flexibility, but that is not how you make a baby. So I'm trying to learn this catalytic architecture, how two or three or four enzymes work together. And that's the future. You see the thinking process?

DOMUSH: [Yes].

SOMORJAI: The dream changes as you get some new discoveries that allow you to go to high pressure, the instrumentation is key. I can buy enzymes. So now what? I have to find the reaction, how it jointly makes something else, and I don't understand it at all. So this is the learning process. What you see is my life, okay, and the dream is the most important. And every point of discovery, you say, [yes], what do I do? And then you find a way of building on the knowledge.

DOMUSH: [Okay].

SOMORJAI: Then we found that an oxide-metal interface does different chemistry. It was known for twenty years, but nobody understood it.

DOMUSH: Right. How much longer do you anticipate running a group that's approximately twenty people to work on trying to understand this architecture as best you can? Or if that's not a question you can answer at this point—

SOMORJAI: Look, I'm seventy-eight. The probabilities of something happening to me health-wise exponentially increase with every year. So I'm thinking that for two more years, then I will be eighty. Fortunately, I'm healthy.

DOMUSH: [Yes].

SOMORJAI: And with good health and luck—

DOMUSH: Exactly.

SOMORJAI: —I can handle this. At least, I think. Next week, I go to Penn State and Iowa State [University] to visit some of my old students who are on the faculty there, because I promised. Now to go to Iowa and Pennsylvania in the middle of February may be tempting God. But it becomes harder because I'm fearful that something [could] happen, and that's no good, because it's a global thing, and I have to go to the academies, you know, **<T: 50 min>** for funding, you have to sing for your supper.

DOMUSH: Right.

SOMORJAI: A major review is [. . .] coming in March. So I can find jobs for people. I'm basically an employment office. I think I can do it definitely for two years, until I'm eighty. At that point, I'm looking for a young guy who is likely to be a superstar, and I have two of my students here who are like them—one of them, Elad Gross, he's Israeli, he decided to go back to Israel. He got all the offers of every university, and he doesn't want to stay here, with his wife and their three children.

The other guy who's excellent, who was here while you were here, [L.] Robert Baker, is a Mormon. Fantastic. Experimentally, he's creative. He's doing and dreaming, and he can get his dream fulfilled, because he's so talented. If I can convince my colleagues to give him that assistant professorship—and he just interviewed here, but he's looking elsewhere. He got an offer from Ohio State [University, Athens, Ohio], Texas A&M [University, College Station, Texas], and let's see where else. But in fact, I want him here; he can certainly work in California. I have to tell you, the judgment is crucial.

DOMUSH: [Okay].

SOMORJAI: In addition to these two, I had no more [at present] than two who I thought was Berkeley caliber.

DOMUSH: Wow.

SOMORJAI: And they're all employed and they do beautiful science. But that creativity in combination with experimental prowess, and the dream [is rarely found].

DOMUSH: Right.

SOMORJAI: Okay? It's not something you can teach, and so this guy, he interviewed. I think he interviewed very well. I listened to him. And if he gets an assistant professorship, then I can help him set up the laboratory. We have lots of equipment. And then I will retire to be professor of the graduate school, which means I will not teach. And I'm teaching a physical chemical laboratory in this building. You know, I mean, I've been teaching full-time teaching. [. . .]

I would think that if he could be employed here, that it would be fantastic. But there are other demands in the department, although I'm doing my best to sell him.

DOMUSH: [Yes].

SOMORJAI: All right? It will be decided if I would say within the next three months. Then everything looks better, and then I will retire, or be the professor in graduate school. I will still be in research, but probably will no longer have any graduate students, only postdocs. Basically, I can get postdocs free of charge, because they come here with their own money to get a degree.

DOMUSH: Right.

SOMORJAI: Because that's a ticket for the jobs. So I have no hobbies other than science. I don't play golf. I'd like to keep [doing science], as long as my health allows. Fortunately, my brain is okay, and that's, I would say, the most important part of my body in this situation. Exercise is very important, so I try to do that with my wife, and we walk. We don't run anymore. We walk. But as long as I can, I'd like to do it.

DOMUSH: You mentioned **<T: 55 min>** the difficulties of traveling across the country in the winter, and especially this winter it's been so cold and snowy in so much of the country. Do you do much international travel still?

SOMORJAI: Yes. You know, I am the chair of the international advisory board for the Norwegians that convert natural gas to liquids.

DOMUSH: Okay.

SOMORJAI: They have a law that they cannot burn natural gas from the North Sea.

DOMUSH: Right.

SOMORJAI: They have to convert it to something else. And that is basically gas to liquids, Fischer-Tropsch reaction, and a similar thing. I had that for six years now, okay? And I'm the advisor of the UniCat [Unifying Concepts in Catalysis]. The Germans put in five hundred million Euros to Berlin, [Germany], for that combined catalysis institute, the idea being that they do homogeneous, heterogeneous, and enzymes. But they focus on methane [. . .]. So there is a major interaction with the international community.

And then I have to show—you know, there is the Somorjai Award, in my name, for the ACS [American Chemical Society]. We donated the money [. . .]. And I have a Berkeley Award, the Somorjai Professorship, which is in the Miller Institute [for Basic Research in Science, University of California Berkeley], actually. So young professors come [to work] in chemistry for six months to two year visits.

DOMUSH: Okay.

SOMORJAI: So, you know, I don't need more money. I mean, that's not a question of money. But as long as I'm active, there is some money flow, which I can use to donate. But I just like to stay healthy with my brain in the foreseeable future so I can do work, even though I will not take graduate students.

DOMUSH: Right. You mentioned, of course, the Somorjai Award that ACS gives out in your name, but you've been the recipient of quite a few very exciting awards.

SOMORJAI: [Yes].

DOMUSH: You're not only a member of the National Academy,—

SOMORJAI: Yeah.

DOMUSH: —you know, you've won the Priestley Medal, you've won the National Medal of Science, you've won the Wolf Prize, a number of other awards. And I was wondering if you could just talk a little bit about what those have meant.

SOMORJAI: Well, if you look at the book, in the final chapter, I listed prizes. This is part of the selection of faculty or anywhere else in sciences and technology, of achievement. And it's very important, because it separates people by an award which may be [worth] two thousand dollars or five thousand dollars. And there are other ways of separating, because you can measure success, other than awards. But this is a very national award, and then it becomes also an international aspect of visibility.

DOMUSH: Oh, yes. Of course.

[Background voices]

SOMORJAI: So these awards have a pecking order. The ACS does an excellent job of giving—for young people, you know, achievers. Also NIH [National Institutes of Health] does a good job, in the institute. I don't know what to say. I mean, this is a selection process, and when we pick new faculty or **<T: 60 min>** try to get somebody, the recognition is partly of these awards, [and is] very competitive [to gain]. And there are a few awards that are very personal awards, which doesn't necessarily go for quality. The Templeton [Prize], is for science and religion. It's an important award, but very specialized.

Have you read the *New York Times*?

DOMUSH: [Yes].

SOMORJAI: The Sunday *New York Times* wrote a beautiful article, a review of the week, and there was three professors, I think two [Yale University] professors [who asked], "What do we mean by upward mobility?"[16] You ought to read that. So the US is wedded to upward mobility. So how does that happen? What's the qualities you need to [achieve this]? They said that, well, people who are upwardly mobile have no self-confidence, but also have a superiority complex, combined. And they know that they are good, but they are not feeling how to accomplish the rewards of their work.

And so they are always looking for other ways of proof, you know. So the award system speaks to that, okay, because you distinguish yourself, and it makes you feel good, and it adds to your superiority feeling. It distinguishes you from the masses. But on the other hand, it's always you need to prove yourself, to get another award. It gives you that satisfaction.

But the third thing in upward mobility that's very important, according to this article, was the delayed gratification. So you build up knowledge or whatever you want to reach that critical point. And— [Interruption]

So this does not exist in most other countries. England has something. Germany, not too much. Other European [countries such as] Hungary. Okay, so there is a psychology here that appears to help to separate excellence.

DOMUSH: On a completely different topic, one of the things that I was curious about—of course, we talked at length yesterday about your life in Hungary and leaving Hungary with your sister and your soon-to-be wife. And I was curious if you went back to Hungary at some point, if you've gone back to visit.

SOMORJAI: Yes. Yes. I didn't go back for thirty-one years, because when I escaped, I was convicted to ten years of labor, forced labor, and I was not about to try them out. So then after ten years, there was an amnesty, around '68 or so. Then I didn't go back because anybody who **<T: 65 min>** went back was immediately requested by the security police to try to spy on the country that they came from. This was a typical communist, socialist regime—I was invited. You know, I became an Academy member in '79, and then I got an offer from the ETH [Swiss

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[16] Amy Chua and Jed Rubenfield, "What Drives Success?," *New York Times*, January 25, 2014, http://www.nytimes.com/2014/01/26/opinion/sunday/what-drives-success.html

Federal Institute of Technology] Switzerland to take over from a Professor Piero Pino, who was retiring. They have very strict rules of retiring, it was sixty-five, he was a homogeneous catalyst guy, to take over, and they got beautiful compensation and infrastructure.

And so I went there, and while I was there, I visited the Soviet Union, because the Russians invited me. There was a catalysis institute in Novosibirsk, Siberia, [Russia]—anyhow, they invited me, and Novosibirsk assured of safety. It was rather curious, but as stupid as I was, I had a sort of superior feeling that I'm untouchable, because I'm good, and it could cause an international scandal or something, which was not true. I mean, the stupidity of people who feel secure is not to be underestimated. I can tell you when I went to Nanjing, China, which is close to Taiwan, the Taiwanese and the Chinese were shooting at each other. And so I tried to take a walk, and I was not allowed to take a walk. When life is good, you forget about all the bad stuff. And then an accident happens that jars, shocks you back to reality. And that happened to me in China. And I just wanted to get out of there, because I was afraid for my security.

So I went to normal cities, and I came out—that was a very interesting visit for many reasons. And so then I got this offer. I went from Switzerland, went back to Piero Pino, and I was there. Then came a Hungarian invitation in 1987, all right? Thirty-one years after I escaped, I was invited back. Hell, I survived Siberia. Why not go to Hungary? So I went back to Hungary, Budapest, with my wife, and I was hand carried everywhere. And they gave me the honorary doctorate degree at the Technical University that I never finished, okay?

DOMUSH: Right.

SOMORJAI: And then I became a foreign member of the Hungarian Academy. They were very nice. At that point, they asked me to chair an advisory board, international advisory board, to take the Academy institutes, to bring them up to modern standards. And there are fifty-two institutes. I have the book right there to show the institute. And in the chemical side, I put together a group of scientists, Peter [J.] Stang—I don't know whether you know—

DOMUSH: I know the name.

SOMORJAI: [Yes]. Peter was also of Hungarian origin. Hungarian origin who was in Germany, then in Denmark for a period. So we went in there and **<T: 70 min>** consulted them and tried to see what to do and how to do it. And for six years I was on the advisory board, and we made great advances.

DOMUSH: [Yes].

SOMORJAI: But then there was a government change, and the new government became very nationalistic. And within a year, they dismantled all the international advisory boards, because only Hungarians can advise Hungarians, which is as stupid as you can think of. The problem is in a small country, you cannot be honest in your evaluation because if you have a bad opinion of something, they know immediately who—

DOMUSH: Right.

SOMORJAI: —where is it coming from. And then there is revenge, because they do that to you. You have to have an advisory board that is decoupled from the system, and we do that here in the US, and that's the only way it works.

So they dismantled the advisory board, and I haven't been back. But I went back twice to take my grandchildren back to look at my old family house, and my wife's family house. These are two families. I have two children, and they have two children of their own, and I took them separately.

DOMUSH: Okay.

SOMORJAI: And to revisit that, and the countryside, so at least they have a sense of their roots.

DOMUSH: Right. Do your children speak Hungarian?

SOMORJAI: No. No. My daughter, who is the oldest of my two [children], speaks Hungarian, has a very nice vocabulary, but she cannot write.

DOMUSH: Yes.

SOMORJAI: It's very interesting. And my wife and I mix the language, but more and more we speak English, because we speak English all the time. But when my mother-in-law or my mother was alive, when we visited them, it was obvious that we had visited them, because then we would speak to each other more Hungarian. So it was immediately obvious, what did we do with our parents.

DOMUSH: Right.

SOMORJAI: Because of the languages. I'm fluent in Hungarian, I can write, of course. No problem. But you acclimatize very rapidly.

DOMUSH: Now did your parents ever have an opportunity to leave Hungary, or did they—

SOMORJAI: Oh, [yes]. So I came out, escaped, and then we got a green card in '57. [Yes]. Yes. And then five years later we became citizens. And by that time, I was at IBM. And so we hired a lawyer, and he got our parents over here.

DOMUSH: That's great.

SOMORJAI: And my father was—1962, he was sixty years old. He was born 1902. So sixty years old. And my father and mother opened their children's clothing store, between babies to four years old, something like that. And the two of them were running that shop, very successfully, and they were totally independent. My father never accepted anything from me. It was a matter of, you know, of his decision. It's amazing. And then he died at age eighty-two. And my mother lived another ten years. And then she passed away. And so she ran the store after my father died, and they made a very **<T: 75 min>** decent living in that small store. But it gave them independence.

DOMUSH: That's wonderful.

SOMORJAI: [Yes]. The bottom line is that all the talent that my father had, and he was a genius with math, [was] spent with survival.

DOMUSH: Right.

SOMORJAI: Hundred percent, and trying to give us something in the worst of circumstances that allowed us to function. And I have none of that problem. Maybe I have problem, but I can use my talent doing things that are constructive.

DOMUSH: Right.

SOMORJAI: And not survive. And so this is not unlike, you know, the immigrant situation, except we came first and they came after us.

DOMUSH: That's wonderful, though, that you were able to bring them over here for so long. That's great.

SOMORJAI: [. . .] Have you ever read a book called *The Pity of It All*?[17]

DOMUSH: No. It sounds familiar, but I have not read it.

SOMORJAI: You must read that. *The Pity of It All* was written by [Amos Elon]. I think he was an Israeli writer. It's about the German Jews, [and] it starts around the 1650s, when—what was the name of the philosopher?

DOMUSH: Spinoza [Benedictus de Spinoza]? Is that—

SOMORJAI: German, and there was a musician with the same name. Mendelssohn [Felix Mendelssohn Bartholdy].

DOMUSH: [Yes].

SOMORJAI: Mendelssohn. [Moses] Mendelssohn arriving at the gate of Berlin, at the gate where only animals and Jews could enter. And he had to pay, okay, he entered. And so that started the influx of Jews to Germany. And to Berlin. And so he describes history and how the book— [he] assimilated in society, [including] the musician, the poets, the writers, all the bankers, and the scientists. And it ends at 1933, January, when Hitler took over. And so that's the end of the—he Elon] showed how they integrated into the society. And the book's title, *The Pity of It All*, it expresses the whole story which describes the destruction of Jewish subculture which contributed greatly to Germany.

DOMUSH: Right.

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[17] Amos Elon, *The Pity of It All: A History of the Jews in Germany, 1743-1933*, (New York: Metropolitan Books, 2002).

SOMORJAI: It's a very interesting story. The Hungarian story was not that long, but it was very interesting, because they integrated into society, and there was in Hungary, unlike in Germany, no middle class. There, it was a feudal country, and the peasants didn't get any voting rights until the end of the nineteenth century.

DOMUSH: Oh, wow.

SOMORJAI: And so they were a feudal and agricultural country. When they become modern, from after 1848, the revolution came, then they became lawyers, doctors, the middle class, and businessmen, etc., and I would say 90 percent of the middle class was Jewish. And **<T: 80 min>** so it was not a question of religion, but it's a question that they emigrated into a vacuum, okay, from Poland or from Austria or Germany. And so then anti-Semitism came, it instantly affected the middle class. It's a very interesting story. This is not something that I want to talk about in my autobiography.

DOMUSH: It is very interesting. My mom's family were German Jews, but they came in the middle of the nineteenth century, so they came to the United States much, much earlier. And my father's family was Russian Jews, but they came at the turn of the century. But it's such interesting history.

SOMORJAI: Absolutely. Absolutely. But you ought to read that book, because that will resonate.

DOMUSH: [Yes].

SOMORJAI: You ever go to New York City?

DOMUSH: Not recently, but I have family there.

SOMORJAI: There is a museum one block from the Metropolitan [Museum of Art]. It is a Austrian-German art museum [Neue Galerie], where this guy [Friedrich Altmann] who escaped after the *Anschluss* and went there, and got all the refugees' art pieces.[18] And he focused on

[18] Altmann was released from Dachau concentration camp after convincing his brother to sign over their family's textile factory; he and his wife escaped house arrest to the Netherlands.

[Gustav] Klimt, you know, the gold lady [Portrait of Adele Bloch-Bauer I]. It is a fantastic museum. And they have an Austro-Hungarian restaurant in the bottom and great food. And it's a small museum. And so in that shop or library, bookshop, they have the books. I saw that book *The Pity of It All*. So if you want to buy it, you can buy it here. But I bought it on Amazon.

DOMUSH: [Yes]. I've heard of it before.

SOMORJAI: [Yes]. It was such a complete history of the starting from nothing—

DOMUSH: Yeah.

SOMORJAI: —and then the book ends they became exterminated. So that's—the reason I wrote this autobiography is to put a historical perspective on the rise of US science through my [science perspective], which I know.

DOMUSH: Right.

SOMORJAI: I don't want to write about things that I don't know. And there is an enormous change, and the exponential rise was due to the exponential rise of talent. Of course, the foundation [of the rise of US science], you know, of many things, one hundred fifty billion dollars in 2012, out of one hundred fifty million dollars in 1957. I mean, we are rising like a renaissance.

DOMUSH: Yes.

SOMORJAI: And that made us world-class. Now I don't know how the Chemical Heritage [Foundation, Philadelphia, Pennsylvania] had a view of—a dream of how to present this, but it is such a tremendously inspiring story. It ought to be presented as such.

DOMUSH: Yes.

SOMORJAI: And it has many facets, so the manufacturing facets, the chemical problems of industrial pollution, and how we get out of this. The reach, the military reach, for example, Dow [Chemical Company] using, or whatever, Agent Orange or something in Vietnam. Basically, the chemical warfare is part of the story.

DOMUSH: Yes.

SOMORJAI: And just as Bhopal, **<T: 85 min>** that we sold the technology that we never used because it was so dangerous in the US, but we used it in India. And then the rise of the oil industry, and then the science. The science, and how it increased life expectancy. And all the things we live with that were scientifically inspired. [. . .]

But everything else, I mean, the catalysis is absolutely [important] to what we are doing. And how it changes from industry to academic. And this change occurred in the last twenty-five years.

DOMUSH: Yeah.

SOMORJAI: With the segmentation of the technology, and then how you combine the two. The problem is that in industry, they hardly have any good science left, and you ought to have scientists on the industrial side.

DOMUSH: Right.

SOMORJAI: To be able to talk with the academia. And that is a major, major problem we have now. The reason I have a beautiful interaction with industry is due to one man, who was a small guy, and if he was not there, all the rest were totally hopeless because of the lack of knowledge of how science and that technology operates on an atomic scale. And at Honda [Honda Motor Company, Japan] it's the same. A guy named Chris Brooks from Ohio, comes to the Honda laboratory, does science [involving] the light source here, and he gives us money to work on the lithium battery. So he's one man in the whole company that works on this interest. This is an extremely fragile system.

DOMUSH: Right.

SOMORJAI: But I think we will overcome that when companies go bankrupt. I mean, they don't keep up with the technology, they lose their scientific infrastructure. You know, General Motors went bankrupt, but they seem to be coming back, and I don't understand that, because I don't see their talent pool to be able to move with the new technology. But that means I don't understand the strengths and weaknesses of that system.

DOMUSH: Right.

SOMORJAI: But that interaction, academia and industry, is our weak link, and exceedingly important. I mean, if you develop an institutional structure somehow that will serve a certain industry, it will help the research arm of the ESSO that work in Chicago. And they're still in Chicago, and they develop the technology [which was initiated by] a professor in Northwestern, [Vladimir N.] Ipatieff in the 1930s. You know, have you read the book of his life history.[19]

DOMUSH: I don't know.

SOMORJAI: Ipatieff. It's a tremendous story. Ipatieff was the father of Russian [chemistry]—he discovered the Russian clay pipe, and he put some organic vapors there, and that was oxide catalysis. And Ipatieff was a war criminal, like Haber was, and he developed chemical gas warfare from the Russian side. And so then after the revolution, the Russian [Revolution], Lenin put him in charge of the Russian Academy of Sciences, to build up the chemical industry in Russia. **<T: 90 min>** And he had very close contact with people doing catalysis in Russia. Then finally Lenin died, and Stalin killed all of his coworkers. When it happened he took the last train out of Russia toward Berlin, and escaped. He came to Northwestern [University] in the US, became professor at Northwestern, and the director of UOP [Universal Oil Products, Riverside, Illinois] and the Rockefeller SO [Standard Oil] research laboratory. And in that capacity, he and Herman Pines, his graduate student assistant, developed isooctane.

DOMUSH: Yes. [Yes].

SOMORJAI: You probably know that story.

DOMUSH: [Yes]. This is part of the story.

SOMORJAI: It was fantastic. And then the English took over, and by the Battle of Britain, the English had run the Spitfires with one hundred octane gasoline, while the Germans run on synthetic gas.

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[19] Vladimir Nikolaevich Ipatieff and Xenia Joukaff Eudin, "*The Life of a Chemist: Memoirs of Vladimir N. Ipatieff*", (California: Stanford University Press, 1946).

DOMUSH: Yes.

SOMORJAI: Synthetic liquids. Fifty-six octane. So they did the same plane, basically [could] stay in the air twice as long. So that was a chemical version of the end of the Battle of Britain. And people like this make marvelous stories of catalysis.

DOMUSH: [Okay].

SOMORJAI: In the Russian winter, you had to light fire under the tank, a German tank, because [their synthetic fuel] was so solid. The melting point was very high. And so, I mean, they couldn't fight with tanks with the fuel there. Anyway, lots of stories like this. And if you do it in catalysis, I'd like to look at these stories. How the million dollars in gold was placed at the foot of the Saudi sheikh was able to get the oil out from Saudi Arabia. The whole change from an oil-based industry, and from coal and gas industry. Anyhow, the catalysis story is marvelous. You should look at it and my book has some of this, but very narrowly. [Yes]. The modern story is probably the most interesting [in regard to] the academia/industry separation, and how it plays out.

DOMUSH: Well, we've been talking for a long time, and we've come to the end of my questions. So if there's anything else—

SOMORJAI: Thank you for coming.

DOMUSH: Thank you.

SOMORJAI: And you are trying to do a good thing.

DOMUSH: I hope so. Thank you very much for all of your time.

SOMORJAI: Very good.

[END OF AUDIO, FILE 2.3]

[END OF INTERVIEW]

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