Oral History Center
The Bancroft Library

University of California
Berkeley, California

Alexis T. Bell

Alexis T. Bell: A Career in Catalysis and University Administration at UC Berkeley

Interviews conducted by
Roger Eardley-Pryor, PhD
in 2018 and 2019

Since 1954 the Oral History Center of The Bancroft Library, formerly the Regional Oral History Office, has been interviewing leading participants in or well-placed witnesses to major events in the development of Northern California, the West, and the nation. Oral History is a method of collecting historical information through recorded interviews between a narrator with firsthand knowledge of historically significant events and a well-informed interviewer, with the goal of preserving substantive additions to the historical record. The recording is transcribed, lightly edited for continuity and clarity, and reviewed by the interviewee. The corrected manuscript is bound with photographs and illustrative materials and placed in The Bancroft Library at the University of California, Berkeley, and in other research collections for scholarly use. Because it is primary material, oral history is not intended to present the final, verified, or complete narrative of events. It is a spoken account, offered by the interviewee in response to questioning, and as such it is reflective, partisan, deeply involved, and irreplaceable.

****

It is recommended that this oral history be cited as follows:

Alexis T. Bell, "Alexis T. Bell: A Career in Catalysis and University Administration at UC Berkeley," conducted by Roger Eardley-Pryor in 2018 and 2019, Oral History Center, The Bancroft Library, University of California, Berkeley, 2020.

Alexis T. Bell, circa 1999.
Photo courtesy of Peg Skorpinski.

Abstract

Alexis T. Bell is the Dow Professor of Sustainable Chemistry in the Department of Chemical and Biomolecular Engineering in UC Berkeley's College of Chemistry. Bell was born on October 16, 1942 in New York City to immigrant parents who fled the Soviet Revolution and taught Bell to speak and read Russian fluently. Bell earned his PhD in chemical engineering from the Massachusetts Institute of Technology in 1967, and then joined the faculty at UC Berkeley's College of Chemistry in what is now the Department of Chemical and Biomolecular Engineering. At Berkeley, Bell became an internationally recognized leader in heterogeneous catalysis and chemical-reaction engineering who pioneered the development and application of spectroscopic methods to elucidate catalytic processes, as well as the application of experimental methods in combination with theoretical methods. Bell has been a Principal Investigator in the Chemical Sciences Division at Lawrence Berkeley National Laboratory since 1975. He is an elected member of the National Academy of Engineering, the National Academy of Sciences, and a foreign member of the Russian Academy of Sciences. Bell's work in administration at Berkeley includes twice chairing his department, serving as dean of the College of Chemistry, and chairing various committees in the Academic Senate. In this interview, Bell details his family's Russian ancestry, his education, the academic evolution of chemical engineering, and his research in four thematic areas: reaction engineering of plasma processes; heterogeneous catalysis research on new materials and energy resources; multitechnique catalysis studies in structure-property relations; and applications of theory to catalysis. Bell then outlines his administrative career at UC Berkeley, and he discusses his personal life as a father and a husband.

Table of Contents

Interview 1: September 13, 2018

01-00:00:01
Eardley-Pryor: This is Roger Eardley-Pryor, conducting an oral history interview of Alexis T. Bell. We are in Alex's office in Gilman Hall on the campus of UC [University of California] Berkeley. Today's date is September 13, 2018. Alex, can you spell your name for me?

01-00:00:19
Bell: Yes, my name is Alexis Bell, A-L-E-X-I-S, middle initial T, last name Bell, B-E-L-L.

01-00:00:28
Eardley-Pryor: And what does that middle initial stand for?

01-00:00:29
Bell: The middle initial stands for Tarassov, which was my mother's maiden name, and which she chose to add to my name as my middle name.

01-00:00:39
Eardley-Pryor: Now, how do you spell that? I've seen it spelled a few different ways.

01-00:00:42
Bell: That's right. It's T-A-R-A-S-S-O-V.

01-00:00:47
Eardley-Pryor: V, not O-F-F. Alex, tell me, when were you born, and where?

01-00:00:52
Bell: I was born October 16, 1942, in the French Hospital in New York City, New York. I spent my early years in New York City, Midtown, Manhattan.

01-00:01:06
Eardley-Pryor: Tell me about the family that you were born into, your parents. What were their names?

01-00:01:09
Bell: My mother's name was Olga Tarassov Bell. My father was Vladimir Daniel Bell, and he had changed his name from Vladimir Danilovich Belsitzman, which was his original Russian name, when he took citizenship in 1929.

01-00:01:28
Eardley-Pryor: Great. So [he] took citizenship. Where did your father come from initially?

01-00:01:33
Bell: My father came from the capital of Georgia, the country known as Georgia, Tbilisi—"Tiflis" in English—and he was born in 1900, and lived there until he was twenty years old, so 1920, when he came to the US for the first time and went up to Cambridge, Massachusetts to become an undergraduate student at MIT [Massachusetts Institute of Technology].

01-00:01:59
Eardley-Pryor: In 1920?

01-00:02:00
Bell: In 1920, to study chemical engineering.

01-00:02:02
Eardley-Pryor: All right. Well, isn't that a fitting early connection?

01-00:02:06
Bell: That's right.

01-00:02:08
Eardley-Pryor: Your dad came all the way from Georgia. What brought him to MIT? What was he looking to do there?

01-00:02:13
Bell: It's an interesting history. His father, Daniel Belsitzman, had a plumbing contracting business in Tiflis, a very well-established plumbing contracting business, and also sold plumbing goods. He had two sons, an oldest son and a younger son. My dad was the younger one. He wanted the two sons to go into business with him in Iran, producing sunflower oil, which was a staple food product for Russians. So he sent his oldest son to Germany to study technology. He sent his youngest son to the West to study chemical engineering and process engineering. The plan was that after four years at MIT, my dad would return, and the three of them would go into business. Of course, the Russian Revolution intervened.

01-00:03:11
Eardley-Pryor: Before we get into the Russian Revolution, tell me a little bit more about your dad's family. How is it that a plumber in Georgia is sending his sons off to become sunflower-oil producers?

01-00:03:21
Bell: Well, it's an interesting story. Several generations before my father, the predecessors moved from a town called Belsitz, which was on the Polish-Russian border, but part of, at that time, Russia, the empire. They were a Jewish family, and they felt persecuted, so they moved to a country, which was associated with Russia, Georgia, that had a much more hospitable climate. So the capital, Tiflis, was largely built up—the economy and the city was largely built up by two communities, Armenians and Jews. The Georgians were kind of secondary in the city, but very prominent in the countryside, where they were farmers, vintners, and were involved in agriculture more than manufacturing. Early on in his career, my grandfather, my father's father, started a business. He was a self-taught hydraulics engineer, and he developed a business, which became quite prominent. They would do the plumbing for the whole building. He also had an interest in new technology. In the early part of the twentieth century, refrigeration for food was becoming a subject of interest. And so my dad told me that his father built the first refrigerator on the ammonia cycle. Not the safest thing to have in

your house, but it worked, and it was very effective. So my grandfather built himself a refrigerator.

01-00:05:09
Eardley-Pryor: That's fantastic. What happened to your dad's older brother that went to Germany?

01-00:05:15
Bell: All of the children, all three children—there was a sister in the middle, Klara—Fritz was the older brother—they all moved to Germany, as did my father, eventually. The sister perished in the Holocaust. She was transferred to a camp, and she and her family perished there. I believe that Fritz died in Germany before the rest of his family moved to Israel in 1934.

01-00:05:44
Eardley-Pryor: Oh, wow. Was your father part of that move to Israel in '34?

01-00:05:46
Bell: No, my father had already moved back to the US But the family sensed that things in Germany were not going to be stable for Jews, and they took the opportunity and moved to Israel. Then, for many years, they received payments from Germany for Jews who had suffered during the war.

01-00:06:05
Eardley-Pryor: Oh, that's interesting. When your grandfather sent his two sons off to do this technological training, what was his impetus for becoming a sunflower producer when he had this successful business as an engineer?

01-00:06:19
Bell: Well, he was an entrepreneur. He was successful in his business. He made a good deal of money. He invested some of it with other businessmen of the area into building the military road to the north, to the Russian border, for sales and merchandising. So he invested in that. He invested in a railroad as well. The next thing he saw as an opportunity to make money was to produce sunflower oil.

01-00:06:51
Eardley-Pryor: The fields were, again, in Persia, did you say? In Iran?

01-00:06:54
Bell: In Persia, yes. He bought fields in Persia. So the land was there. The sunflowers were growing. You just needed to pick them and process them.

01-00:07:02
Eardley-Pryor: Around the time your father comes to the US to begin his training, 1920, the [Russian] Revolution is already moving forward pretty quickly.

01-00:07:07
Bell: It's well underway, from 1917, but by 1920, the [Russian] Civil War was just starting, and hadn't percolated to the southern provinces.

01-00:07:18
Eardley-Pryor: Down to Georgia?

01-00:07:19
Bell: Yes. It did get there in 1921, and as a consequence, my father only lasted two years at MIT, '20-'21, '21-'22. Then he had to withdraw, because his father couldn't supply him with the money to pay for tuition and living expenses. So Dad left MIT, and for a period, he was a purser on a ship that went back and forth between the US and Europe. Then he joined the rest of his family in Poland, in Warsaw. I don't know exactly what year they moved from Warsaw to Berlin, but that's the last place where he stayed in Europe. Then he left somewhere in the late [nineteen-] twenties, I think 1929. He returned to the US because he saw more opportunities for himself there.

01-00:08:17
Eardley-Pryor: So all of that experience back and forth, working on the ship that was throughout the [nineteen-] twenties?

01-00:08:22
Bell: Yes, early twenties.

01-00:08:24
Eardley-Pryor: What does your dad have memories of, for MIT? What are some of his—the time that he spent there?

01-00:08:29
Bell: He remembers one of his professors, Warren K. [Kendall] Lewis, who was one of the founders of our [chemical engineering] discipline. Warren Lewis was—or Doc Lewis as we called him, because I got to know the man, too—was educated in Germany, which was, at the time, the best place for chemical technology, came back to MIT, and really played an important role in building up the program there, as department chair and as a technical leader. Then, later, during the war, he worked with Esso [Standard Oil, now ExxonMobil] to develop what is called catalytic cracking of petroleum, to make all the products you get into aviation fuel and motor fuel. His contributions, Warren's contributions, to the technology were really fantastic, because it enabled the Brits to have the aviation fuel they needed for their Spitfires.

01-00:09:31
Eardley-Pryor: That was pretty important. What are your dad's memories of meeting him?

01-00:09:34
Bell: Well, he had fond memories. I have a very few photographs of him from that period. He enjoyed being there. He thought it was a very vital place. When I came to the age where I was looking for a university to do my technical training, he certainly recommended MIT.

01-00:09:53
Eardley-Pryor: It stuck with him. What was the work you mentioned? He was on a ship back and forth across—?

01-00:09:57
Bell: He was a purser on the ship.

01-00:09:59
Eardley-Pryor: What was that ship doing?

01-00:10:01
Bell: It was taking passengers from New York to Europe.

01-00:10:05
Eardley-Pryor: I imagine that was a dangerous thing to be doing at that time.

01-00:10:08
Bell: It was moderately dangerous, yes, that's right.

01-00:10:12
Eardley-Pryor: Does he have any stories that he told you about that time?

01-00:10:13
Bell: No, no, I don't have any stories that I learned from him.

01-00:10:17
Eardley-Pryor: All right. So your father decides to return to the United States, late [nineteen-] twenties, 1929, 1930. Where does he go, and why?

01-00:10:24
Bell: He went to New York, because he had some connections with people who were in the distilling business. While he was in Europe, he worked with another Georgian person there to try and put together a distillery for making vodka, taking his knowledge of distillation from his chemical engineering training. That didn't work out. He went to New York to do something—he wanted to develop what was called the Peter the Great Vodka. I just found the business prospectus for that that was written up. That also never flew. Then he got involved with a fellow named [Georges V.] Matchabelli who was another Georgian, who was a prince, and they went into the perfume-making business for a short while. But the business capabilities of Prince Matchabelli were not up to the market, and so that business failed as well.

01-00:11:25
Eardley-Pryor: That's a challenging time. I'm imagining your father coming here in the start of the Great Depression—

01-00:11:32
Bell: That's right.

01-00:11:33
Eardley-Pryor: —during Prohibition.

01-00:11:34
Bell: During Prohibition, right.

01-00:11:35
Eardley-Pryor: And yet trying to launch these businesses distilling vodka. That's a little bit under-the-table sort of work in New York, but lucrative, perhaps. What are his memories that he shared with you about living in New York at that time? That's a challenging time for that city. The unemployment rate is skyrocketing up into the twenty percentiles—

01-00:11:52
Bell: He didn't talk so much about the period in the late twenties, early thirties. He eventually got into the theatrical business, as the business manager for Sol Hurok, and I don't know how he made that transition. He never talked about that.

01-00:12:09
Eardley-Pryor: When did he start working with Sol?

01-00:12:11
Bell: It must be in the early thirties. I pieced that together, because by the mid-thirties, he had become familiar with the singer Feodor Chaliapin—who passed away in '34, so that's kind of a benchmark—and with that family. So he got into the theatrical business, and eventually he moved into Greenwich Village because it was a very active artist community, and lots of interesting people. He was, he said, a bachelor. He didn't have too much money. He needed to eat, and he got tired of going to Horn & Hardart, which was a business at that time, where you went in, all food was prepared, and they had not vending machines, but little turnstiles. You put your nickel or dime in, and you got your pie or your meat out, and got your meal that way. He said that became too expensive, so he taught himself to cook. He became a marvelous cook, in both Georgian and Russian foods. And then he cooked for the rest of his life, even after he married.

01-00:13:25
Eardley-Pryor: That's beautiful. Take me a little bit back to Sol Hurok. Who is this person, and what kind of work was your father doing?

01-00:13:32
Bell: Sol Hurok was very well-known as an entrepreneur, and what was called, at the time, an impresario.

01-00:13:38
Eardley-Pryor: What is that?

01-00:13:39
Bell: This is a person who made arrangements for European singers, musicians, et cetera, and well-known artists, to come over and perform in New York City at Carnegie Hall and other venues of the time. He had probably the best artists coming over. My dad was his business manager, until they had a falling out about how to run the business.

01-00:14:07
Eardley-Pryor: When did that falling out happen?

01-00:14:08
Bell: That must have happened somewhere in the late thirties. I don't know the exact date.

01-00:14:14
Eardley-Pryor: So for several years, your father did this work.

01-00:14:15
Bell: Yes, for several years he was working in this community, and he made a lot of interesting friends, including the Chaliapin family. Because not only the father, but the father's first family—there were five children, four of whom ended up living in New York City. They became like aunts and uncles to me. That part of the family became very close with my family, and we grew up together.

01-00:14:42
Eardley-Pryor: It sounds like your father really leaned on the immigrant community, the ex-pat community, and that became even a part of where he learned his cooking training.

01-00:14:51
Bell: Yes. Well, he acquired the cooking techniques on his own, he told me. I watched him cook. In fact, my best recollections of being with my dad were either making dinner or washing up dishes after dinner.

01-00:15:04
Eardley-Pryor: What kind of things would you talk about then?

01-00:15:07
Bell: Just his experiences as a young man. His thoughts about dating women, when I was more of that age. Just allowed us to become close, because it was not a formal conversation about anything in particular. Of course, we didn't have a dishwasher, and so he washed the dishes and I dried them and put them away.

01-00:15:38
Eardley-Pryor: Who were some of the other folks? You mentioned Chaliapin. Were there other folks that were kind of in and out of your life, or even your father's life early, that were part of this artist community?

01-00:15:47
Bell: The Chaliapins were the most prominent part. There were friends of my mother's who were ballet dancers and choreographers. [George] Balanchine was one of them whom she knew. He had his company in New York City, and a school also.

01-00:16:07
Eardley-Pryor: That might be a nice segue for us to talk about your mother. Your father Anglicized his name in a way. Did your mother?

01-00:16:15
Bell: No, my mother never did. My mother was born in Russia, in the southwest corner, in a small city named Armavir, which is in the Kuban area. A very fertile area not far from the Black Sea. Then she moved to Moscow with her parents. She was born in 1902, so a little bit younger than my dad. She grew up—first three years, she lived in Armavir. Then she moved with the family to Moscow, and they settled there. So most of her youth was in Moscow.

01-00:16:57
Eardley-Pryor: What was the family that she was born into?

01-00:17:00
Bell: What was the family?

01-00:17:01
Eardley-Pryor: Yeah, what was that family like? What was her [family history]?

01-00:17:04
Bell: It's a complex background. They're what are called Cherkesogai, which means they're Circassian people who are of Armenian extraction. There are a very, very small number of these people. Their history is that the Armenians were persecuted by the Muslims, the Persians and the Turks, going back many, many centuries. Depending who was in ascendancy, one or the other was attacking Armenia and trying to take it over. Many Armenians dispersed. Some went to the Crimea. Some went to Turkey, even, and settled there, before the Turks became less friendly towards them. So this family went to the Crimea, and then—no, sorry, they didn't go to the Crimea. They went to Azerbaijan, which was another safe haven at the time. Then they left Azerbaijan as that became more Muslim, and they went into the Caucasus Mountains and settled there in small villages. That's where they were for generations, starting from the sixteenth century. Some of them became traders and merchants, because this was something that they were good at, and the local people didn't particularly want to do. They were herders for the most part, living up in the mountains.

So my great-great-grandfather, Aslan—who didn't have a last name at the time, by the way, just went by the first name—was a trader and a dealer in lamb, meat, vegetables, whatever could be bought and sold. He had, eventually, five children, all boys. And with his sons—and before the last child was born—he petitioned, and some of his contemporaries petitioned, in 1839, the tsar of the time to come down from the mountains and settle in the Kuban region, near the river. It was a good place to be for trade, and so a group of these Circassia settled—made the town and built it up. It became, I'd say, the equivalent of a Dodge in the US, kind of a trading center on the edge of the Wild West. Here they are in the southwest corner, very fertile area not far from the Black Sea, lots of people to trade with and then send their produce and products north to the motherland. That part of the family went into merchandising. And eventually they made big money when they decided to bring cotton from Kazakhstan and Uzbekistan—where there were fertile fields, lots of cotton—and produced the cotton into fabric. That business grew. They had five warehouses in different parts of Russia from which they sold the fabric to the whole country. In addition, other brothers started a rubber business, rubber goods business, a theater, a hotel, a bank, and so forth. So they owned a large part of the city. When I visited in—when was it? Four years ago, in 2014, what was left of those buildings were shown to us.

So they helped make the city. That's where my mother was born. Then they moved to Moscow, and then, of course, in 1917, the Russian Revolution starts. And because my maternal grandfather was very prominent—he was a very successful businessman, but he had a friend in the secret police who informed him that my grandfather's name was on a list of people to be arrested and executed. Grandfather took this seriously, packed up the family. They went south to the Kuban area and a city called Kislovodsk, which means "sour waters." It was a resort city, which had, indeed, sour waters, sulfur baths, where people took their vacations. This was 1919. They spent eight months there, until it became clear that the Revolution was coming south, and they wouldn't be safe. That's when they left, the whole family left. They went to the Crimea. From Crimea, they then took a boat to Turkey, to Istanbul—Constantinople—and from there to Venice, and ultimately to Paris, where they settled.

01-00:22:19
Eardley-Pryor: That is an adventure.

01-00:22:21
Bell: Yes, it was a real adventure.

01-00:22:23
Eardley-Pryor: Take me back to Aslan, your great-grandfather, and the founding of this town, coming out of the mountains. The family that he came from, that was living in the mountains previously, were they Christians?

01-00:22:35
Bell: Yes, they were Christians. So what was really remarkable is that the Armenians, by history, were the first Christian nation. In 301, I think, they became Christian, even before Rome became Christian, about thirty years or more. The second state that became Christian was Georgia. That's why you have this little enclave of Christianity in that part of the world. So they were Christian, and they continued to practice Christianity through the centuries, even in the diaspora. But they were embedded in a society which was areligious, they were believers in animals and other things. They weren't Muslim, but the people were very tolerant. As long as you didn't interfere with the local customs and you produced things which were useful, they were willing to accept you.

01-00:23:43
Eardley-Pryor: So your mother comes from this long lineage of Christians that were in the mountains. Your father comes from a Jewish family, in a similar area.

01-00:23:52
Bell: Similar part of the world, yes.

01-00:23:54
Eardley-Pryor: From what I'm hearing, both of your great-grandparents were involved in the Industrial Revolution.

01-00:24:02
Bell: That's right, very much so.

01-00:24:03
Eardley-Pryor: It sounds like Aslan, as a founding father of the city—

01-00:24:07
Bell: Armavir.

01-00:24:08
Eardley-Pryor: —Armavir—helped bring industrialism and—

01-00:24:11
Bell: He did, yes.

01-00:24:12
Eardley-Pryor: Almost in the British model, taking the cotton—

01-00:24:14
Bell: Very much so. Very much so.

01-00:24:16
Eardley-Pryor: Do you know where his influences came from? Was he looking at the British model and saying, "We can do this here?"

01-00:24:19
Bell: I don't know if he looked at the British model, but if you look at the Russian history of the late 1890s—even 1890 and beyond, just a bit before the beginning of the twentieth century—there was a lot of Industrial Revolution, self-driven by people. There was a relatively quiet period in terms of warfare and so forth, and so there was an industrial boom. Railroads were being built not long after ours were in the nineteenth century, 1860s, to cross this huge country. That made trade much more practical than going by river. So both grandfathers were involved in that in different ways, completely different ways.

01-00:25:13
Eardley-Pryor: What was Aslan's role? You mentioned your paternal grandfather was investing in some of these railroads.

01-00:25:19
Bell: That's right. He also invested in railroads.

01-00:25:21
Eardley-Pryor: Aslan did as well?

01-00:25:22
Bell: Yes, yes.

01-00:25:23
Eardley-Pryor: It sounds like they made quite a run for it in this hub in Armavir.

01-00:25:29
Bell: That's right, yes.

01-00:25:30
Eardley-Pryor: What led them to go to Moscow, then, and when? When did they go up there?

01-00:25:33
Bell: Starting in 1905, there was already turmoil about needing to evolve or have a revolution. The first evidence of revolutionary forces started in 1905. That's three years after my mother is born. They felt that it probably was not the best long-term investment to stay down in this corner of Russia, where there are a lot of very volatile people. It's a very ethnically diverse region. I think today, there's something like seventy-five ethnicities in the city, but they harmonize and live together. So it was a family decision to open up a branch of the business in Moscow. They moved up there eventually, all the brothers moved there. They retained their holdings in the south and would view these as summer homes, go there and spend the summer months. But their base was now in Moscow.

01-00:26:36
Eardley-Pryor: Do you know where they settled in Moscow?

01-00:26:37
Bell: Yes. I've seen the house where my mother lived most of her youth, and grandfather owned it. They owned a whole city block in Moscow in the center of town, in what's called the Arbat region. They had two L-shaped houses that made up the block. One was my grandfather's, the other one was his father's—Great-Grandfather. These buildings that are still standing. They date back from the late 1890s. They're occupied by offices and businesses, Russian businesses, but they're quite attractive. I have photographs of it that I've taken. I've never seen this, but according to my grandfather, in the center was a courtyard, which provided space for both garages for the cars but stables for the horses, because this is a period of transition between transportation by horse and by car.

01-00:27:39
Eardley-Pryor: What were some of your mother's memories of growing up in pre-revolutionary Moscow?

01-00:27:43
Bell: Oh, she loved it. She thought it was a very rich period. She had private tutors who taught her French, and some German, but mostly French, because French was the language of the cultured people. She grew up in a home where she had two brothers, her mother, her father, her father's mother, who was still alive at the time, and twelve servants. This is really like *Upstairs, Downstairs*, the TV series. When she came more of age—I think around sixteen, or close to that—she went to her first ball and was presented to society. This was the norm of the day. Then there started to be suitors who would come and visit my grandfather and say, "Your daughter is very attractive. I'd like to offer my hand in marriage. What do you think?" Fortunately, my grandfather was modern enough to say, "Let me consult with my daughter before saying yes or no." My mother turned all these suitors off.

01-00:28:55
Eardley-Pryor: What was her thinking in this?

01-00:28:58
Bell: Well, it's quite characteristic of her. She was a very independent woman, and as her brother writes in one of his stories about the family, she was a tomboy. Contrary to her mother's wish to have her look feminine and dress her up, she would take these nice clothes and get them all ripped up by climbing trees, and being in the rocks, and playing bandits and so forth with the boys. So she was a tomboy, and very independent. She told me a story of a young dentist who came to ask for her hand. Grandfather came to her, and she immediately said, "Dentist? Absolutely not. I don't want somebody who has his fingers in other people's mouths all day long." That was her character.

01-00:29:51
Eardley-Pryor: You mentioned that she had siblings. Who are your aunts and uncles?

01-00:29:56
Bell: She had two younger brothers. She's the oldest in the family. Alexander was born in 1911, and he became an electrical engineer, educated in Paris at École Supérieure. He became a very successful head of a laboratory and telephone communications for the French branch of a Dutch company. The company is Philips, in Amsterdam, and TRT is the branch in Paris. He headed up telephone communications there, and he and his engineers developed digital communication for telephoning. This was used first by the French Army, then it was licensed to the American Army, and then it became available to the public.

01-00:30:48
Eardley-Pryor: Wow.

01-00:30:49
Bell: So he was a technology leader. His younger brother was born in 1912, is Henri Troyat—his pen name. He was originally Lev, or Leon [Aslanovich] Tarasoff [how he spelled our last name in French]. He started writing just as

he went to school. He would spend the evening sitting on his bed writing, on a pad, stories for his family, and read them. He became a novelist. He got an education in law in Paris, but he became a novelist. And he became very prominent already at the age of twenty-one, when he published his first novel. His publisher, Plon, said, "This won't sell because you have a Russian name, and people will think that this is in French but it's translated. So think of a pen name." He thought about it, and he said, "I want to retain the first letter of my last name [Tarasoff]," so he proposed Troyat. And his publisher said, "Well, we can't use Leon with that," and he offered him—this was all over the phone—he offered him the name Henri, which is French-sounding. So that's how he became Henri Troyat. He used it only as his pen name for a few years, and then he changed his name legally for the rest of his life.

He ended up being extremely famous. He won the Goncourt prize—it's like the Pulitzer—at the age of, I think, twenty-six or twenty-seven, for his second novel. Then he was elected to the French Academy at an early age. Until he passed away, he was the longest living member of the French Academy. He published 105 novels. Some of these are truly novels. The others are historical novels about all the tsars of the Romanov dynasty, so three hundred years' worth of history there. He published novels about all of the famous Russian writers, so Pushkin, Tolstoy, Dostoyevsky, Gogol, Chekhov, and so forth. He published a couple of books about the Decembrist movement and the people who were involved in that. Then he also wrote books about the great French authors. These were extremely popular, and certain circles say he was the best-read French novelist of his period.

01-00:33:28
Eardley-Pryor: It sounds to me like Uncle Henri was trying to come to terms with the family's exile.

01-00:33:35
Bell: Exactly. That's a very good description. He left Russia when he was six years old, six going on seven, and never returned. So his memories, his own memories, are from a very young age, supported then by stories that his father told him because he lived at home. He developed just a wonderful and very deep love of the culture, of the history, of everything Russian. He spoke Russian fluently. He read it easily. So all the research he needed to do, he did in the French libraries, but he would read original sources. He had a wonderful grasp of history, as well as being a very good writer. His books received a lot of popularity. Unfortunately, not many of them were translated into English, but all the major ones about historical figures and literary figures were translated, not too long ago, into Russian. But the print runs were small, like 5,000 books at a shot. Some are reprinted, but they're now hard to find. I have a complete series in both French and Russian at home.

01-00:34:56
Eardley-Pryor: Of course you do. It sounds to me like Henri was active in publishing almost to the equal of you in your publications.

01-00:35:05
Bell: Yes, he published at least a book a year. I talked with him on various occasions during my visits to France about writing, and the different context in which I write. We enjoyed these one-on-one conversations a great deal.

01-00:35:25
Eardley-Pryor: What kind of things came up during that?

01-00:35:28
Bell: Just the pleasure of practicing your craft. For him, the pleasure was standing at an old pulpit and writing by hand. He never used a typewriter, or certainly not a word processor. He wrote everything by hand, and he set himself a goal of writing five handwritten pages a day. He'd start in the morning after breakfast, write until lunch, write for a few more hours after lunch, and then enjoy the rest of the afternoon and the evening visiting with family and friends. Then he had a typist who would type up these pages and give it to him the next morning. And then he would correct these by hand again, and hand it back. So this was the process. He said by following this discipline, if you did it every day, you got a book out.

He did all his own research. Some things weren't available in Paris, he would get [it] from Moscow, sent to him. But he never went to Russia. I talked to him about this, and many people have interviewed him and asked him why not. He said, "Well, I didn't want to spoil my childhood memories." He admitted it was kind of a fantasy world for him that he didn't want to ruin. That was the basis for a lot of his writing. I can understand that. I can appreciate that. He was very interested in the fact that I started going to Russia in 1974, and would ask me about my impressions, and how things were over there. And so I shared all of that with him very candidly.

01-00:37:08
Eardley-Pryor: Your style—maybe not your style—but your audience is certainly very different from the literary one he was reaching towards.

01-00:37:14
Bell: Completely.

01-00:37:14
Eardley-Pryor: What did you take away from his writing experiences that informed your own?

01-00:37:20
Bell: I don't think I took a lot away from that, because he was great at describing people, situations, human interactions. I'm dealing in a completely different context. I'm dealing with the physical world, the chemical world. If there's any overlap, I'd like to say that it revolves around telling a story. You can tell a story in human terms. You have a narrative about what is happening between people. You can tell a story also about a technical problem that you're solving.

The thing that I've evolved for myself, but I haven't really ever talked to him about, is the notion that every story has a beginning, a middle, and an end. So when I sit with my students these days and talk about writing the next paper, we begin with my asking, "What's your story?" By that, I mean, don't pull out graphs and tables; tell it to me in your own words. Let's say we went for a walk. What would you tell me? If they can articulate it, great. If they can't, then I help them articulate the story and put the story into the context of existing literature. What came before? What are the open issues? Why does more work need to be done? What did we do to contribute to these? Then, how did we do it? What did we do? And then, what does it all mean? And put it back into context. I have found that this is a very successful formula, or skeleton, for writing the story.

The other part that I like to describe is, imagine that you're making a sculpture and you have clay, which is not in the form of anything, but it's malleable, and you can create a figure of a person, or whatever object you want. Your first attempt is pretty crude. It has lumps and valleys where they do not need to be. So you go back and you smooth them out, and you keep refining it, until it's a recognizable object, and it portrays exactly what you'd like. I think that people who write literature, who paint, who compose music, who do science, in very different ways, are doing the same thing. So that's where the overlap comes.

01-00:39:53
Eardley-Pryor: That's wonderful. Take me back to this exile that Henri is wrestling with—that you have then since explored in your own travels—from Moscow, finding themselves to Paris. What was that journey like? What happened across that, and when?

01-00:40:08
Bell: This was a journey that started in 1919 and ended up in '21. So it's a relatively short period, two years, with my grandfather—and I heard this from him—thinking that, "Well, this whole revolutionary thing is going to blow over. It can't be stable." Nineteen eighteen, the tsar's family is killed. Well, that's a big blow because they thought that the tsar was going to rally the troops and they would win. Then the Civil War that runs from '19 to '21, and secures the Soviet authority in Russia. They had taken away, and had in bank accounts in Europe, enough money to survive for the first few years, with the expectation, "Well, we'll just wait it out. We'll wait it out, try different places."

Eventually, they got to Paris because my grandfather had some business connections there, and they couldn't wait it out, and the money ended. So when the money ended, they became quite poor. This is when my mother, the oldest child, went to work dancing, providing money for the family. Eventually, she helped put the two brothers through university, and once they became older, they also helped the family. So it was a bootstrap operation.

And fortunately, through his business contacts, my grandfather met a German-born Frenchman who was also in the same trade of producing, in this case, cotton goods, mainly men's underwear. He had a firm, which today would be considered completely politically incorrect, called Petite Nègre, "Little Negro," and their symbol was a very black child in white underwear with two dogs pulling on the elastic. As I said, totally politically incorrect, but very cute in its day. He went to work with him, and that helped him survive. By the time I got to know him, from 1945 into the '70s when he passed away, he lived comfortably. He was well above middle-class, living in the center of Paris. They had a very nice apartment.

01-00:42:52
Eardley-Pryor: How were they even able to get out of Moscow? You mentioned they went south. They went back to the summer estates where their family originated.

01-00:42:58
Bell: The trick was to get into Turkey. They wouldn't have been accepted as Russians, so they got passports made as if they were Armenians.

01-00:43:08
Eardley-Pryor: Why would they not have been accepted as Russians?

01-00:43:10
Bell: Because the Turks didn't want to rile up the Soviets by accepting refugees. So they got passports showing that they were not Tarassov, but Tarassian, I-A-N being a typical Armenian ending to a name. I have photocopies of those passports at home. That's how they got in.

01-00:43:35
Eardley-Pryor: Wow. Who was it that was helping them make these journeys? Business associates or—

01-00:43:40
Bell: No, it's actually my grandfather's cleverness. He was driving the whole system. One story that I've been told by my mother and was recorded by my uncle—he wrote a novel in French about this journey. He actually wrote several things that were, but this one is specifically about the family. It's *My Very Long Journey*. It's about his youth, the escape, then growing up in Paris and becoming an author.

He says that when they got into Istanbul, it was late in the evening—off the boat. They have no place to stay. You didn't use the Internet and make a reservation in advance. So Grandfather and his bodyguard, his Circassian bodyguard, took off from the port and left for several hours. When they came back, they said, "Okay, everybody come on, hurry. We found a place where we can stay for a short time." So they went. And the next part is my grandmother telling me, "I wake up in the middle of the night, and there are doors slamming and women giggling, and I couldn't figure out, what is this hotel that my husband brought us to?" The next morning, she realizes where the family is, and she got indignant with her husband, and she said, "How could you bring us to a house of ill repute?" He said, "My dear, it was the only thing available." [laughter] He did with what he could.

01-00:45:24
Eardley-Pryor: Why did they end up in Paris?

01-00:45:26
Bell: I think they ended up in Paris because there were already a lot of Russian émigrés there. It was a big community, and they thought that they were more likely to find kindred spirits, which they did.

01-00:45:40
Eardley-Pryor: What happened to the family's great resources that they left behind?

01-00:45:43
Bell: It was all consumed by the Soviets. The buildings—there were several buildings that they owned in Moscow—they were all consumed by the Soviets. All the money was taken away. They never got anything back. Really, they got to a point where they were—in today's terms, it would be in the low billions of dollars' worth of enterprise, to nothing, in a span of a year or two.

01-00:46:13
Eardley-Pryor: And your mom's going through this. She's eighteen, nineteen, twenty throughout this really, really rough time. What did she say about these experiences?

01-00:46:21
Bell: Well, she recognized it was really rough, and she loved her parents, and cared about her brothers, and she did what was necessary to help support the family.

01-00:46:31
Eardley-Pryor: How did she get involved in dancing? You said that's how she helped the family.

01-00:46:34
Bell: This started before they emigrated. This was my grandmother's doing. My grandmother was ever-concerned that my mom was too much of a tomboy, would never be an attractive bride, so she got her enrolled in some dance classes, already in Moscow. Mother has actually written—I saw some things that she wrote—some stories about the fact that she got through the elementary part, but then when she had to start dancing on toe, the teacher required that each child bring their own ballet slippers. Some of the girls who were Russian extraction actually brought them out of Moscow and had them, but she had nothing. But she had some slippers with a sole made of rope, and she said somehow she rigged this thing so she could stand on her point. She came to class, and her teacher saw this ugly thing and said, "What is this?" My mother said, "These are my slippers, my toe shoes." The woman said, "No, you can't dance on toe," and my mother said, "Yes, I can," and she

started to twirl in front of her. Long story is that my mother took a liking to dance and ballet, and stuck with it.

When she got to Paris, grandmother helped her find a school. Even though they were pretty poor, she found a school. One of her teachers was Mathilde Kschessinska, who was the tsar's first lover and introduced him to the joys of sex. She, of course, couldn't become his wife, so they separated. But he bought her a beautiful apartment house where she lived, until she emigrated to Paris. That was the house that [Vladimir] Lenin occupied when he first got into Moscow, and he spoke from the balcony to the crowds.

01-00:48:50
Eardley-Pryor: Wow. And that was your mother's ballet teacher?

01-00:48:51
Bell: Yes. I met Mathilde Kschessinska when she was already in her eighties, because my mother, whenever we went to Paris, would come to the old-age home where she was living and pay her respects. So I came with her. Kschessinska eventually married, in France, one of the crown princes, one of the brothers of the tsar. Then he passed away, and she passed away.

01-00:49:20
Eardley-Pryor: It sounds like your family made some inroads with that ex-pat community within Paris to help them get through.

01-00:49:24
Bell: They did, yes. They did.

01-00:49:26
Eardley-Pryor: I'm wondering what your mother's experience was through the twenties. I'm picturing your father going through similar kind of challenges, with the family moving around and trying to resettle, in a way. Your mother doing something similar, grounded in Paris, but—

01-00:49:40
Bell: She's grounded in Paris, and she completed her ballet training and started to perform with first one company, and then another. There's something like half a dozen different companies that she performed with, and toured. She went to Latin America, she went all over Europe, in this context, and eventually, in the early [nineteen-] thirties, came to New York. Two things happened there. First of all, during a rehearsal, she fell and hurt her knee, badly enough that this put an end to her dancing career as a performer. But fortunately, she also met my dad.

As I told you when we spoke earlier, her cousin, who was already resettled in New York, was renting a room in his home, and my dad at the time was renting that room. Knowing two young people of roughly the same age, he connected them. They're both same age, from the same region of Russia, same language, similar backgrounds, and they hit it off. It wasn't too much later that they got married. My mother then said bye-bye to the troupe and stayed in New York, and didn't want to sit on her hands, and so she first taught in an existing ballet school, and then, somewhere in the late thirties, opened up her own school.

01-00:51:14
Eardley-Pryor: As your parents are meeting in the early 1930s, they're in New York City, still in the depths of the Great Depression in New York—these two Russian émigrés are meeting here. They're in their early thirties at this point?

01-00:51:34
Bell: Yes, yes. Early to mid-thirties, yes.

01-00:51:36
Eardley-Pryor: I imagine your mother had many suitors that were interested.

01-00:51:40
Bell: She did.

01-00:51:41
Eardley-Pryor: Especially through her dance career in the twenties. What did she say about those times, as to why she didn't settle earlier?

01-00:51:49
Bell: Why she didn't settle earlier?

01-00:51:50
Eardley-Pryor: Settle down and marry. That's such an expectation, especially thinking of the family trying to make ends meet.

01-00:51:55
Bell: That's a very good question. I don't know, and she never talked about her personal life to that detail that I would know. You could ask also how come my father didn't settle down either, because he was a very attractive young man. I know from his stories that he had girlfriends in New York. I only know from his side that, until he met my mother, he never found the person that he wanted to be with long-term. That mattered to him. And I think this is often the case, that you don't marry until you find the person who's really going to be harmonious with you.

01-00:52:44
Eardley-Pryor: And they found that?

01-00:52:45
Bell: Yes, and they found that.

01-00:52:46
Eardley-Pryor: Was Sol Hurok involved in bringing your mother's ballet troupe to New York?

01-00:52:50
Bell: Not that I know of, no.

01-00:52:51
Eardley-Pryor: So it just happened to be these different artistic worlds collided?

01-00:52:54
Bell: That's right, they just collided, they met, and that was good.

01-00:52:59
Eardley-Pryor: So that's in the early thirties, and you were born in 1942.

01-00:53:03
Bell: Yes, so it was an eight-year period where they were married. They had tried to have children, and my mother miscarried a number of times.

01-00:53:13
Eardley-Pryor: When you arrive, in '42, your mother is in her late thirties.

01-00:53:17
Bell: My mother is forty.

01-00:53:19
Eardley-Pryor: Is forty. And so your father would be?

01-00:53:20
Bell: My dad is forty-two.

01-00:53:21
Eardley-Pryor: Forty-two at this time. World War II has begun in the United States at this time.

01-00:53:26
Bell: That's right.

01-00:53:27
Eardley-Pryor: What are their stories about what life was like when you arrived?

01-00:53:31
Bell: Okay, so first of all, my mother's side is now unable to visit her brothers and her parents, who are in occupied France. They didn't stay in Paris. They went south and stayed with the Vichy government and sat out the war. But it was not possible to visit them. There was some correspondence, just by mail, but that took weeks and weeks to get back and forth letters. My dad was concerned about being drafted, but fortunately, given his age and the fact that he had a child, he was outside the limits of being drafted.

They survived the war in the US, in New York City. And shortly after it ended, they would send, I remember, boxes of canned goods, Spam and other products that wouldn't be damaged, by ship to Paris. I even saw some of these products when I visited my grandparents in '45 and late forties. They had a closet with stuff, and in there were some of these cans that we'd shipped over.

01-00:54:47
Eardley-Pryor: Wow. Where in New York did you live in your first years?

01-00:54:52
Bell: We lived in a building. It's 141 West Fifty-Fourth. I misspoke earlier, but 141 West Fifty-Fourth, which is Midtown, Manhattan. It's in the heart of the theatrical district of its day. This was a three-story walk-up brownstone, which, before we lived in it, many years before, was a veterinary stable. Much later, when the building next to ours was torn down for renovation, we could see an exposed side wall, and hand-painted on there was the advertisement for the vet stable.

So anyway, by the time I came along, this building was owned by a framer, who made frames for pictures. The workshop was on the second floor, the store to sell the frames was on the first floor, and we rented the flat on the third floor. It was just a loft when my dad rented it, and he and a friend of his converted this into two thirds in the front which was my mother's studio, and one third in the back which was a small apartment for the family, for the three of us. So it's kind of a kludgy situation, but my mother would open the door and walk out to work. So that was great.

She had a baby grand piano in the studio. There was a special floor for dancers built there, big glass mirrors for reflection, and bars. Everything you expect in a ballet studio. So the whole day, there was live music coming from pianists who would play for the various classes. My mother would pop in for lunch, and then pop out again to go teach. There were several other people who rented the studio in the evenings from her as well, so there was music there all day long.

01-00:57:00
Eardley-Pryor: And this is the world that you grew up in?

01-00:57:01
Bell: This is the world I grew up in. My first home I can remember.

01-00:57:04
Eardley-Pryor: Your father is still working, at this time, with Sol Hurok and doing some of the business management work?

01-00:57:08
Bell: He's starting to do various things. He's no longer working for Hurok. I don't have the sequence quite right, but I know he worked for various import/export firms, trading in Italian-made leather goods at one point. Later on, he was selling liquor, being a liquor distributor, and going around to bars and restaurants selling whatever they had to offer.

01-00:57:37
Eardley-Pryor: Getting back to that initial drive to create the vodka.

01-00:57:39
Bell: [laughter] Right. Then he ended his career as the business manager for the Stanhope Hotel, which is an upscale hotel located across the street from the Metropolitan Museum of Art.

01-00:57:53
Eardley-Pryor: And that's right around the corner from where you grew up?

01-00:57:55
Bell: Well, it's not around the corner. It's within walking distance, a few miles away.

01-00:58:00
Eardley-Pryor: I'm wondering, with your parents being older, and you not having other siblings—

01-00:58:05
Bell: No, there were no siblings.

01-00:58:06
Eardley-Pryor: What was the impact of having these traditionally older parents in your life?

01-00:58:14
Bell: I missed the company of young people, having sisters and brothers. When I was really little, I would say my prayers and ask for a little brother. My mother thought this was very cute, but never said anything. That never happened. The young people I got to know were mainly through school, first public school, then private school. What I did like, though, was that I was always included in all the meals in the evening. When we had company, there would be a table full of adults and me. A good boy in a Russian family, you kept your mouth shut and didn't speak unless you were spoken to.

01-00:59:00
Eardley-Pryor: What did you take away from all this interaction with these adults?

01-00:59:03
Bell: I liked it. This is what gave me my sense of the Russian language, because all the conversation was carried out in Russian. A lot of telling stories, jokes, sometimes off-color stories, even ignoring the fact that I'm sitting at the table. I liked the sense of camaraderie and warmth that was there. I've carried that forward into my adulthood.

01-00:59:31
Eardley-Pryor: With the Russian being spoken at home, with these guests, it sounds to me like there was a strong ex-pat New York Russian community—

01-00:59:37
Bell: There was.

01-00:59:38
Eardley-Pryor: —that your parents were plugged into.

01-00:59:39
Bell: Yes, yes. In fact, I have to say that for a long time, growing up and going to school, I felt a tension between home life and school life. School life was all-American—football, baseball, the usual stuff that kids talk about. At home, it was completely different. None of that existed. I don't think my parents cared one wit about what the Yankees were doing. It was all about music, art. My mother, when I grew up a little bit, started taking me to museums, to acquaint me with the art world. Not that I was really super excited about it at the time, but she did her best. So there was that tension between living between two worlds. Two languages, two worlds, cultural perspectives. Very different.

01-01:00:34
Eardley-Pryor: When the war ends in '45, and Europe is going through its own transition of recovery, what was your relationship with your mother's family back in Europe?

01-01:00:44
Bell: We went to Paris the first time in 1945.

01-01:00:50
Eardley-Pryor: Do you have memories that young?

01-01:00:53
Bell: Very vague. Yes, very vague. But I do remember that we sailed on the *Mauretania*, which was part of the Cunard Line. It took the better part of a week to get over there. I do remember my grandparents' apartment on Place Joffre. [Joseph Jacques Césaire] Joffre was a World War I general. This was number four Place Joffre, so it was a corner building with a very nice view onto the place, and Les Invalides was across the way. This is the hospital that Napoleon built for the military. So a very prominent place in Paris. The Champ de Mars—"field of Mars"—was within walking distance. So was the Eiffel Tower. So you can imagine where this is in Paris: right in the middle. I enjoyed meeting my maternal grandparents. They were very warm and loving individuals.

I enjoyed meeting my cousins who were living in Paris at the time, who were closer to my age. We eventually worked out a way of speaking with each other. They spoke a little Russian, hardly any English. I spoke hardly any French, but somehow kids found a way to communicate. As we got older, I learned more French, they learned more English, and so we'd use all three languages to communicate.

My maternal grandparents were great. My grandfather, also Aslan Alexanderovich, would like to reminisce about his time in Russia, and remember only good things. He was very fond of horseback riding, as was my mother. I think I mentioned that he, in addition, raised horses—he had a horse farm and sold horses to the Russian Army. He would remember the kinds of horses he had and some of the names of his personal steeds that he rode.

These were some of the images. I'm sure that my uncle also picked up even more of this, living with grandparents.

My grandmother was very much a nineteenth-century kind of woman: very dignified, required everything to be done according to proper protocol. Tea was always at four o'clock, and there would be something sweet, and she would prepare tea. Actually, not she, but her woman working for her would prepare tea. There would be a big brass samovar with hot water, and this concentrated tea sitting on top. She would pour and mix the amount of water. The whole thing was to bring the family together and have just general conversation, and kids were very much involved.

01-01:03:58
Eardley-Pryor: What was your grandmother's name?

01-01:03:59
Bell: Lydia.

01-01:04:02
Eardley-Pryor: So, Aslan and Lydia. The cousins that were around, did they, in some ways, become the brother that you wish you had?

01-01:04:11
Bell: Not really. We never got to know each other that well. We didn't stay together long enough, and they never came to the US

01-01:04:19
Eardley-Pryor: So it was always you going there?

01-01:04:21
Bell: Yes, it required my mother and I going there.

01-01:04:23
Eardley-Pryor: What was your father doing?

01-01:04:25
Bell: He was working in New York, keeping the family alive. So he didn't come with us. There were only one or two occasions where he would come for a week. But we'd be gone for a month or more. It was expensive to go over, and if we went by boat, better part of a week to get there, and likewise to come back. So often, we would rent a house somewhere—not in Paris, but either in Normandy or in the south, Sainte Maxime. Grandparents, my mother and I, and as many of the aunts and uncles and cousins that we could get together would share the house. That was nice.

01-01:05:11
Eardley-Pryor: That sounds pretty beautiful, visits to France as a young boy. How often did these visits happen, every summer?

01-01:05:17
Bell: It happened, on average—no—every second summer, until dad's money couldn't support it, and then at one point he was actually taking loans to pay for my mother's trip, and then working his tail off to repay the loan in the next couple of years. This was now a period where money was tight in our family.

01-01:05:41
Eardley-Pryor: It was a similar story with the family recovering in France?

01-01:05:43
Bell: Yes, yes. As I remember it, money was never very lavish, except in the very early years. But all the teenage years and twenties, funds were quite tight for my parents.

01-01:06:00
Eardley-Pryor: Let's take a break here, and we'll revisit some of your education.

01-01:06:04
Bell: Okay, good. [Break in audio]

01-01:06:07
Eardley-Pryor: All right, Alex, you had mentioned that, growing up in New York, you had this tension between the very Russian-oriented and very cultured experience, and then the school life being very Americanized, the little boy life of sports in New York City. Where did you go to school?

01-01:06:26
Bell: I started going to school a few doors down from where I lived, PS 69, Public School 69. It was well-known in the city, because Bernard Baruch, who was one of the advocators of advanced education, had worked at that school many years before.

01-01:06:45
Eardley-Pryor: Baruch had worked there?

01-01:06:46
Bell: Yes.

01-01:06:46
Eardley-Pryor: Before he became a financier?

01-01:06:48
Bell: Yes. That was the claim to fame of that school. I was there for preschool, so the first six years, and then it became apparent that the quality of education and what would happen in high school through the public school system wasn't going to cut it. So my parents found this private school called McBurney's. It was run by the YMCA.

01-01:07:19
Eardley-Pryor: Before we move into McBurney's, what are some of your memories from PS 69? What were the things that were prominent in your world then?

01-01:07:24
Bell: The main thing I remember is the diversity of students there. I remember we were all mixed together, boys and girls. You had your place where you sat every day, and one of the kids sitting next to me was of Chinese background, and we got to know each other. I found out that he went to Chinese school every Saturday and spent the whole day studying Chinese, driven by his parents, of course. While lessons were going on, I'd see him with his pen drawing Chinese characters, which intrigued me. I asked him if he could teach me how to do some of this, and he said sure. I tried my hand at it. He had so many characters to copy—that was part of his assignment—and he would criticize me that the pen strokes weren't right, and the balance wasn't right. But eventually I got it right, so I would do some of his homework for him.

01-01:08:26
Eardley-Pryor: In Chinese?

01-01:08:27
Bell: Well, copying. The symbol was there, you just had to copy. I didn't know what it meant, but it was kind of fun to do. It was something different.

01-01:08:34
Eardley-Pryor: So as he's taking these Chinese lessons, are you also learning how to read Cyrillic at home?

01-01:08:40
Bell: Eventually I did, yes. My mother took me in hand, so to speak, and taught me to read and write in Cyrillic. She would have weekly lessons, which I protested vehemently. She was very stern and said, "Come on, it's only an hour. You will find it useful in your life." This is when I'm eight years old. I used to tell people that my mother got to me before I could put up my defenses. [laughter]

01-01:09:13
Eardley-Pryor: Have you since found it useful?

01-01:09:14
Bell: Of course I have, yes.

01-01:09:15
Eardley-Pryor: In what ways?

01-01:09:16
Bell: Various ways. It allowed me to appreciate Russian literature and Russian language to a much deeper extent than I could have just knowing the spoken language. When I got to college, I told you that I helped run a Russian dormitory. We'll talk more about that. Then it really helped once I started to travel to the Soviet Union and make contact with people there. Eventually learned enough technical Russian that I could give lectures in Russian. Finally, my second wife whom I met over there, we only speak Russian at home.

01-01:09:57
Eardley-Pryor: Very much a part of your life.

01-01:09:58
Bell: Yes.

01-01:09:59
Eardley-Pryor: So, "Thanks, Mom!"

01-01:10:00
Bell: Right. Thanks, Mom, indeed.

01-01:10:03
Eardley-Pryor: You mentioned staying at PS 69 until you were, about the sixth grade, so you're around eleven years old. This is in the early 1950s. We're talking around 1953, 1954. You have this family that's very connected into the Russian ex-pat community, but this is also the time when McCarthyism is running rampant across the United States. Do you have any memories of that?

01-01:10:24
Bell: No, I don't. This didn't seem to come up in conversation or affect anybody in the family. So yes, it's quite right in terms of the timing. No, that didn't come up.

01-01:10:35
Eardley-Pryor: You also have a very artistic-oriented family. Your father had been in the art business, and your mother is clearly deeply connected to the art scene. You have artists visiting, the Chaliapin family. I'm wondering if there was an encouragement for you to take sort of an artistic bent?

01-01:10:55
Bell: No. In fact, my mother was definitely afraid that I might develop an interest in dance, and she didn't want me to do that.

01-01:11:05
Eardley-Pryor: Why?

01-01:11:06
Bell: Well, for a variety of reasons. She thought that this was going to be a very difficult life for any young person, either woman or male. She also had a concern that I might drift into being gay. Was very outspoken. And why? Because she had a business partner who was gay, shared the studio at that time with her. And many men—not all, not a high proportion, but a definite proportion—were gay in the ballet world. My mother was very traditional in her outlook on gender identification.

01-01:11:47
Eardley-Pryor: With that, the same way that you protest your parents—as we all do—against the language lessons, was there ever an interest, if not ballet, but other aspects of art—singing, or artistic creation visually?

01-01:12:02
Bell: No, not really. I developed an early interest in science and wanting to know how things work. That was self-motivated. Nobody encouraged it. I would spend endless hours at the public library, which was only four blocks away, the closest one. And I could go up there in the stacks and sit down on a stool, and spend an hour reading a physics book, or finding out how TVs work, and how do you get that image across into electronics and transmit it, and so forth. All sorts of questions, which I thought were great, and you can find, free of charge, these books. Today I would have gone online.

01-01:12:45
Eardley-Pryor: Do you remember the first time a television came into your home?

01-01:12:47
Bell: Yes, I brought it. I wanted a television set because I saw them in my friends' homes, and I asked my dad if he would buy one for the family. He said no. So I saved up money, and I went and bought a big clunker with a tube, a used television set, and set it up in the living room. My parents never watched it.

01-01:13:10
Eardley-Pryor: When did you do this? Where was the money coming from?

01-01:13:13
Bell: Various birthday gifts, and Christmas gifts, and odd jobs. I think I paid all fifty dollars for it.

01-01:13:22
Eardley-Pryor: What do you remember watching in those early days?

01-01:13:26
Bell: Sid Caesar shows. *I Love Lucy*. Pretty kitsch stuff. The time I watched would be when I came home and before my parents came home from work. This would be somewhere, three thirty to maybe five, six o'clock, that window. I didn't watch later or earlier, so whatever was being shown at the time. It was all black-and-white, of course, with the rabbit ears on top of the television set.

01-01:13:57
Eardley-Pryor: When you went to McBurney School, this was beginning in seventh grade, around—

01-01:14:01
Bell: Sixth grade.

01-01:14:02
Eardley-Pryor: Beginning in sixth grade. This is also as thermonuclear concerns are being raised, so I imagine there were drills done in school?

01-01:14:12
Bell: There were drills in school, but what I remember more of that, now that you bring it up, was Boris Chaliapin, who was a close friend of my father's—he's an artist—had a home near Westport, Connecticut, out in the countryside. And

he was really concerned, so when he built this home, he had a bomb shelter built into the basement. So what's the bomb shelter? Well, it's just a smallish room with cement walls. I'm sure it wouldn't have withstood any shock. It didn't have supplies. It had a steel door. And God help you if you had to stay there for an extended period of time. But he was convinced that the Soviets might one day come and bomb New York City, and so this was maybe forty, fifty miles outside of the city. He thought he was going to be safe there. Of course he wouldn't be, but you know. That's what I remember of that period.

01-01:15:17
Eardley-Pryor: Tell me a little bit about your memory of the man himself, of Boris.

01-01:15:20
Bell: Oh, he was a wonderful person. As I say, he was an artist. He did portraits of various people, including the shah of Iran and various presidents, from life. He did a lot of this work for *Time* magazine. This is in the day before digital art. There were three artists who took turns, because every week they had to come up with a cover. There was Chaliapin, [James Ormsbee] Chapin, and [Boris] Artzybasheff, all three Russians. I didn't meet the other two, but I knew Boris very well. He lived part-time in New York City, because he could go to the headquarters of *Time* magazine, get all the materials, and then he would drive home to Westport and work over the weekend, develop the artwork, and bring it back into the city on Monday. That was his work style. He came often to dinner with the family, and he was a wonderful storyteller, as were his two sisters, and a brother who was an actor, Feodor—the younger Feodor. Tatiana and Lydia were the sisters. So especially when this family, all of them, got together with my parents, there would be singing of songs, because Boris and Lydia were good singers. There would be telling—

01-01:16:53
Eardley-Pryor: From their father?

01-01:16:54
Bell: Huh?

01-01:16:54
Eardley-Pryor: From their father, I imagine.

01-01:16:55
Bell: From their father, yes. And telling of stories about their youth and their experiences. All very animated, lively individuals. Boris became like an uncle for me. I didn't have any uncles in New York City, any close family. He also loved to tell stories about driving around the US He lived in Los Angeles for a while. He was married to a woman who brought him to Hollywood, his first wife. So he lived in Hollywood for a while and worked there, and he traveled all over the west. He told very colorful stories about traveling to the southwest, seeing Native Americans there, traveling through the Rocky Mountains going east. As a kid, this engendered in me kind of a love of the west, kind of a mythical fantasy land, which I only heard through his stories.

Not a lot of pictures. Then he showed me some drawings he had made, paintings he had made of various places, which further intrigued me. He knew I loved horses. So at one dinner party, he sketched a horse in a stable for me, which I still have at home. He made a sketch of Navajo Indians, which I also have.

He was a great person. He would get all his friends and family together in his Connecticut home for Russian Easter. We'd arrive and spend several days with him, and help prepare the Easter meal, decorate eggs. He'd boil up the eggs, and you got a little brush, and you had pots of gold and silver paint, anything, and you would decorate these eggs and then put them out to dry. The next morning, you'd crack the eggs and eat them. It was a wonderful experience. We also spent a number of Christmases with him. He'd always have a big tree. It's nice because that part of Connecticut would get cold, and you'd have snow on the ground at Christmastime. Yes, a lot of wonderful reminiscences. He played an important part of my life. He was my father's closest male friend, so that was important, too.

01-01:19:28
Eardley-Pryor: Bringing up Christmas and the Easter eggs, it makes me think that you had a Christian upbringing.

01-01:19:33
Bell: I did. My mother had me baptized in the Armenian Orthodox church in New York City. She was Christian. My dad was Jewish. My dad was not particularly religious. When he was approaching the age of thirteen and should be bar mitzvah in Tiflis, he protested. He went to the first few of the teaching periods with the rabbi, said, "This is nonsense," came home, told his mother, who got terribly upset, he says. The father reacted and says, "If the boy doesn't want to, don't make him do something he doesn't want to do." So my father went off, being a little rebellious, and sang in the Russian Orthodox choir instead, because his friends were doing this.

01-01:20:27
Eardley-Pryor: Was the Christian aspect—growing up baptized—was it part of your regular life, aside from the major holidays?

01-01:20:32
Bell: No, not really. My mother was not—she believed in God and in her religion, but she didn't profess it or force it on anybody. So it was private for her. She respected the fact that her husband, my father, was a Jew, and they lived harmoniously together. That was never an issue of discussion. There were Jewish friends. Boris's second wife was Jewish, a Polish Jew, and that never entered into the discussion.

01-01:21:03
Eardley-Pryor: What about your own philosophizing on higher powers and that sort of thing? Was that something you remember having at this time?

01-01:21:10
Bell: I didn't as a child, and it was never a subject of discussion, either in school or at home or elsewhere. So it was a non-issue. I think everybody felt that being a good human being, and being moral, was far more important than being religious. I think especially this generation of people had lived through so much trauma, political and social trauma, that it raised a kind of skepticism in them about organized religion, and I think for good reason. I'd say that I feel that way even today, that you don't have to practice an organized religion to be a moral person. You can be moral because you adhere to a code of ethics, which actually transcends all religions, and is common to many of the religions.

01-01:22:08
Eardley-Pryor: Tell me a little bit about McBurney School. It was run by the YMCA, you said?

01-01:22:11
Bell: Right, it belonged to the YMCA, which is an unusual thing. It was part of a school system, I now read, starting back in 1916, so it had a long history before I became acquainted with it in the fifties. By then, it was down to one school, which was part of the YMCA on Sixty-Third Street, 15 West Sixty-Third.

01-01:22:37
Eardley-Pryor: Just off of Broadway?

01-01:22:38
Bell: Yes, off of Broadway in one direction, and what is the street abutting the park on the other. I think that's West End.

01-01:22:44
Eardley-Pryor: Off the West End of Central Park.

01-01:22:46
Bell: Yes. So nice location. What was particularly nice is that you got to use all the YMCA facilities, sports facilities. The drill in the morning—well, first of all, everybody had to wear a tie and jacket, and come dressed appropriately.

01-01:23:08
Eardley-Pryor: Was this a coed school?

01-01:23:09
Bell: No, it's an all-boys school. All-boys school. You had to come dressed appropriately, and the very first thing you did is you got undressed, and you either went to gym, or you went swimming, depending on the day of the week. Sports was very much an integral part of it for everybody. Then, in the afternoon, if you became part of a team, you had your sports activities. And that was convenient because I played soccer, and so we just crossed the street, literally, and went to the fields, Shepherd Fields in the [Central] Park, and

played. It was a great school. I was there in the lower school until I got to high school, and then high school four years.

The teachers were all very serious, well-educated. All men, of course. I had great teachers in science—physics and chemistry. Two gentlemen. William Hardenberg was the physics teacher, and Eugene Paganelli was the chemistry teacher. Particularly, Hardenberg inspired my love of science and encouraged it.

01-01:24:25
Eardley-Pryor: In what ways?

01-01:24:29
Bell: He saw that I had a talent and an interest in it, and so he would hold me aside, or ask me to stay after class, and get me interested. I worked, eventually, as his lab assistant helping prepare demonstrations for the next class, and cleaning glassware, and so forth. He allowed me to use the school labs to try out things on my own, as long as it was safe.

01-01:24:53
Eardley-Pryor: Like what kind of things?

01-01:24:54
Bell: Do some chemistry things. I told you the story that eventually I got involved in this program at Columbia University. He allowed me to set up some organic chemistry experiments and do them after hours in the school lab.

01-01:25:10
Eardley-Pryor: Was he the one who introduced you to this chemical engineering program at Columbia?

01-01:25:15
Bell: I think it was he, in fact. Yes, that's right, because I wouldn't have heard about it otherwise. It had to be through some network.

01-01:25:21
Eardley-Pryor: So that program, can you tell me a little bit about that? It was your junior year?

01-01:25:25
Bell: It was my junior year in high school. He'd heard about this program, which was to bring a small number of talented young men and women to Columbia University on a Saturday, all day Saturday, to hear some short lectures about chemical engineering—it was run through the chemical engineering department—"What is applied chemistry all about?" Then each student was encouraged to develop his own little project, which they could carry out either there or elsewhere, and then come back and tell people about. One of the coordinators was a man named Ed Leonard. He's now an emeritus professor at Columbia. He was very good at working with young people and inspiring them, and engaging them, and being very supportive. A few years ago, I went

to New York to give a lecture at Columbia, and he's there. So we sat and reminisced.

01-01:26:26
Eardley-Pryor: That's wonderful.

01-01:26:27
Bell: Which was wonderful, yes.

01-01:26:29
Eardley-Pryor: Tell me a little bit about, well, first off, chemical engineering. What drew you to that so early?

01-01:26:35
Bell: My father, I think, had biggest influence, telling me about what you could do with those skills, and saying, "Yes, if you like chemistry, that's great. But if you're only doing chemistry, then you're going to be involved in looking at fundamental science and figuring out new reactions, and so forth. But if you're interested at all in applications, you should think about chemical engineering." So between that, the experience at Columbia made me think, "Well, maybe my opportunities will be broader if I go into chemical engineering rather than chemistry."

01-01:27:09
Eardley-Pryor: Did your father have regrets about not completing his program that he began in 1920?

01-01:27:12
Bell: Yes, he regretted not finishing his education, not necessarily in chemical engineering, but finishing his university education. He felt badly about it. He felt his life could have been a lot better, financially and otherwise, if he had had this opportunity.

01-01:27:32
Eardley-Pryor: Tell me about the project that you chose to do at Columbia that summer.

01-01:27:38
Bell: I had read about carbon-14 dating. This is the work of Willard Libby.

01-01:27:45
Eardley-Pryor: A PhD out of Berkeley.

01-01:27:46
Bell: Yes, and a Nobel laureate. This intrigued me, that you could date things back to 10,000 years, just looking at the decay of carbon-14. Then I read that, as things got older and older, there was less of the carbon-14 there, so you had to put it in as concentrated a form as possible. It seemed that the techniques that were available at that time weren't doing [it] the best possible [way].

So I concocted a notion that you would take the organic matter, burn it to make CO2, carbon dioxide; convert the CO2 to calcium carbide, by reacting calcium with the CO2; and then, adding water to the calcium carbide, you would make acetylene. Now you have two carbons together, and two hydrogens. Then you could run the acetylene over a catalyst, and convert that into either benzene, or better yet, toluene. Toluene has an aromatic ring, six carbons in it, and a methyl group on the side. That way, all the carbon that you put in would end up in toluene. So, why toluene? Well, toluene was the solvent for the phosphor that's used in counting the beta decay from the carbon-14. So now the solvent was comprised all of carbon-14—or not all of carbon, but from the dated material. You would have as high a concentration in the material you wanted to date as possible.

So this [is a] high school junior's dream, but it's a lot of chemistry to put together. I tried to do parts of this chemistry. I never succeeded, but it got me to going to the AEC Library in New York City and getting out now-declassified reports about some of the chemistry in carbon-14 dating.

01-01:29:45
Eardley-Pryor: This is the Atomic Energy Commission Library in New York?

01-01:29:48
Bell: In New York, right, which was publicly available at the time, could go up there. It's a small library, but it had a lot of chemistry reports. I had the report number, so I could ask the librarian for those, and sit there and read them. Then I tried some of this chemistry out. Even if it didn't work, I taught myself a lot of chemistry. I was delighted with the fact that I could have this fantasy and be allowed to pursue it. I thought that was pretty rich.

01-01:30:21
Eardley-Pryor: This experience is rich in its own, that, as a young man, a junior in high school, you're doing experiments in organic chemistry, and understanding how the benzene rings are working at this time.

01-01:30:33
Bell: Yes. I knew what a benzene ring is. I knew basic organic chemistry from high school.

01-01:30:39
Eardley-Pryor: As a junior in high school?

01-01:30:40
Bell: Yes, yes.

01-01:30:41
Eardley-Pryor: That's just really astounding. I'm also struck [how] you eventually, later in your academic career, come to Berkeley. Carbon-14 is discovered, invented, by [Martin] Kamen and [Sam] Ruben here. Willard Libby gets his PhD from

Berkeley. He eventually has his career in Chicago and elsewhere. When does Berkeley come onto your radar?

01-01:31:03
Bell: Very late in the game. I'm finishing graduate school. Nineteen sixty-six is the first time I even thought about Berkeley.

01-01:31:13
Eardley-Pryor: Okay, we'll get to that as we move through. But I was wondering if perhaps the carbon-14 had suddenly sparked anything?

01-01:31:19
Bell: No, it didn't have any connection. No, no, no.

01-01:31:22
Eardley-Pryor: Very autodidactic sort of experiences here in teaching yourself. Where does that come from?

01-01:31:28
Bell: It's purely internal. I'm self-driven. I've always liked to learn new things. I've always had curiosity, not only about science, but about other aspects of life and history. I'm convinced that if I put my heart to it and my head, I'll get somewhere.

01-01:31:49
Eardley-Pryor: Where did that confidence come from? Was that something—your parents, your family? Was it just part of being in this competitive school?

01-01:31:54
Bell: I think part of it was being in a competitive and very rigorous high school. Part of it is just my nature. As I told you earlier, I like to be independent. I hate to be told what to do. That's from my mother's side of the family, I think, more than anything. I enjoy the privilege of being able to pursue my own interests. That's what brought me here, eventually.

01-01:32:25
Eardley-Pryor: Back at McBurney's—it is a very prominent school. Including yourself, a number of well-regarded figures have come out of there. I looked back and saw that, at the time you were there, Henry Winkler, the actor who, of course, is best known as the Fonz—and Ted Koppel were not in your same grade, but there at the same time. Do you have memories of interactions with some of these guys?

01-01:32:45
Bell: No, I have no memories of interacting with them.

01-01:32:48
Eardley-Pryor: No thumbs-up with the Fonz early, huh?

01-01:32:49
Bell: No, no, no. In fact, I was quite interested to see this when I picked up a history of the school.

01-01:32:56
Eardley-Pryor: Another very well-regarded person who spent some time at McBurney's was J.D. Salinger. He was there in the early thirties. But when he wrote *Catcher in the Rye*, and it was published in the early 1950s, just before you're about to arrive there, he sets a few scenes where Holden Caulfield is connected to McBurney's. Do you remember reading *Catcher in the Rye* in high school?

01-01:33:17
Bell: Yes, I did.

01-01:33:18
Eardley-Pryor: Was there a connection with the school, [since] it was brought up?

01-01:33:20
Bell: Yes, I noticed the connection, and I didn't think too much about it. I didn't know that J.D. Salinger had been at the school, and nobody mentioned it, either, in the school.

01-01:33:29
Eardley-Pryor: Oh, it wasn't talked about?

01-01:33:29
Bell: No. No, it wasn't talked about.

01-01:33:31
Eardley-Pryor: Do you remember identifying with the character of Holden Caulfield in any way?

01-01:33:35
Bell: Only very roughly, in the sense that—his cynicism about formal education and the way things are structured, and his rebelliousness. That I could relate to.

01-01:33:51
Eardley-Pryor: As high school is coming to a conclusion here, it sounds to me like you were very much encouraged that college would be the next step.

01-01:33:57
Bell: Yes.

01-01:33:58
Eardley-Pryor: What were your thoughts?

01-01:33:59
Bell: About college? Oh, I was excited about it. I thought that, "Hey, this is an opportunity now to focus more on the things that I like"—science and its various aspects. I was not interested in pursuing, say, a career or getting an

education in the social sciences or humanities. I thought my skills were more in the STEM [science, technology, engineering, and mathematics] areas. So I started reading up about various universities. I looked at Cornell; I looked at Columbia; MIT, because of my father's connection; considered Caltech. Where else? Rutgers. I got in everywhere except Caltech.

01-01:34:47
Eardley-Pryor: So you applied to a number of these places?

01-01:34:48
Bell: I beg your pardon?

01-01:34:49
Eardley-Pryor: You applied to these places.

01-01:34:50
Bell: Yes, I applied to all these places.

01-01:34:51
Eardley-Pryor: Did you visit any of them?

01-01:34:53
Bell: No, no. It was not the thing you did, and my parents didn't have the money. I could have gone to Columbia on the subway, and I'd already seen the place. I knew what that was like. But I didn't want to stay in New York City, so I ruled that out fairly early on. When I got the offer from MIT, both my father's connection with it, everything I'd read about the Institute—I was interviewed by a professor of linguistics who had a connection to MIT. It was part of the process of selecting freshmen, they would have somebody who was either formerly on the faculty or an alumnus interview candidates from their region or their city. I remember being interviewed by this person, and that seemed to help get me in. So, I went.

01-01:35:52
Eardley-Pryor: From linguistics? That's interesting. Noam Chomsky, of course, part of that department later. So you decide to go to MIT. You begin there around what year?

01-01:36:04
Bell: Nineteen sixty, the fall of 1960.

01-01:36:05
Eardley-Pryor: Nineteen sixty, you move up to Boston.

01-01:36:08
Bell: To Cambridge.

01-01:36:09
Eardley-Pryor: Or to Cambridge, okay. Had you lived anywhere else outside of New York?

01-01:36:12
Bell: No.

01-01:36:12
Eardley-Pryor: Had your family stayed in that third-floor walk-up that whole time?

01-01:36:15
Bell: No, no. The family, by then, had moved a block away to Fifty-Fifth Street, closer to Seventh Avenue.

01-01:36:22
Eardley-Pryor: So still in that Midtown area.

01-01:36:23
Bell: They're still in the Midtown area, and that's where they stayed. We had three apartments, all within a block of each other. This was the third.

01-01:36:31
Eardley-Pryor: Your parents were entering into their sixties. They're in their sixties at the time you're beginning your undergraduate. I don't think I've heard when they passed away.

01-01:36:44
Bell: My father had reached seventy-nine. My mother was a few months short of seventy-nine.

01-01:36:49
Eardley-Pryor: So by the time you're already out in California?

01-01:36:51
Bell: Yes, I was here at the time.

01-01:36:54
Eardley-Pryor: We can talk about that as we move into it. Tell me about your experiences in Cambridge.

01-01:36:59
Bell: Cambridge was a fascinating place to be. The Institute [MIT] had lots and lots of bright people, mainly men, all who were top in their high schools. One of the things I realized right away is, while I was top at McBurney in my area, so were a lot of my contemporaries there. This was a little off-putting.

01-01:37:23
Eardley-Pryor: What did that engender within you?

01-01:37:25
Bell: A certain insecurity that I wasn't going to be the best dog anymore, and that I had to compete now with a different group of people, who were all very bright and had expertise in other areas of science. But I accommodated to that. The freshman year, then as now, is common across the Institute. You didn't specialize. Everybody took courses in mathematics, physics, chemistry,

humanities. I think two humanities subjects. There were five subjects that you signed up for. Fifteen weeks per semester. Every Friday, you had an exam in one of the five subjects. You had three midterms, if you like, before you rolled over to the final at the end. So you were well-drilled in taking exams.

01-01:38:21
Eardley-Pryor: What was your routine like?

01-01:38:23
Bell: My routine was get up in the morning, go to Walker Memorial—this was a short walk, from the dorm to the main cafeteria—have breakfast with friends, and then off to class. Go back, have lunch, go back to class. Not much of a break during the day, because you had five classes. Then, in the evening, grab a quick bite to eat, and go to your dorm and study. Study involved sitting there with a desk and a lamp, and reading the text over and over, marking it up, taking notes, doing homework. You got plenty of homework to do. Then dropping off to sleep. The next morning, you repeat the stuff.

The difference in the routine was, Friday night, many of us went to a movie, either on campus in the main auditorium there—they would show movies, which were pretty good, and not very expensive—or you'd go up to the Brattle Theater in Cambridge, in Harvard Square, and see something there. That was pretty much it. Come back, have a hot dog or a hamburger, and go back to bed, and study the next morning again.

01-01:39:45
Eardley-Pryor: Five classes is a lot to deal with at once.

01-01:39:46
Bell: It's a lot to do, yes. They're all at a high intensity, including the humanities courses, which were very well taught.

01-01:39:55
Eardley-Pryor: Tell me a little bit about the dorm. You mentioned living in the dorm.

01-01:39:59
Bell: When I first came, I was assigned a dorm on one end of campus. I took an immediate dislike to my roommate. I would call it at the animal level, because I didn't know him very well. But somehow, I didn't like his attitude, and I can't even remember what he was like. I went to the dean of students and complained, and he said, "Well, you've put me in a very difficult situation, because everybody's been assigned. There are no free rooms. Are you sure you can't come to terms with this young man?" I said, "No, I don't think so." So the dean of students thought about it a little more, and he looked at my papers. He said, "I see you speak Russian. There is one place where we might be able to put you, and that's the Russian dormitory," which was newly formed in what's called Senior House. It's a dorm right behind the president's quarters. I said, "Sure, let me go check it out," which I did.

I found that I both liked the young men there, and I very much liked the tutor, David Perlmutter, who was a linguistics graduate student. I said Harvard before, but I checked him out online. He actually got his PhD from MIT in linguistics. So I was off on that. He was a very bright, animated young man, who had served as an interpreter at the first Soviet-American trade exhibition in Moscow. This was in the fifties.

01-01:41:34
Eardley-Pryor: Was this when [Richard] Nixon goes, and [Nikita] Khrushchev, and they have the Kitchen Debates?

01-01:41:37
Bell: I think it may have been, yes, right. He was there for that. He's not too many years older than we are. He's probably in his mid-twenties, and we're eighteen, nineteen. He was living in the dorm. He had his own room. He was also an instructor in Slavic languages at the time. Chomsky was there in linguistics, and we heard a lot about him from David.

01-01:42:08
Eardley-Pryor: What kind of things?

01-01:42:10
Bell: That he was very taken with his [Chomsky's] whole approach to linguistics. Not so much his politics. That came later, but his linguistic abilities. So I signed on. There were fifteen of us on two floors. I've forgotten how many rooms. I think we were three to a room. That worked out very well, because we would either go to breakfast together, or we would—not necessarily lunch, but dinner was always together with this group. The rules of the road were that you spoke Russian for the duration of the meal. When back to the dorm, you didn't have to. Every Saturday, we went out into Boston and had a dinner out. During that transit period and dinner, you had to speak Russian. It helped all these young men become fluent in spoken Russian.

01-01:43:04
Eardley-Pryor: The other men that were a part of this, what brought them to this learning environment?

01-01:43:08
Bell: I think that Russian was a more exotic language for them than French or German. There were not comparable programs in other languages. This was one of a kind. I think David Perlmutter was the nucleus for this. So there's that. The sort of intrigue with finding out what is Russia really about, and if you don't know the language, you don't find out, really. I think that's what brought them together. Quite a few mathematicians in this group. A few engineers. Nobody else from chemical engineering—I was the only one—or chemistry.

01-01:43:48
Eardley-Pryor: How long did you live in the Russian-speaking dorm?

01-01:43:50
Bell: A year and a half. Then I moved out. This is '61, '62. I moved out with a fellow who had been in the dorm who I met. He's an American but he was born in Rosario, in Buenos Aires. His father was an American who was down there running a bank for the US Bank of America, as bank vice president. So he was born in Argentina, spoke Spanish, of course, and French, and knew some Italian, English. Multi-lingual. Very delightful young man.

01-01:44:34
Eardley-Pryor: What was his name?

01-01:44:36
Bell: Now you're going to challenge me. Let's see. The other one from that period was Peter Wells, who at one point was here in Berkeley, in fact. This fellow's name—now, let me see— [Peter Dunn].

01-01:44:54
Eardley-Pryor: Tell me, before we move forward to living off-campus, the experience back in Senior House. What happened with David Perlmutter? Where did he go with his career?

01-01:45:04
Bell: David finished his PhD in linguistics, and then went on, and I see that he went to UC [University of California] San Diego and had a brilliant career there as a linguist. Out of curiosity, knowing that we would be talking about him today, I went online yesterday and saw that he became an expert in blending linguistics with American Sign Language. There are a couple of videos of him I watched, and my God, almost sixty years later, I can see the face, of course much older. But the same hand gestures and facial expressions. He became very well known in interpretation of sign language and how signs are formed. Now he's emeritus.

01-01:45:55
Eardley-Pryor: I understand there was a moment where his job at MIT was at risk.

01-01:45:58
Bell: That's right.

01-01:45:59
Eardley-Pryor: What happened with that?

01-01:46:00
Bell: After the first year, it was at risk because the Slavic department didn't have enough money, soft money, to pay for him. The guys in the dorm were very upset by this, because we really came to like this guy, both in terms of his manner as a mentor in the dorm, but also his very spirited way of teaching the class. We thought about it, and I had the idea that, "My God, we have to figure out a way to raise money for him."

I knew that you could rent Russian language films from an outfit called Brandon Films in New York City. So I looked into this, and proposed that we run a film series. Everybody thought it was kind of a clever idea. I looked into it. The rentals were very inexpensive, and you could do this by phone. They sent you a catalog, a printed catalog, and you picked out your films and called up, and they would mail them out to you. We arranged to have them mailed out on Friday. Somebody would pick them up at the post office. Then we'd run it Saturday-Sunday, two sessions, and then we'd send it back first thing Monday. That met the contract terms.

Now, of course, you weren't supposed to make money off the rentals, so of course we were breaking the law this way. But we got away with it long enough to make 5,000 bucks from selling tickets to students on campus, and a few from Harvard, who had come down for the showings. And we paid for a semester of his time. He was very thankful, and we were delighted. We put the Brattle Theater out of business for showing Russian films for a period.

01-01:47:52
Eardley-Pryor: Bring a little Russian culture to Cambridge. This is very entrepreneurial sort of stuff that you're doing at this time. How did that play out later in your scientific career, this entrepreneurialism?

01-01:48:06
Bell: I never went into business as an entrepreneur. I've been much more interested in doing science and intellectual things. But it plays out in the sense that I've never been afraid of going into new areas of science and technology on my own. Not being told that this is an interesting area, or because I'm following some other lead, but kind of sniffing it out on my own. Very often, I'm told I'm nuts, and I'm wasting my time, and it's not practical. And my response is, "Okay, that doesn't matter to me." I go where my nose wants me to go.

01-01:48:55
Eardley-Pryor: Something else I'm thinking about that happened, [with] relation to the Soviet Union, is the 1962 Cuban Missile Crisis. That happened while you were at school, and I would assume still plugged in with a number of these people that are interested. What was your experience like with the Cuban Missile Crisis?

01-01:49:12
Bell: Well, keenly interested. It didn't have any impact on us there. I'd say everybody stayed interested, and of course we were delighted when it diffused without any conflict. Now, a year later, 1963, is the assassination of [John F.] Kennedy. That I was involved in, in the following way. Just before that happened, we were entertaining a group of Soviet engineers and scientists from the Soviet Union—the Institute was. They were brought in. They had to be housed and taken around, and needed interpreters. The Institute asked me to serve in this way, and I agreed, as an interpreter.

I remember I got a young man from Magadan, which is in the far east of—near Vladivostok. We hit it off. I took him around the neighborhood where I lived at the time; introduced him to my neighbors, so he would get a sense of what is American life all about; translated for him. Then happens the assassination, and this was a blow for everybody. The group that was coordinating the Russians got them all together in the evening, and we watched the newscast, and the acknowledgement the president was dead. Everybody broke out crying. It was very emotional, involved Americans and Soviets sharing a traumatic experience together. Everybody acknowledged that this was a great man, this was a tragedy. Then they were sent home, to avoid possible problems.

01-01:51:14
Eardley-Pryor: You mentioned the first year at MIT, the Institute, there's a standard class [schedule], everyone takes the same, and then you specialize. What did you specialize in?

01-01:51:23
Bell: I then chose to specialize in chemical engineering, starting in the sophomore year until the senior year. Fortunately, the chemical engineering program at the time had required courses, but not so many that you couldn't fill in the blanks with things of interest to you. Also fortunate for me, about this time, Raymond Baddour, who became my research director later on, decided that it would be good to have a sub-program for interested individuals who wanted to pursue really more science orientation within chemical engineering. So more physics, more chemistry. I signed onto this program because it looked intriguing. I took advanced courses in physics, in electromagnetic theory and quantum theory, advanced physical chemistry courses taught for chemists, not for chemical engineers. This, I felt, broadened my horizons and satisfied my needs. So, I liked the program in that respect.

01-01:52:30
Eardley-Pryor: Tell me a little bit about the difference between the chemists' training and the chemical engineers' training at MIT. How are they different?

01-01:52:39
Bell: There, the two departments are completely separate. Chemistry is in the school of sciences, and chemical engineering is in the engineering school. At the time, chemical engineering was largely traditional apparatus—unit operations, they're called. Dryers, distillation columns, absorber-strippers, reactors—things that you string together to make a process, and how do you design all of this. Some of the people who were really well-known in the field were members of the faculty there.

01-01:53:14
Eardley-Pryor: Who are some of those people you remember?

01-01:53:15
Bell: Tom Sherwood, Ed Gilliland, Alan Michaels—some of the people that I remember who were there. Ed Merrill, Larry Evans—they were part of this formulating the traditional picture of chemical engineering. You got taught all of that, but it seemed to us young bucks that it might be more interesting to also learn more about modern science. You got a whiff of that from your lower division courses. And now, if you wanted to, you could pursue it. So I did. That's what got me interested in how basic science relates to engineering.

01-01:54:03
Eardley-Pryor: In your undergrad in this period, in the early sixties, you mentioned the unit operations as a kind of grounding pedagogical device. If I'm correct, that was something in the teens and twenties that William H. Walker had developed at MIT?

01-01:54:18
Bell: That's right. That's right.

01-01:54:19
Eardley-Pryor: But around that time is also when [R. Byron] Bird, [Warren E.] Stewart, and [Edwin N.] Lightfoot at [University of] Wisconsin are pioneering another form.

01-01:54:26
Bell: This is coming later. Bird, Stewart, and Lightfoot is in the early sixties. In fact, we got the first version of Bird, Stewart, and Lightfoot as a mimeographed draft of this book, before it was published by Wiley.

01-01:54:45
Eardley-Pryor: When? There's import to that. What was the context for having this mimeograph, and what do you remember from that moment?

01-01:0054:52
Bell: I remember that it came in the midst of a course on transport phenomena taught by Harold Mickley, who was also involved in this area. We got this thing, and it was, for people who were oriented towards mathematics and transport theory, like having—wow—this new novel that's rich with all this mathematics and stuff you didn't know about. And you wanted to learn it, and devour it, and see what you could do with it. That was the experience. It came while I was an undergraduate. Then the published version came shortly behind it. We ate that stuff up and loved it. Now, it's at a fairly advanced level. Today, you can't teach out of that book at an undergraduate level because the students don't know enough mathematics to read and appreciate it. You had to know vector calculus, you had to know tensor calculus, because it's used in this materials. It had a big influence, and for a while I even thought that, "Hey, this would be a great research area to pursue." Which I didn't do eventually, but anyway.

01-01:56:09
Eardley-Pryor: While you're at MIT as an undergrad, what are your thoughts as to what the next steps would be? Did you think you would leave and take a career in industry? What were you thinking?

01-01:56:18
Bell: I wasn't thinking that deeply. I knew that I wanted to pursue research, and therefore graduate school was the obvious next step. When I got to be a senior, the thing that you were encouraged to do was look around and find another school, and go west, go to the Midwest, go somewhere else.

By then, I was doing a bachelor's thesis with Raymond Baddour—who also developed this program—on the use of electricity to induce chemical reactions in a plasma arc. We were making acetylene from methane and carbon, and the chemistry worked, and you had this big arc. It made a tremendous noise. You got the flash. It was exciting to see. It produced lots of soot. You were covered with black when you took this thing apart and cleaned it out. But that was great fun.

Then I decided, well, I'd like to stay and work with the man on something else, but in this plasma area, because it seemed very different from the traditional chemical engineering. That's what I ended up doing. I had to talk my way into the program.

01-01:57:37
Eardley-Pryor: How did you do that?

01-01:57:39
Bell: Just by talking to Ray and having him be my advocate, and to Tom Sherwood. They felt that it would be okay. As I told you, Bill Koch, who had been an undergraduate with me, also did the same thing. He also ended up working with Baddour, but in a different area.

01-01:57:58
Eardley-Pryor: So you and Bill Koch continued and worked with Ray?

01-01:58:02
Bell: Right.

01-01:58:05
Eardley-Pryor: So you decided you were going to stay, and thought, "This is what I'm going to do. I want to do research." Did you think you wanted to do something further with that research? Was academia on your mind, or was it something else?

01-01:58:16
Bell: Not in the beginning. It only came into my mind as I started entering the third year of my residency at MIT, third year as a doctoral student.

01-01:58:28
Eardley-Pryor: In your PhD courses.

01-01:58:29
Bell: I had to start thinking, "What do you do when you grow up and leave home?" so to speak. I decided, well, I didn't really want to work for industry because I knew I would be told what to do there, and I don't like that, and there's a hierarchy, and I don't like hierarchies. So what can I do where I'm working largely for myself? I knew nothing about teaching because I never served as a teaching assistant. But I liked research, and so academic life sounded good.

01-01:58:59
Eardley-Pryor: So you decided to stay in Cambridge after you finish your bachelor of science in chemical engineering. I recall you telling me that the first time you went west was between the end of your undergraduate and the beginning of your PhD coursework.

01-01:59:16
Bell: Let me think. Yes, that's right. That was the first time. Yes, '64.

01-01:59:19
Eardley-Pryor: So this is around 1964. Had you traveled much of the country, aside [from] New York and the Boston area?

01-01:59:25
Bell: Except for the East Coast, no, I hadn't. No, I'd never been west.

01-01:59:28
Eardley-Pryor: Tell me about this. What brought you, and what was it like?

01-01:59:31
Bell: Well, I was motivated by the fact that I had, as I told you, a girlfriend at the time, who was born and raised in Corvallis, Oregon, and she wanted to go back and see her mother. So we drove west in her VW van and shared the driving. That was an interesting experience.

01-01:59:53
Eardley-Pryor: Tell me about it. How did you get from Boston to Corvallis?

01-01:59:56
Bell: By the US highway system. A VW bus is sturdy enough that it will take you there. We didn't have much money, so we stayed in campgrounds, and cooked and prepared our own food. Then, as I told you, we got out of the mountains near Custer, South Dakota and parked. We heard a snap, and it was the brake cable that parted, finally. Now, it's a good thing it parted when we were stationary, and not when we were moving.

But it didn't take me long to figure out that it was this cable that needed to be replaced. The cable ran from the pedal in the front all the way to the back, where the brakes were, through a tunnel that was filled with grease.

Somewhere in the middle of the tunnel, the thing had parted. So I pulled out the two pieces. You can't put them back together. This was a Friday late afternoon. [I] went to a Chevy dealer and said, "Is there a VW dealer in town?" "Absolutely not."

01-02:01:06
Eardley-Pryor: Not in Custer, South Dakota.

01-02:01:08
Bell: Yes, right. "But there is on the other side of the mountains." He called in. "Yes, they have a cable, and they'll put it on a bus. It will be here Sunday morning." He said, "I'll pick it up after church." I said, "Thank you very much. We'll be here to pick it up from you." I figured I can install it with some tools. It's about as difficult as changing a brake cable on a bicycle, except this is much longer. I got a pot of grease from him to grease this thing, and I ended up doing this Sunday morning, under the VW with my legs out, my body under there. A couple of the locals came by and said, "Young man, what are you doing there?" [laughter] So I explained, and they thought that was rather clever. We got it fixed, drove it around town to make sure the cable worked, and then went on.

01-02:02:03
Eardley-Pryor: What were your thoughts about visiting the west? You're driving through the Badlands. You're stopping through—

01-02:02:06
Bell: Oh, I thought it was fascinating. I'd never seen this part of the country. I loved it. I loved the big stretches of nothing. We would stop and just walk away from the car and take it all in. Then [we] got to Corvallis, had a good time there, and drove back.

01-02:02:24
Eardley-Pryor: Did you take the same route back through the Dakotas?

01-02:02:26
Bell: I've forgotten which route we took.

01-02:02:30
Eardley-Pryor: As a child, you mentioned having this sort of southwest fascination with Native Americans and the stories that Boris would tell you. Were those kind of coming back to you as you traveled west?

01-02:02:41
Bell: Not so much, because we weren't traveling through that part of the west. We were going northwest, and I didn't have any images of that. The second trip, which I took in '66, took me further south and towards California. That was more to the point.

01-02:02:56
Eardley-Pryor: This seems like it would be probably a good time for us to pause here. We'll start again in our next session. We'll talk about your experiences in your PhD program.

01-02:03:04
Bell: Okay, great.

01-02:03:04
Eardley-Pryor: Thank you, Alex.

Interview 2: September 18, 2018

02-00:00:01
Eardley-Pryor: This is Roger Eardley-Pryor, here for our second interview session with Alexis T. Bell. Today is September 18, 2018. We are in Alex's office here in Gilman Hall. Alex, last time you and I spoke, we moved into some of your work at MIT, and eventually your quick transition to Berkeley. I'd like to revisit some of the stories from your MIT undergrad experience.

You attended undergrad at MIT between 1960 and 1964. Something you had mentioned to me before was some of the elective topics that MIT—once you passed through those first few years, or first year or so at MIT, it opens up once you choose your major to having a lot of flexibility in courses you took. Can you talk about some of the courses you took that weren't necessarily chemical engineering?

02-00:00:47
Bell: Sure. As background to this, I have to say that the man who became my research director for my graduate work, Raymond Baddour, had convinced the department to take on a select number of undergraduates and shepherd them through a science-oriented set of electives, as a complement to chemical engineering required courses. I was asked to join that program, and I did. So I took extra courses in physical chemistry, physics, including solid state physics, electromagnetic theory of waves, and I found that very enriching. It opened up my eyes to all the other things that are relevant to chemical engineering, but you wouldn't necessarily get as a part of your undergraduate training and education.

02-00:01:37
Eardley-Pryor: Who were some of the other colleagues you had that took these specialized courses?

02-00:01:41
Bell: In terms of names of the students, you mean? I don't remember them right now. That's more than fifty years ago. It's a long time.

02-00:01:50
Eardley-Pryor: I'm thinking about some of this work in physics that then helped lead you to some of your senior thesis work. Can you tell me how you came to be working with Raymond? It sounds to me like Raymond helped create this program that you took.

02-00:02:04
Bell: Ray Baddour helped to create the opportunity for me. I worked with him in the summer of my junior year, junior to senior year, as an assistant, and worked alongside one of his postdocs, who was doing the synthesis of acetylene in an electric arc furnace. It was a big piece of apparatus, about ye big. Made a horrendous noise. You could see the arc through a darkened window to make sure it was lit. We produced copious amounts of acetylene.

We studied the various operating conditions to produce acetylene. This intrigued me, because the environment is a super-hot gas, which is hot enough to be ionized. You're actually ripping electrons off of the molecules and getting cations and electrons. You reach temperatures of thousands of degrees Celsius. At this point, you get all sorts of unusual chemistry happening. This intrigued me.

Then I went on, in my senior year, to do my bachelor's thesis, which was a requirement for the department. Each student had to do a bachelor's thesis. I chose to do this with Ray Baddour. But this time, we used a low pressure, high frequency discharge. The basic concept is you take either microwaves, which we did at that time—basically, you have a microwave oven, with a horn, it's called, extending out from the oven. So you have a generator inside the oven [that] produces microwaves. Then you drill a hole in this wave propagator, and you put a glass tube in there, and you have gas at low pressure. Under the influence of the electrical wave, the gas breaks down. If you have a high enough electric field, it breaks down, and you get a nice glow, very much like a fluorescent tube. Then, if you have—

02-00:04:16
Eardley-Pryor: Similar to the way that neon signs are—?

02-00:04:18
Bell: Very similar to neon signs. Yes, exactly identical, except neon signs have electrodes at either end, and this is a DC discharge, direct current discharge. Here you have a radio frequency—or a microwave frequency—discharge, but the same concept.

02-00:04:35
Eardley-Pryor: What kind of power sources are you using to create these high radio frequencies, especially for this carbon arc? Those things are power-intensive.

02-00:04:43
Bell: It is power-intensive. And so Raytheon and a number of other companies that were producing microwave generators for communications would sell you a generator. You could put a microwave guide, it's called—a rectangular guide, metal guide—on it, and propagate the waves out. Then at the end of this was a slot, into which we would put our quartz tube. I studied the chemistry in that quartz tube for part of a year, did my bachelor's thesis, and was intrigued, and decided that it would be fun to do this for longer, as a PhD thesis. This was part of my motivation for staying at the Institute and seeking to work with the same person.

02-00:05:32
Eardley-Pryor: When Raymond Baddour decided to take you on for the PhD work, had you thought about other places to go? It sounds like you made your decision. You wanted to complete—to get the PhD

02-00:05:42
Bell: Right. I really hadn't thought about other universities.

02-00:05:45
Eardley-Pryor: What was it about being in Cambridge and being at MIT that you thought, "This is the place?"

02-00:05:49
Bell: MIT was a very exciting place intellectually. No matter which department you looked at, there were very strong people there, doing exciting research. The whole environment was just an intellectual supermarket, we used to call it amongst undergraduates. In fact, every fall, when we returned to campus, the catalog was a big telephone book. You didn't have it online in those days. We would quickly go through that, identify courses we wanted to take, and then you had to go in person and sign up for courses. You couldn't do this online. So, we read through this catalog. It was as much fun as going through the Sears catalog of the time, for all the different things that you could study.

02-00:06:32
Eardley-Pryor: What was sign-up day like?

02-00:06:34
Bell: Sign-up day was pretty busy. You had to queue up at the registrar's office, and then when your turn came, you handed in your sheet with the courses that you wanted to take. This was all done by hand at the time.

02-00:06:45
Eardley-Pryor: That's fun. You mentioned doing summer work that junior year. Other summers, what were you up to in undergrad?

02-00:06:53
Bell: My freshman year, I went back to New York City and worked in the clothing-industry insurance company, which was an interesting experience.

02-00:07:01
Eardley-Pryor: What happened there?

02-00:07:02
Bell: This was run by the clothing workers' union—an insurance company for health insurance, as a basically paper-pushing operation. You'd go and find the files that were assigned to various cases, bring them to the adjustor, put back files that had been already processed, and so forth. What was kind of fun is on Friday evenings, when work was done, we'd go bowling, drink some beer, and have some fun.

02-00:07:34
Eardley-Pryor: That sounds like a good undergrad experience.

02-00:07:37
Bell: That was in my early undergrad days, yeah. Then later, I worked—I think it was my sophomore year—I stayed at the Institute and worked with Warren K.

Lewis, who was the grand old man. He was in his eighties at the time. He had been a longtime consultant for Esso, later to become Exxon, and then Exxon Mobil. He was interested in thermal losses from big storage tanks of tar, asphalt, which were available in the Bayway Refinery in New Jersey. They were having a problem with the wind going through this tank farm, cooling the asphalt, and then it would cake on the inside of the tanks. He assigned me the project of developing a flux meter that would measure the heat loss from a tank. So I developed this idea of a thin rubber pad with thermocouples on either side, and by measuring the temperature on either side, you would then be able to calculate the flux of heat through the pad. This worked wonderfully in the laboratory. We had a little heater. We calibrated everything.

Then he and I went out to the Esso refinery in Bayway, and we looked at these tanks. They're like small houses. They're huge. On top of it, the surface is with corrugated aluminum siding, so not like what I had in the laboratory, which was a flat surface. What I ended up doing is finding some thermally conductive putty to fill in the ripples, and putting my little pad on top of that so I could get a signal. Well, that worked fine, except I didn't count on the fact that the wind was blowing all the time. So unlike the laboratory, where I would get a steady signal that I could measure with a potentiometer, here you had a fluctuating signal that wasn't even reproducible, and we didn't have oscilloscopes or detection devices that were time-dependent.

So the experiment never really worked out, and never made progress there. But as a result, I went back to the Institute, and in the fall, I studied transient heat transfer from surfaces, and found the mathematical solution to that for a sinusoidal wave, a regular wave. If you do a Fourier transfer on the wind, you could actually represent it as a series of sinusoids. I later used that information as part of my qualifying exam for the PhD

02-00:10:37
Eardley-Pryor: How so?

02-00:10:38
Bell: You had to take the qualifying exam. At the time, it consisted of a written exam, a set questions given by the faculty. Once you passed that, you had to pick a topic that you would present orally to a small panel of faculty and explain why you picked it, what you found as a solution, and what you thought you would do next. So I built it around this summer research experience, and it apparently was good enough to pass me.

02-00:11:07
Eardley-Pryor: It sounds like your work in the field opened up a lot of theoretical doors.

02-00:11:11
Bell: It did. It did.

02-00:11:12
Eardley-Pryor: How have you taken that work forward through the rest of your career?

02-00:11:16
Bell: I've always been interested in applying theory, at various levels and forms, to the interpretation of experimental data. This started out when I was a PhD student, trying to explain the results that we saw in the plasma, the chemistry, and explain it in terms of a model of a chemical reactor. All undergraduates study what's called chemical reaction engineering, or CRE for short. This teaches you how to put together kinetics of chemical reactions with heat transfer, mass transfer, all the transport phenomena, and predict what comes out at the end. So input, conditions, output. I introduced into this picture the influence of properties that dictate the plasma temperature and energy release in the plasma. This was a novel contribution. I was one of the first people to apply chemical reaction engineering principles to plasmas, and I did this while I was a graduate student.

02-00:12:28
Eardley-Pryor: As you're doing this work with Raymond Baddour, what was his interest in working with these plasmas?

02-00:12:34
Bell: His motivation was that electrical energy from nuclear power plants would be so cheap that it would be possible to produce commodity chemicals and specialty chemicals using electricity. Now, in the end, it never proved to be the case, but it was a legitimate motivator, and he got funding from—I forget who it was who funded this research—probably the National Science Foundation, to do the research. So we did it.

02-00:13:08
Eardley-Pryor: So his interest was more in the chemical manufacturing and that acetylene work you had done earlier?

02-00:13:13
Bell: Yes. Most of the people on the faculty in chemical engineering at the time were very applications-oriented, very heavily tied to industry on the East Coast and in the Texas area. It was mostly motivated by engineering applications. My interest, though, was in the scientific aspects of it.

02-00:13:35
Eardley-Pryor: Why was it—about the plasma—the theoretical work around plasmas, that drew you in? What was that?

02-00:13:39
Bell: I think it was the visual aspect, that you got these colorful glow discharges, like neon tubes. The fact that little was known about it, so there was kind of a curiosity of how does it happen. And the fact that the low pressure plasmas are not at equilibrium, which means that the electrons are much hotter than the gas. The gas could be at maybe 300 Celsius. The electrons could be anywhere from 1,000 to 10,000 degrees Celsius. So they're not in equilibrium with each other. They don't have the same temperature.

02-00:14:17
Eardley-Pryor: Was that as a result of using the radio frequency, moving it through?

02-00:14:20
Bell: Yes, and the low pressure. The electrons didn't collide frequently enough with the molecules to equilibrate. You could, with the electric field, boost their energy up quite high.

02-00:14:35
Eardley-Pryor: Talk to me a little bit about what the lab was like. What was the feel? How were things laid out?

02-00:14:40
Bell: This is now the lab where I did my doctoral work. It was across the street from the chemical engineering department, and it was in a building that had been the original machine shop for the whole Institute. It was laid out on two floors, and the middle area was open, so they could have tall machinery in there. The machinery was powered from steam engines originally, and so the belts and the pulleys and so forth for transmitting power from downstairs where the steam engine is, to the upper floors, were still in place. The steam engines had been removed many years before. I think this dates to the early part of the twentieth century.

I had a small lab on the second floor, on the deck floor. It was not enclosed. You only had the outer walls, the structural walls, and then you had kind of a fence, and then there was this big pit to the ground floor. You set up your apparatus on tabletops and built everything yourself. For analysis, I used a gas chromatograph, which were just then becoming commercial. I ended up putting it all together. Then, towards the end of my thesis, mass spectrometers became commercial. And so here came this mass spectrometer in bits and pieces, which I had to put together and make work, which was fun.

02-00:16:18
Eardley-Pryor: Had you ever done any kind of that work before, even as a child? Model-making or anything like that?

02-00:16:22
Bell: I'd been interested in radio communication. I never was a ham operator, never got the license. But I read a lot about radios and how television worked. So I could read a schematic and do diagnostics, say, on the radio frequency generator, and tell where a part had blown out and needed to be replaced. This was in the day where much of the electronics were still tube-based, before transistors became prevalent—just at the transition. It was easy to read schematics and figure out what was going on.

02-00:16:58
Eardley-Pryor: Putting these things together to make it work. With the carbon arc—it is creating such intense heat and extremely bright light—what kind of shielding was there from other people doing experiments on the second floor?

02-00:17:10
Bell: There was a stainless steel sheet that built a box—literally a box, a little room—around the arc. When the arc was running, you closed the door and you fired the thing up from outside, and you had just a little window to see that, in fact, the arc had struck and you were getting what you wanted. Then when it all was over, you turned off the power and opened the door and went inside and worked on the machine.

02-00:17:36
Eardley-Pryor: That sounds like fun.

02-00:17:38
Bell: Yes, it was fun.

02-00:17:39
Eardley-Pryor: If Professor Baddour was expecting to have massive amounts of nuclear energy to make this an affordable process, where was your power coming from, if not the steam engines anymore?

02-00:17:50
Bell: No, it was coming out of the plug, out of the wall.

02-00:17:54
Eardley-Pryor: That was enough power generated to that building?

02-00:17:55
Bell: Yes, a 240-volt power-supply.

02-00:18:00
Eardley-Pryor: Significant [enough]. You had told me in previous conversations that, although Raymond Baddour had helped bring you into this specialized field, had done summer work with you, that as an advisor, he wasn't quite as present as you expected.

02-00:18:14
Bell: That's true. That's very much true, yes.

02-00:18:15
Eardley-Pryor: Tell me a little bit about that.

02-00:18:16
Bell: Well, he was always an entrepreneur, and about the time that I joined him, he got the idea to start a company called Abcor. It was a successful company. Its objective was to scale up chromatography so it could be used for the preparation of specialty chemicals.

Chromatography is a technique for separating mixtures that involves having a packing, a solid. What you do is you introduce your mixture at the top end of this column, and then you have a carrier, typically nitrogen or helium, carry this mixture through, and different components separate or move through at different velocities, because they're held up to greater or lesser degrees on the solid. Then they come out in pulses. If you had a valve at the end and you knew when the desired product was coming through, you could direct it into a pot. Developed originally for doing analysis of products, and that's what the commercial chromatographs of the time were able to do: very small amounts of material.

Ray had the idea that you could scale this up and use it in what was called preparative chromatography, to prepare materials, or separate them from mixtures. Of course, they would have to be valuable enough that you would want to do this. The proof of concept for his company came from a laboratory experience that Bill Koch and I ran. We were lab partners, and in—

02-00:20:04
Eardley-Pryor: Tell me who Bill Koch is.

02-00:20:05
Bell: Bill Koch is one of the brothers of the famous Koch Brothers from Wichita, Kansas. Their father had founded Koch Industries, which was first involved in petroleum exploration, later in equipment for the petroleum industry—basically, a conglomeration of industries. Very wealthy family, billionaires. Three of the Koch brothers, Charles, David, and Bill, went to MIT. Charles was older, so he'd already graduated and was working with the company. David and Bill were fraternal twins. They were, more or less, my contemporaries. They were a little bit older than I was, so they were a year ahead of me. Bill and I were undergraduates at the same time and worked together as lab partners.

02-00:20:59
Eardley-Pryor: What was Bill like?

02-00:21:01
Bell: Very outgoing, friendly. A little bit testy when confronted on science. He liked to have his own way.

02-00:21:12
Eardley-Pryor: Did this come up between you two?

02-00:21:13
Bell: Yes, it came up. Yes. Since I was younger, he felt that I had no right challenging him, even though the age difference wasn't tremendously different. So we got into arguments on that subject. The lab that we had to take was a projects lab. You were assigned a faculty member, you came to that person, and he told you what he thought was a project you might pull off in a semester. Ours was to demonstrate proof of concept of preparative chromatography.

The concept was that you'd take a mixture, you'd send it through a large column. Now, the bigger the diameter of the column, the harder it is to get all the components moving at the same velocity across the radius. This was not original to Ray Baddour, but already in the literature; it had been suggested that if you used a set of discs and donuts—literally, round discs and donuts—interspaced axially, that you could remix the material and prevent this decoherence of the wave. So, we were to prove that.

We needed a lot of packing material. That is very expensive. We couldn't afford to buy all that packing material, because we had a column a couple of inches diameter, a glass column. What we did is we bought the family-size box of Tide cleaning powder. I took it home, put it in the oven, and we burnt off all the volatiles from this material, leaving behind the inorganic material, which is, I think, silica-like, and cleaned it up.

02-00:22:59
Eardley-Pryor: So all the volatiles are just coming out through the kitchen vent?

02-00:23:01
Bell: It's coming out of our oven. It made a terrible stench, and my housemates were not happy. We piled the baked material into the column. We cut the discs and donuts out of cardboard, by hand, with an X-ACTO knife, and then packed this column. As a mixture, we took a combination of benzene, toluene, and xylene. These are compounds that start with benzene, and then toluene has one methyl group on it, and xylene has two, so they're very closely boiling. Put it in, and we found a detector that we could use to distinguish between these. Sure enough, the idea worked. We came to Ray the next morning and showed him the results, and he was all excited. He made us immediately sign a disclosure saying that we had no patent rights. It was his idea. As a result, he then got a patent on the idea and started the business.

02-00:24:06
Eardley-Pryor: Well. [laughter]

02-00:24:07
Bell: So this is what I did as—I think it was junior year.

02-00:24:11
Eardley-Pryor: You helped launch Abcor.

02-00:24:12
Bell: Yes, I helped launch one of the parts of Abcor, right. Bill and I then ended up both working for Ray, but in completely different areas. As I say, the undergraduate experience at MIT was very rich, and as a result, and the people that I met there, I wanted to stay there. I felt very comfortable there, and liked it.

02-00:24:38
Eardley-Pryor: And exciting.

02-00:24:38
Bell: Exciting, yes.

02-00:24:39
Eardley-Pryor: One of the things I've noticed throughout your career afterward, after leaving MIT and here at Berkeley, is the embrace of new measurements, new forms of measurement, and drawing theoretical work from those, and really pushing that part of the field forward. Where at MIT—you're doing early work with gas chromatographs, mass spec—where are you getting the training and interest, and how are you learning how to put these together, if these are just coming commercially available?

02-00:25:10
Bell: It's all, I would call, autodidactic—is a simple word. I like to teach myself things that I don't know. I'm intellectually curious. I also like to see this, of course, in my students and postdocs. I find the world a fascinating place. There are lots of things I don't understand, but the resources for understanding are there. And I have faith in myself that if, left alone and given enough time, I'll figure it out.

02-00:25:43
Eardley-Pryor: As Raymond Baddour starts doing more of this work with Abcor, you're trying to move forward on your [own] research. As he's focusing more on that, you're moving in a different direction and have needs, a little bit of guidance. Where were you finding some of the collaboration and help through your PhD work?

02-00:25:59
Bell: Not very much guidance or help. As I mentioned, there was a postdoc in Ray's group, a senior postdoc, who helped mentor the students who were working in this general area. He had his own project. So, he and I communicated.

02-00:26:18
Eardley-Pryor: Who was that?

02-00:26:19
Bell: It's Peter Dundes, a Scotsman, with a good sense of humor. Just as an aside, he used to talk about the absurdities of the unions in the UK. He said, in the aircraft industry, if you had to drill a hole to put a fastener, and you had to go through aluminum and wood, you had to have a driller from the aluminum side and a driller from the wood side, because they were represented by different unions. Things like that, we used to share with each other. He also didn't get much guidance, and so the two young men talked to each other.

02-00:27:01
Eardley-Pryor: You had mentioned some work with Sandy Brown, Professor Sanford Brown, at MIT. At the time, I believe he was the associate dean of the graduate school. What was the work that you did with him? How did that help shape your work?

02-00:27:12
Bell: I didn't work with him. I took his course on plasma physics. He had developed the knowledge of plasma physics, I think, during World War II, and how

plasmas interfered with radio communications. He had a general course, and I felt that I needed this background to understand the physics of discharges, so I took his course. I struggled through it, because it was really above my grade and my level of understanding, but it did teach me a lot. Then I kept his book and used it in my own work.

02-00:27:50
Eardley-Pryor: How did you apply some of the physics lessons to chemistry?

02-00:27:56
Bell: The plasma was the first area where I applied it, because creating a plasma is all physical processes, less chemical ones. So that was the first area. Later, I'd say it was in the area of catalysis, when I moved into that area. My knowledge of physics allowed me to start studying quantum chemistry, and some twenty-five, six years ago, I got involved in doing that, never having done it before, but now with the help of young colleagues here [at Berkeley] who were more expert in this area.

02-00:28:35
Eardley-Pryor: But at least you had the language and basic understanding.

02-00:28:37
Bell: I had the language and the concepts.

02-00:28:40
Eardley-Pryor: I want to revisit something we mentioned last time, and that was the way that chemical engineering was taught at MIT. From what I remember we discussed, you talked about Bird, Stewart, and Lightfoot's work on transport phenomena, the continuum work. [It] had really just kind of come out.

02-00:28:57
Bell: Had just appeared, had just been published.

02-00:29:00
Eardley-Pryor: From what I'm hearing you talk about, your understanding with your plasma work, even in your PhD research, you're thinking in terms of continuum. If MIT was teaching the early sort of methodology, the unit operations that became famous under William H. Walker at MIT, how did the transport work become a part of your own thinking if Bird and Stewart and Lightfoot is just now on the cusp of getting disseminated?

02-00:29:27
Bell: There was a man named Harold Mickley in the department. He later left MIT and became a vice president for research at Stauffer Chemical, and then he finished his career in that position. He had started to do the same thing that Bird had, and I think he was planning to write a book on the subject with somebody at Columbia University, whose name escapes me right now, and they got scooped by Bird, Stewart, and Lightfoot [BSL]. But he had started to teach the course on transport, and I was taking that course at the time that BSL came out.

02-00:30:10
Eardley-Pryor: So it wasn't from the BSL that you really started thinking through transport phenomena and continuum work? It was at MIT?

02-00:30:16
Bell: It was at MIT, and this came at the right time. Of course, my contemporaries and I lapped this up, because it was a really exciting, intellectual book.

02-00:30:31
Eardley-Pryor: Aside from Harold Mickley, were other MIT faculty resistant to this transition?

02-00:30:35
Bell: I didn't sense that they were. I didn't sense that there was any resistance. I think there was a recognition that, as in any profession, there are waves where certain concepts and ideas, paradigms, are established and they're worked out. When they're thoroughly worked out, then something else comes along that allows you to think more deeply. From unit operations to transport phenomena, it was kind of a natural progression. The next one later on, in the late seventies and eighties, was the molecular interpretation of transport properties and so forth, and so it goes.

02-00:31:22
Eardley-Pryor: What I'd like to talk to you about is your 1966 visit to Berkeley, because that's sort of the next step as far as moving this dissertation work into a career. What was it that led you to make this West Coast trip in 1966?

02-00:31:38
Bell: I was always interested in seeing the West Coast and getting a sense of it, and this originated with the stories that family friend Boris Chaliapin had told me about, and his pictures, and very graphic description of what the West was like. I wanted to see it with my own eyes, and there was an opportunity to come out here in 1966, which I did. Once I was here for a week, I realized, "Hey, there's the University of California down the hill from me. Why don't I go down there and start seeing what I can learn?"

02-00:32:16
Eardley-Pryor: But the inspiration was really just to get out west, to see the west?

02-00:32:19
Bell: Just to get out west. It wasn't to come to Berkeley specifically.

02-00:32:21
Eardley-Pryor: It was California.

02-00:32:22
Bell: Was California, right.

02-00:32:26
Eardley-Pryor: What was the journey like, and how did you get out here? Was this a summer break?

02-00:32:31
Bell: This was summertime, and there was a French student of—I think it was metallurgy. He was a graduate student. He and I teamed up. My girlfriend was out here studying with George Pimentel. She was a high school teacher, and she was studying with Pimentel, a course that he ran here for high school teachers in chemistry. She left me her old Volvo, and he and I paired up and drove the Volvo out here.

02-00:33:06
Eardley-Pryor: You talked before, in 1964, coming across to Corvallis and taking a VW bus. This was another VW?

02-00:33:13
Bell: No, this is a Volvo now.

02-00:33:14
Eardley-Pryor: Oh, a Volvo. Great.

02-00:33:16
Bell: The sloped-back model, which was very popular for a long time.

02-00:33:21
Eardley-Pryor: Any endeavors getting that Volvo across the country?

02-00:33:24
Bell: The only problem we had was coming down from the Sierra. The engine caught on fire, because of faulty insulation on parts of the ignition. So we burned the car out, but it was still drive-able. [laughter]

02-00:33:39
Eardley-Pryor: So your entrance into California, across the mountains, is with a car on fire?

02-00:33:43
Bell: Yes. Well, we stopped on the highway, pulled off, and got our things out, and wanted to get away from the car because we didn't know whether it would explode or not. Fortunately, a trucker going the opposite way saw our dilemma, stopped, took his fire extinguisher out, and extinguished the fire for us. This was, as they say, brute luck, and awkwardness saved our bacon. We put out the fire, and then he had a radio-telephone in his truck. So he radioed to the closest gas station, which had a tow truck, and they came out and pulled us in. They said they couldn't fix up everything, but they could make the engine operable, sort of jerry-rig it. So, we paid them to do that, and drove it all the way to Berkeley.

02-00:34:35
Eardley-Pryor: I'm sure your girlfriend at the time was delighted to see this torched car. [laughter]

02-00:34:40
Bell: Yes, the blackened car. No, she was not happy at all.

02-00:34:44
Eardley-Pryor: Tell me a little bit about—you're in Berkeley as she's taking these courses, and you thought, I should visit the university.

02-00:34:49
Bell: Yes, I have time on my hands. I should come down, see the university. So I did, and walked into the department here, up to the second floor, where the administrative offices were. Found the administrative assistant, a woman named Ruth Fix, and told her, "I'm a graduate student at MIT. I'm here for a week. I'd like to talk to anybody who might have a postdoc position," because I thought that might be the next step for me, "or possibly about an assistant professorship." Completely naive about how one goes about doing these things. At the time, I'm twenty-three, just to put things in perspective.

She sputtered a bit and finally passed me onto the chairman, Don Hanson, of the day—a wonderful, charming man, who wasn't put out by my approach. He just took me in his office here on the first floor and sat me down, and had me tell him about myself. Then he, on the spot, arranged for me to visit with a couple of his colleagues here. That's how I met Ted Vermeulen, John Prausnitz, Otto Redlich, and several others.

02-00:36:15
Eardley-Pryor: What were your impressions?

02-00:36:17
Bell: First of all, I was amazed at how open people were to seeing this brash young person, and very friendly to me, and curious about what brought me out here, what I was doing. It was all very positive. Then I was told, "Well, why don't you come back Saturday morning? A lot of us are working here. You can spend a little more time." That's when I met John Prausnitz up on the third floor, which has been his office ever since he's been here, since '55.

02-00:36:50
Eardley-Pryor: What do you remember from meeting with John?

02-00:36:52
Bell: That he was very outgoing. I learned about his love of music. He would come and listen to the New York Opera, Saturday mornings, as broadcast on—I think WQXR was the station.

02-00:37:07
Eardley-Pryor: And this came up in your early conversations together?

02-00:37:08
Bell: Yes, yes. I told him of my interest in transport phenomena. At that time, I thought I might want to do something in transport phenomena, and he said, "Well, there's nobody who's an expert in this here." That's not quite true. There was Mike Williams, who was a former graduate student of Robert Bird at Wisconsin. He was the only person who was in that area, but working on polymer rheology. He said, "You should think about things more broadly."

One of the things that struck me is he asked me who I was doing research with, and I said, "I work for Ray Baddour." He smiled and he said, "We don't use that preposition here. We talk about working *with* somebody." I remember that to this day, and he's absolutely right. That's how it should be. But I felt that my choice of preposition was correct.

02-00:38:10
Eardley-Pryor: There's a different culture here.

02-00:38:12
Bell: It's a different culture here. I liked that. After a day and a half of visiting, I left, and that was it for Berkeley. I spent the rest of the week sightseeing, and went back to the Institute [MIT]. I think it was that December or January that I got a phone call from the man who had now become chairman, Charles Tobias.

02-00:38:36
Eardley-Pryor: Chairman of the department here at Berkeley?

02-00:38:37
Bell: This department, yes. Hanson really didn't enjoy the stress and strain of being chairman, and Charles took this on. [Charles was] a Hungarian refugee from the Second World War, and saw the Soviet period in Budapest, and escaped and came here. His brother, Cornelius, was in the medical sciences over in the Donner Laboratory.

02-00:39:13
Eardley-Pryor: Here at Berkeley?

02-00:39:14
Bell: Yes, here at Berkeley. He helped get Charles here. Charles had been here already sometime, and was very well known in the field of electrochemistry—deposition, plating, electroetching, corrosion, all these fields. He was the father of electrochemical engineering.

He called me and used the phrase that I remember. He said, "Young man, when you were out here last summer, were you serious when you said you were interested in a faculty position?" I said, "Well, I wasn't totally serious at the time, but now I'm more serious now." I had already applied to some other places.

02-00:39:58
Eardley-Pryor: This is December [1966]. This is the last academic year before you finish your PhD?

02-00:40:03
Bell: Yes, right. I said, "Yes." He said, "We'd like to interview you. When can you come out?" I said, "Well, as it turns out, I have a trip planned, since Chevron has asked me to come out and visit a couple of locations." He said, "Great. Let Chevron pay for the flight. We'll put you up at the Faculty Club." I came out

here, and I stayed, actually, not at the Faculty Club, but with the friends I had stayed with the previous summer. They put me up.

02-00:40:33
Eardley-Pryor: What time of year was the interview? If he's calling you in December of '66, did you come out that January?

02-00:40:39
Bell: I think it was January, yeah. I don't remember the month, but it was around January.

02-00:40:43
Eardley-Pryor: It's nice to leave cold Boston in January for Berkeley.

02-00:40:46
Bell: That is, right. I came out here, and what immediately struck me was the collegial spirit of the department. Everybody knew what everybody else was doing. They had, clearly, social interactions as well as professional interactions with each other. There was an intense but relaxed feeling about the place, which sat well with me.

02-00:41:16
Eardley-Pryor: How was that different from MIT?

02-00:41:17
Bell: MIT was intense, but you felt that it was more compartmentalized, and there was not as much interaction between faculty members at the time. There was also the fact that I had been at that place for seven years and wanted a change. I didn't want to live that close to New York City and be anchored to the city.

02-00:41:45
Eardley-Pryor: Tell me a little bit about that. Your parents are in, at this point, their late sixties. You're their only child.

02-00:41:52
Bell: I'm their only child.

02-00:41:53
Eardley-Pryor: But there was a drive to not be a part of that orbit in New York. Tell me about that.

02-00:41:59
Bell: I like to be independent, and I wanted to see, what can I do on my own? One way to do this is go to the other side of the country and strike out, see what you can do. As I say, I was out here, in the end, for a two-day visit. I gave a seminar, and then visited with faculty.

02-00:42:23
Eardley-Pryor: What was the seminar on, do you remember?

02-00:42:24
Bell: It was on plasma chemistry. George Pimentel was in the audience, and people from chemistry, because this bridges both departments. I got good questions on the work.

02-00:42:37
Eardley-Pryor: Had you ever done a presentation like that, a job talk?

02-00:42:39
Bell: No, no, no.

02-00:42:40
Eardley-Pryor: How did you prepare?

02-00:42:43
Bell: I put together slides. Just used my best abilities to figure it out, based on my thesis work. No guidance from my research director. No discussion of what a faculty interview might be like. It was just seat-of-the-pants. It came off well enough that, after a day and a half, I was made an offer.

02-00:43:09
Eardley-Pryor: On the spot?

02-00:43:09
Bell: On the spot, which never happens these days, and hasn't happened in decades. I was told later that the chair made some phone calls to the East Coast and talked to some of the principal people at MIT, and got input that I'm a good person, worth the risk. This was very much Charles's style -going by his gut with people, sensing that this would work out. "Yes, he's not doing traditional work, but so what? I have faith in it," and he made the offer.

02-00:43:48
Eardley-Pryor: What was your reaction?

02-00:43:49
Bell: First of all, I was amazed that I was made an offer on the spot, and very pleased. I'd interviewed, by then, with University of Michigan and with Caltech—the only two other places that had asked me to come out for a visit.

02-00:44:10
Eardley-Pryor: And Chevron.

02-00:44:11
Bell: And Chevron. Yes, Chevron was the same visit. I'd gotten two offers from Chevron also when I was out here, so I had two offers. I hadn't [received offers yet] from the other universities—I hadn't heard back. When I got this offer [from UC Berkeley], I felt that I could be successful and happy here—it depended on me to be successful—and I accepted the offer on the spot.

02-00:44:40
Eardley-Pryor: Step me back, because that is a wild, powerful moment. Step me back getting there. You also applied to Caltech and Michigan. Did you have interviews there as well?

02-00:44:49
Bell: Yes.

02-00:44:49
Eardley-Pryor: So you actually went to visit?

02-00:44:51
Bell: Yes, I went to visit both institutes.

02-00:44:53
Eardley-Pryor: What was the experience there, contrasted to the experience you had at Berkeley?

02-00:44:57
Bell: I liked Caltech a great deal. There are a lot of similarities. I might have been interested in Caltech, but I never heard back from them soon enough before I made a decision. Michigan, I probably would not have gone to.

02-00:45:13
Eardley-Pryor: Why is that?

02-00:45:14
Bell: I felt it was a little stiff and cold in terms of feeling about the people in the department. Not to speak that it's a cold part of the country.

02-00:45:25
Eardley-Pryor: January in Michigan is not a friendly place.

02-00:45:27
Bell: Right. But that aside, I felt that I would be more comfortable here, and I liked the West Coast, the Bay Area. What's not to like?

02-00:45:36
Eardley-Pryor: Talk to me a little bit about the decision between academia versus industry. You're coming here with the thought that you might go in either direction. Where were you at?

02-00:45:48
Bell: The principal driving force was not so much teaching, because I really didn't know what teaching was all about. I had never done it at MIT. But I knew that I wanted to do research, and I knew that I wanted to do research on things that were of interest to me. A university seemed like a good option. There was nobody to talk to about what is academic life really all about, because my research director was largely unavailable. At the time, there was nobody else on the faculty that I felt comfortable going and speaking with. Unlike the present time, where students feel free to, if the door is open, walk in and start

a conversation with you, we never would have thought of doing that in my day.

02-00:46:39
Eardley-Pryor: What kind of work would you have been doing in industry? Was the plasma work just simply a precursor, and then—?

02-00:46:46
Bell: It was just an entry into the door. I would have been doing work on petroleum processing, one type or another.

02-00:46:53
Eardley-Pryor: So you get the job offer. You know you have an opportunity in Berkeley. You come back to Boston, or to Cambridge, and you still don't have a thesis. Tell me about that, that last term you're at MIT, working to write this thing up.

02-00:47:11
Bell: The final stage, of course, is to write the thesis. Again, there's no guidance as to what should go into the thesis. I sort of put my thoughts together and made an outline on paper, went off to the then-brand-new student union, because it was air-conditioned. This is now the early summer, and it's quite hot in Massachusetts, in Cambridge, at the time, and humid. I sat there and wrote the thing by hand. Then there was a typist in the department who would type your thesis for you, and grumble if you made mistakes and had to retype many pages. But that is how the thesis got written.

02-00:47:56
Eardley-Pryor: That's the process. Done by hand, and then hand to the typist.

02-00:47:59
Bell: Yes, with carbon copies. No Xerox. Well, there was a Xerox available at the time, but these were carbon copies. I think she made two carbon copies. Handed in the thesis. I don't know how carefully it was read. I only know that it got signed.

02-00:48:20
Eardley-Pryor: And you had a job.

02-00:48:21
Bell: And I had a job, right.

02-00:48:22
Eardley-Pryor: The title of your thesis is "Chemical Reaction in a Radio Frequency Discharge: The Oxidation of Hydrogen Chloride." Talk to me about the choice for using hydrogen chloride for your plasma research.

02-00:48:34
Bell: That was chosen by Ray Baddour. It's a good logic. HCl, hydrogen chloride, is made as a byproduct of chlorinating hydrocarbons. Whenever you make chlorocarbons—Dow [Chemical Company] makes a lot of them—HCl is

produced. Now, chlorine is a fairly expensive reagent, so you can't afford to just neutralize the HCl with a base and throw away the sodium chloride. So the question is how to recover it. The way it was done at the time was to oxidize HCl over a copper chloride catalyst, and get the chlorine back. But this catalyst deactivated fairly readily. This is called the Deacon process. What Baddour had in mind was that we would do the Deacon process in the plasma. Thermodynamics are favorable, so you could take oxygen, HCl, and make chlorine and water, and recover the chlorine from the water, and condense the water, and you'd have chlorine gas. Not unreasonable—

02-00:49:44
Eardley-Pryor: So the radio frequency would create the plasma that would energize the hydrogen chloride. Oxygen gets through, is what the plasma is essentially made of?

02-00:49:54
Bell: Yes, and then you have a gas-phase chemistry that takes you to chlorine. You create chlorine atoms from the HCl. The hydrogen attacks the oxygen and makes water eventually, and the chlorine atoms get together—two of them get together—and make Cl_2.

02-00:50:09
Eardley-Pryor: What came out of this work?

02-00:50:11
Bell: We were successful. I got a thesis. I then wrote a draft of a manuscript, sent it to Ray Baddour by mail, and then nothing happened, and nothing happened. Then I get—I think it was a phone call from him, saying, yes, he'd looked at the manuscript, but he had some doubts about it.

02-00:50:37
Eardley-Pryor: This is after you're already at Berkeley?

02-00:50:39
Bell: Yes, already here as an assistant professor. Doubts about it. They came from there being inconsistencies with things that I had written and what David Lam was now starting to do in the first year of his thesis.

02-00:50:57
Eardley-Pryor: Tell me who David Lam is.

02-00:50:59
Bell: David Lam was a young graduate student at the time, at MIT. I didn't know him that well. He was a couple of years behind me. But he was my immediate successor. He took over my equipment.

02-00:51:14
Eardley-Pryor: He grabbed the carbon arc whenever you left?

02-00:51:16
Bell: Well, it wasn't the carbon arc, but it was the low-pressure plasma that I had used, and [he] used it for his own thesis. Eventually, this is what led David to start thinking about using plasmas for semiconductor processing. He came out here [to California] later and founded Lam Corporation, which is an equipment manufacturer.

So there were doubts about what I had written, and I said, "Well, tell me what the doubts are." I couldn't get a straight answer, and one never followed. I found this extremely frustrating. I remember telling this to Charles Tobias, who offered to call Baddour and sort this out, and nothing ever came of it. So the thesis was never published. No aspect of it. This caused me great concern and upset me tremendously. I felt that my research director was undermining me and wasn't supporting me. I had to then struggle to find things to publish.

02-00:52:25
Eardley-Pryor: What did you publish, then? My understanding, if I remember from some of your early publication lists, is some of this work does come out, including with an edited production in '67 with Raymond Baddour.

02-00:52:37
Bell: Let me see. In '67.

02-00:52:45
Eardley-Pryor: Was that earlier work that wasn't part of the thesis?

02-00:52:47
Bell: No. After the thesis, yes, the next thing is in a book, edited by MIT Press. Yes, a short summary of what I did came out there, that's right. But I had wanted it to go into a regular journal, and that never happened.

02-00:53:13
Eardley-Pryor: Did you understand, when you came to Berkeley, the importance of peer review, that process—publish or perish, sort of that ideal?

02-00:53:20
Bell: It wasn't fully explained to me, and as I said, I had no prior discussion of what it meant to be an assistant professor. The amount of guidance that one got at the time was orders of magnitude less than what we give assistant professors today. They come here with a much better understanding of what is expected of them.

02-00:53:41
Eardley-Pryor: That's typically the role that the advisor will play.

02-00:53:43
Bell: Yes, faculty candidates we see today are older, they have more experience, they've had one or two postdocs. So very different experience. What I had to end up doing was, on my own, do research that I could publish. The first couple of papers, I did on my own.

02-00:54:02
Eardley-Pryor: Out here [at Berkeley]?

02-00:54:03
Bell: Out here, yes.

02-00:54:05
Eardley-Pryor: Let's take a break here for a minute, and we'll revisit your early Berkeley work.

02-00:54:09
Bell: Good. [break in audio]

02-00:54:10
Eardley-Pryor: All right, Alex, in the summer of 1967, you moved to California. You had just submitted your MIT thesis a few weeks earlier, signed and submitted.

02-00:54:19
Bell: Three weeks earlier.

02-00:54:20
Eardley-Pryor: And you're on your way out here. Where did you land when you came out? Where did you end up moving? What was the experience like coming across—

02-00:54:27
Bell: I landed in San Francisco. I took a TWA [Trans World Airlines] flight, and one of the first unpleasant experiences, the airline lost my luggage, and it was never restored.

02-00:54:38
Eardley-Pryor: So you came out here with the clothes on your back.

02-00:54:40
Bell: With clothing [on my] back and a few things in carry-on, but I had to quickly buy clothes. So that was the first issue. Interestingly, Berkeley started paying me from July 1, the start of the academic year, so I had a little extra cash to start things.

02-00:55:00
Eardley-Pryor: That brings up the question of how payments worked then. This is before direct deposits with banking.

02-00:55:08
Bell: I got a check while I was in Cambridge still, and then once I got my Wells Fargo account, the university started sending my salary check directly to the bank.

02-00:55:17
Eardley-Pryor: Oh, it was through direct deposit?

02-00:55:18
Bell: Yes, yes.

02-00:55:20
Eardley-Pryor: I'd love to hear a little about your experience, the context that you moved into in terms of California. In 1966, Ronald Reagan is elected as governor, surprisingly. Part of a backlash, in some ways, to the Berkeley student protests, the Free Speech Movement. Nineteen sixty-seven, the year that you begin your faculty position, longtime UC president Clark Kerr is removed from office, in part from Reagan's desires to have the regents remove Clark Kerr. What was the energy like on campus, this new environment that you're coming to, to begin faculty work?

02-00:55:57
Bell: The department was not highly politicized or political, nor were, really, the graduate students. They might have been outside of the department, but certainly not within. But there was obviously a sense, if you went down to Sproul Plaza, of a lot of interest and concern in national politics. There had started to be at that time, also at MIT. I remember, in '66, '67, marching on the president's house, and protesting—

02-00:56:26
Eardley-Pryor: Were you a part of that?

02-00:56:27
Bell: I wasn't, but I saw it. I wasn't living nearby, but I saw it.

02-00:56:33
Eardley-Pryor: What was that about at MIT?

02-00:056:36
Bell: I think it was about the Vietnam War, and concerns about that. That continued. You certainly got even more of that out here. Later, after that year, as things moved on, especially in 1970, there were a lot of protests about the war and about invasion into Cambodia. This was a very volatile place.

The graduate students, even in this [chemical engineering] department, used to get together periodically and discuss things. And [Charles] Tobias, as the chairman, was very clever, having lived through much worse political turmoil than anything Berkeley was seeing.

02-00:57:20
Eardley-Pryor: Back in Hungary?

02-00:57:20
Bell: Yes, back in Hungary. He decided to confront the student concerns head-on, and he offered them to meet with him at eight o'clock in the morning at the Faculty Club, and he would pay for breakfast. He said, "Anybody who wants to come and talk about whatever issues bother you, come and I'll host you for

breakfast." I think this continued for three or four weeks, and then the students stopped coming, because it was fairly early in the morning.

02-00:57:48
Eardley-Pryor: But some did come?

02-00:57:49
Bell: But some had come. They'd had free and animated discussions. He didn't censor these discussions, in any way, and he let the discussions go wherever they went. He responded sympathetically and constructively, and I think this did enormous good to diffuse the situation, which otherwise could have been confrontational.

02-00:58:11
Eardley-Pryor: Some of the protests that I knew science grad students had in the late sixties especially evolved around university's acceptance of military funding to fund their scientific experiments, and students reacting negatively to that. Was that ever an issue that came up here?

02-00:58:29
Bell: Not so much. There was one faculty member, Bob Merrill, who left us, eventually, to go to Cornell, and has now passed away, who had Force funding. He was confronted once by a reporter from the *Daily Cal,* who came to see him. They said, "How come a Berkeley professor is taking money from the Department of Defense?" This is a story he [Bob] told. His response was, "Well, yes, I am taking money from the Department of Defense to study how hydrazine decomposes to make nitrogen"—it's used as a rocket fuel—"but look at it this way, young man. I'm taking this money, and it's not being spent to buy munitions or fighter airplanes. So I'm actually doing the country a lot of good." Small amount of money, actually. Apparently, he had some effect on the reporter, who left him alone.

02-00:59:26
Eardley-Pryor: That was the limit of most of the DOD funding at that time.

02-00:59:30
Bell: Yes, yes, that's right.

02-00:59:35
Eardley-Pryor: This is also the first time you begin teaching.

02-00:59:37
Bell: That's right.

02-00:59:38
Eardley-Pryor: You hadn't had any experience, as you mentioned before.

02-00:59:39
Bell: Never taught a course before.

02-00:59:41
Eardley-Pryor: What was it that you were asked to teach? What was your first teaching experience?

02-00:59:45
Bell: The first teaching experience was teaching transport phenomena, the first of two courses. I sat down with, actually, Bird, Stewart, and Lightfoot, which I chose to use the text. What a big mistake.

02-00:59:58
Eardley-Pryor: Why is that? Why was that a mistake?

02-00:59:59
Bell: It was well over the capabilities of the students to follow. But it was considered by many at the time the leading text on the subject, and since I had read it, I was familiar with it, and thought that this would be the way to go. Every lecture was a challenge to figure out, what do I want to cover? At what depth? How do I present it? I had no experience, and wasn't particularly good at communicating and doing public speaking. In the first year, I really sweated it out every second day and over the weekend. And then I had to put together problem sets for the first time, exams, the whole nine yards, as they say.

02-01:00:47
Eardley-Pryor: That's a lot of work right off the start.

02-01:00:48
Bell: It's a lot of work.

02-01:00:49
Eardley-Pryor: In the meantime, you're also trying to launch your research program.

02-01:00:51
Bell: That's right. That's right.

02-01:00:54
Eardley-Pryor: Did you have a life outside of the university that first year? I imagine you just working all the time.

02-01:00:58
Bell: Relatively little. My life outside of the university was largely connected to folk dancing, which I had started to do when I was an undergraduate, and then graduate student, at MIT. I got into this through a housemate who was teaching Israeli folk dance. He told me that it was a lot of fun, not too hard to pick up, and that you met many women. So that sounded good to me, and I went with him and took his classes, and then even became more interested in Serbo-Croatian folk dancing. Now, the reason that was popular is that a lot of the servicemen came back from Europe having picked it up, having served in Eastern Europe, and then taught it. It became very popular at universities, all along the Eastern seaboard in particular, and it was popular out here, too. It served the same purpose of providing social contact.

02-01:02:07
Eardley-Pryor: Where did you do this in town?

02-01:02:08
Bell: Here? At Hearst Gym, on the second floor, on—when was it?—Friday nights, and sometimes at I-House (International House, Berkeley). Later on, there was a folk dancing cafe in North Berkeley.

02-01:02:30
Eardley-Pryor: I'm curious as to the Israeli aspect. This was Israeli folk dance that initially got you interested. Around that time, your father's family had settled in Israel. Is that correct?

02-02:02:39
Bell: Oh, yes, they'd already been in Israel since 1934.

02-01:02:41
Eardley-Pryor: Did you have much contact with that family?

02-01:02:43
Bell: No, no, no. I made contact with them much later in my life.

02-01:02:47
Eardley-Pryor: In any way, was this exploration of folk dance a form of reaching out to that, sort of?

02-01:02:53
Bell: No, no, no. It had no connection to that. It was purely for social contact.

02-01:02:59
Eardley-Pryor: You mentioned the first course you taught was the first of a two-semester sequence in transport phenomena. You had mentioned that Mike Williams, a University of Wisconsin student, was also here. Was that something you collaborated on together?

02-01:03:13
Bell: No, no, no. There was no offer of collaboration. I didn't seek him out on this. The whole sense was, as an assistant professor, that you were given an office, given a lab, a little bit of money to start your work, and kind of left alone.

02-01:03:32
Eardley-Pryor: You said you wanted to be independent, and here you are.

02-01:03:34
Bell: I sure was independent. Nobody was telling me what to do or how to do it.

02-01:03:38
Eardley-Pryor: Why do you think that Berkeley faculty here gave the transport course to you?

02-01:03:44
Bell: I have no idea. I don't know how it was assigned to me. It was never explained.

02-01:03:49
Eardley-Pryor: You talked a little bit about how the unit processes at MIT had just been slowly shifting into the continuum analysis. What was the story at Berkeley? What was the form of teaching that you came into? What was the departmental culture?

02-01:04:03
Bell: It was less process-oriented—I think it just reflected the people who were here at the time—and more science-oriented. That also reflects the fact that the department is part of the College of Chemistry, and had been since its founding in the late [nineteen-] forties.

02-01:04:21
Eardley-Pryor: Tell me a little bit what you mean by the difference between process- versus science-focused.

02-01:04:26
Bell: The process approach begins with asking how does one analyze the process? You can break it down into what are called "unit operations"—heat transfer, separations, chemical reactors—and you put these together as building blocks. In fact, you have what's called a flow sheet that takes you from reactants, to intermediates, to final products. The traditional way of designing these was to first design the individual units, then link them together, because one thing feeds another, and then take that into account, and then start optimizing the individual units. A lot of the work at the time, as computers were just starting to come into play in the late sixties, was writing computer codes to do the optimization of processes to make the volumes smaller, take reactants to products more efficiently, use less heat, which was a driving force. So all of that was moving along.

Now, here [at UC Berkeley], because [the Department of] Chemical Engineering was always within [the College of] Chemistry, there was a tendency for people to work on what would be called "chemical-engineering science" today—that's an actual term used in the profession, which looks at the scientific underpinnings of process-engineering. A nice example of that is John Prausnitz's work. He came in, I think, '55, so he'd already been here twelve years. Having come here, he moved out of chemical-reaction engineering, which he had done for his thesis at Princeton, to start working on molecular thermodynamics. So, influenced by [Joel Henry] Hildebrand and [Kenneth S.] Pitzer, he moved into that area and became one of the leading figures in it. I think that was one of the influences. Mike Williams coming out of Wisconsin was, in transport area. Gene Petersen taught the chemical reaction engineering courses here, and he was interested in poisoning of catalysts. His molecular interests were more on the poisoning side.

02-01:06:45
Eardley-Pryor: Bringing in some biological reactions.

02-01:06:47
Bell: Biological reactions also came into play here in the early seventies with Charlie Wilke. It's one of the first universities to take up bioprocessing, but as a process, not so much the of the biology itself. That came later, with people like Harvey Blanch. That's how the flavor differed at the two institutions, and why. It reflects, very much, the context—are you in an engineering school versus a college of chemistry?—and also the individuals.

02-01:07:26
Eardley-Pryor: Was there much oversight on the Chemical Engineering Department from the College of Chemistry? Was there more of a push from the top down to have that sort of influence?

02-01:07:35
Bell: Really not, no. There was a dean, and for all the early years, it was a chemist. The chemist let the chair of Chemical Engineering steward this department.

02-01:07:52
Eardley-Pryor: At Berkeley, when the Department of Chemical Engineering solidified itself as a part of the College of Chemistry, rather than into the Engineering Department—that happened around the mid-[nineteen-]fifties, '54 or so—were there any kind of aftershocks by the time you came here in the late sixties from that?

02-01:08:08
Bell: No, no, the aftershocks had passed, and the people who had moved from one place to the other had left the university and gone to UCLA or other places in California to teach.

02-01:08:21
Eardley-Pryor: It sounds to me like you also had a real clear sense of what other people were doing—the culture of the department. How did you absorb that when you first came here? You didn't really know anyone. You were just moving in. How did that get explained to you?

02-01:08:33
Bell: Part of it was talking with the younger faculty, so Mike Williams, John Newman. Gene Petersen was considerably older than I was, but very open, and so we struck up a friendship as well as a professional connection. That's how I learned about what's going on. Charles Tobias, who was considerably older than I was, also became a friend. We just hit it off. We both liked classical music. He was a very fine violinist, and at one point in his youth, thought about becoming a concert violinist, and his father said, "No, no, you're not going to make money that way. Keep up with your engineering studies." And so he did, and violin was something only a hobby for him.

02-01:09:26
Eardley-Pryor: It sounds like similar trajectories, in some ways, from your own family background.

02-01:09:29
Bell: Yes, similar.

02-01:09:31
Eardley-Pryor: Let's talk a little bit about your early research efforts there, the early work being around reaction engineering, plasma processes, continuing the PhD-level work here in Berkeley. This was also something I've heard your students say about the ways that you approached this, something that becomes evident in the rest of your career. Approaching a topic from a scientific standpoint, trying to figure out what the important questions are in that, mastering some of the spectroscopic and the instrumentation work needed to address the problem, doing the detailed reaction chemistry, and then sharing your knowledge with the community to see what can be done with them. Tell me a little bit about the process of you starting your research here. Where did the funding come from? Where were you doing the work? What was the experience?

02-01:10:20
Bell: The funding came from some start-up funds and support of graduate students by the department, so that helped. The first independent funding I got was from the National Science Foundation.

02-01:10:38
Eardley-Pryor: You put a grant forward through them?

02-01:10:39
Bell: Yes, yes. In those days, you had maybe 25, 30 percent chance of getting something funded. It's not 5 percent, which it is today. Much better chances [then]. After a few false starts, I got funding, and that carried me through into the early seventies. That's when I started to get funding from what was called ERDA at the time, Energy Research Development Agency, which had evolved out of the old Atomic Energy Commission, AEC. ERDA didn't last more than a few years, and then it became the Department of Energy.

02-01:11:18
Eardley-Pryor: What became the DOE [Department of Energy] and the AEC, this ERDA funding, what were they interested in in your work?

02-01:11:25
Bell: At the time, this was the period of the first oil crisis in the early seventies. What motivated going to ERDA, and then DOE, was an interest in looking at alternative energy sources. The two interests that several of us here in the department pursued, coal liquefaction and coal gasification. Soo, coal-based chemistry became the subject of interest, as opposed to petroleum chemistry, since petroleum had just become more expensive and scarce, and we had a lot of domestic coal. The other topic was taking synthesis gas, a mixture of CO and hydrogen, which you can get by gasifying coal, and converting this into hydrocarbons. South Africa, by then, was well-known to have done this successfully when their sources of oil were cut off because of apartheid. This

was thought as a possible alternative. No solar energy, no wind energy at the time. That comes much later.

02-01:12:41
Eardley-Pryor: Before we get into the hydrocarbon research in the early seventies, take me back to '67. It's your first year there. You are getting start-up funds to build your lab. Where was the early lab that you worked in?

02-01:12:54
Bell: The first lab was on the third floor of Lewis Hall. Lewis Hall was built in 1947. I don't think these labs were remodeled since then, so twenty years later, I get the lab with soapstone benches, tops, wooden cabinets beneath, hoods which have wooden sashes and real glass frames.

02-01:13:19
Eardley-Pryor: Wooden hoods?

02-01:13:20
Bell: Wooden hood, yes. There's a backplane, which is fireproof, and I think it was made of asbestos board, none of it which you would do today. And that was it. Empty lab, and "Go to it, young man."

02-01:13:37
Eardley-Pryor: What did you need to get with these start-up funds? What did you need to purchase in order to build your lab?

02-01:13:42
Bell: I purchased a radio frequency generator. They were available commercially at the time. Glassware and things were fashioned by the glass shop that we needed.

02-01:13:53
Eardley-Pryor: Here on campus?

02-01:13:54
Bell: Yes, in the College [of Chemistry], actually. We had, I think, at one point, three glassblowers, which is a luxury nobody has today.

02-01:14:02
Eardley-Pryor: What was the process like of working with the glassblowers to see what you needed and what they could make?

02-01:14:05
Bell: You came down with a sketch. You had to specify what kind of glass, whether it had to be quartz, or could it be Pyrex or other things. You then had to specify whether you could take preexisting joints between glass pieces, which sometimes had O-rings in them, or it had to be fused all the way, which meant more work, or whether you needed a Pyrex-to-glass transition, because you were going to a piece of metal equipment. You could buy these transitions, and then they would fuse the glass part onto a piece of glass that you were

working with. That involved doing a sketch, identifying the bits and pieces that you would have, and then sitting down with the foreman of the glass shop and seeing how it could be made. And then finding out how long it would take to make it, because it was usually multiple weeks between when you submitted the request and when you got your requested glasswork, finally.

02-01:15:09
Eardley-Pryor: That's great. What about the machine shop on campus?

02-01:15:12
Bell: The machine shop here in the College was very good. I think we had half a dozen machinists here. So it was a real machine shop, with lathes and things for building large pieces equipment. They made everything from ultra-high vacuum equipment, which they did for [Gábor A.] Somorjai, who was at the height of building that kind of equipment for himself—not available commercially at the time—to making parts for the Mariner space probe for [George C.] Pimentel. That's probably the most notable piece of equipment that they built.

02-01:15:51
Eardley-Pryor: What was your experience like with them? Was it similar? You came down with a design?

02-01:15:53
Bell: Similar. You came down with a set of drawings, and you talked to the foreman, and he loved working with students, or with faculty, to say, "Well, we can't build it this way, but let me suggest this way." A lot of the questions were about how do you seal things, if you had to contain gas or a vacuum, how do you put what are called throughputs for electricity, or cooling water, and how are you going to do the welds, and so forth—things that were not obvious.

Now, I have a fairly good visual intuition, and so I would draw to scale, by hand, drawings of what we wanted to build, take them down to the shop, and they didn't require too much modification. I liked working with students on design of equipment. Today, a lot of this stuff can be purchased from various companies, at a fair cost. But, then, you couldn't purchase the stuff. You had to build it or not have it.

02-01:16:55
Eardley-Pryor: Where were the people that worked in these—both the glassblowing and the machine shop—where were they coming from, these skilled technicians?

02-01:17:02
Bell: They came from all over. Some from Europe, who had been educated and trained in Europe. They came to the university, and you asked them, "Why are you working here and not for industry?" Because the pay was better in industry. They said, well, they liked working with students, and they liked the originality of the work, contributing to the mission of our research program,

and no two jobs were identical. So the diversity of the jobs was what kept them here.

02-01:17:34
Eardley-Pryor: When you started doing your work, you also got your first graduate student. Who was that?

02-01:17:40
Bell: Let's see. It was Lloyd Brown.

02-01:17:45
Eardley-Pryor: How did you and Lloyd begin working together?

02-01:17:50
Bell: He was already here as a graduate student, and he had started to work with a fellow who left, because it was apparent he wasn't going to get tenure. It was suggested to him (Brown) to come and talk to me. He did, and we hit it off, and so he agreed to work with me.

02-01:18:11
Eardley-Pryor: What kind of work was Lloyd doing before he joined you in the plasma work?

02-01:18:14
Bell: I must say I don't remember.

02-01:18:17
Eardley-Pryor: How did you convince him to jump onboard with your research process?

02-01:18:19
Bell: I just told him about the excitement of doing things with a plasma, and he agreed to take it on.

02-01:18:27
Eardley-Pryor: What was it that you did together?

02-01:18:29
Bell: Ah, now I have to stop and think. I'd have to look at my list of publications to remember what we did together. I think part of it was to develop a mass spectrometer for probing inside a plasma. One of the things I wanted to do is not just take final products, but look at intermediates that were produced in the plasma. We built a cone with a micron-sized hole in the tip that would suck gas out of the plasma and into a vacuum system. We had to design that cone—get the machine shop to drill something that fine, make a hole that fine—and then develop a vacuum system behind it and put a mass spectrometer behind that. The whole thing worked. It was home-built. We used the literature as a guide, but we had to design it, and build it, and make it work.

02-01:19:40
Eardley-Pryor: What were the questions you were pursuing for this work?

02-01:19:43
Bell: We wanted to understand if, for example, you have an oxygen plasma, could we see the oxygen atoms, as opposed to just molecular oxygen, and could we see some of the ions, and the anions? Depending on how you biased this cone, if you put a potential on it, you could sample either cations—accelerate them in—or anions, by having the positive voltage on there. Then we had to figure out how to look at the neutrals, which we had to ionize, because the mass spectrometer works on ions, either negative or positive. The whole thing worked, but it was never perfected. We didn't spend enough time really making this a perfect device, as we might have if we were physical chemists.

02-01:20:32
Eardley-Pryor: This was mostly just curiosity-driven work?

02-01:20:34
Bell: This is all curiosity-driven work, right.

02-01:20:36
Eardley-Pryor: At the same time, you also are realizing there are pressures for publication. As you're doing this work, this is also your first forays in trying to get some of your academic work published. What was that experience like?

02-01:20:49
Bell: This was difficult. The first couple of papers I wrote were based on calculations I did. We tried to get it published in *Industrial and Engineering Chemistry Fundamentals*. There were several divisions [of] *I & EC Fundamentals*. Bob Pigford was the editor of that journal, and Bob had moved here from Delaware, to Berkeley, upon retirement. Spent a number of years here, and then was not fully happy. Moved back to Delaware, where he finished his career. But he was here at the time, and so I submitted the paper to his journal, and it got questionable reviews. I think, between my responses to the reviews and Charles Tobias interceding on my behalf with the editor, it finally got published. The couple of papers got published. That helped me get off the ground. But after that, it was publications which I did on my own. I did one with Don Hanson on developing a sensor for small particles. When particles go through a hole, they disrupt the field around the hole, and you get a blip. You can see this on an oscilloscope. So we developed a device for looking at particles, dust particles, this way.

02-01:22:14
Eardley-Pryor: Was Don also a grad student?

02-01:22:16
Bell: No, Don was a faculty member. He was the previous chairman.

02-01:22:18
Eardley-Pryor: How did you end up collaborating together on this?

02-01:22:20
Bell: He was interested in the charging of dust particles, and so somehow we had a conversation about this, and we decided that we could actually not only charge the particles, but measure their size this way.

02-01:22:35
Eardley-Pryor: It sounds almost similar to the work that you and Lloyd Brown had been doing with charging this conical.

02-01:22:39
Bell: Yes, there are similarities there, except here you have particles rather than gas. But here again, we had to design this apparatus, figure out the physics. We had one publication out of that, which was good.

02-01:22:52
Eardley-Pryor: Someone else in early publications, some of your first publications that you co-wrote with was Kam Kwong. Who was Kam? How did you end up working with him?

02-01:23:01
Bell: Kam was a graduate student here, and I convinced him to work with me. Originally, he was going to be a doctoral student, but eventually he finished with a master's degree. He and I did a very nice study on atomic oxygen generation in an oxygen plasma. The reason that this was of interest at the time is that the oxygen atoms could be used to etch away the photoresist in semiconductor processing, so there was a practical end. We wanted to quantify how much oxygen, O_2, could you convert into atomic oxygen in a plasma. A well-defined problem in chemical reaction engineering with a plasma.

He did a very nice thesis, but then decided he didn't want to pursue a PhD So he left here in the early seventies. Kam couldn't find a job in chemical engineering, because there was an economic downturn at the time. He took what little money he had, and with his brother, opened up a flower stand on the north side of campus. That flourished. Then they opened one up on the south side of campus, and then they had even more money. They opened up one near the BART station, which was a good location and it made a lot of money. Eventually, Kam moved his business operation to San Francisco, where he had, first, a Chinese restaurant, and then, eventually, he converted that into a trading business with the People's Republic of China. So he made his whole career, his money, doing that.

02-01:24:50
Eardley-Pryor: From chemical engineering, to flowers, to Chinese food, and then international trade.

02-01:24:57
Bell: International trade, right. Maybe a year ago—I keep my door open here when I don't have visitors—he wanders in, and says, "Hi. Do you remember me?" It

took me a while, after all these years. Yes, I did remember him. He told me that he was now retired, enjoying himself. I went to his wedding, by the way, in Chinatown. He had 400 guests, three floors of a Chinese restaurant. [He] is retired, enjoying himself, and we reminisced about his days here at Berkeley.

02-01:25:38
Eardley-Pryor: The work that you did with Kam sounds to me like that was the first, or at least one of the first, times where you're realizing the practical applications of your plasma work toward the semiconductor industry. You had mentioned David Lam had started doing this work in your wake at MIT. How did the semiconductor applications come into your world?

02-01:26:00
Bell: There was a company in the Bay Area here, in the North Bay, called Tegal, built out of the name of the founder, Ted Gallagher. This is where he and John Hollahan were working together. The idea was that Gallagher was building these plasma generators and vacuum systems for the semiconductor business, for—it was called plasma ashing of photoresist—was the only application at that time. The applications extended later. I think Tobias put us in contact, as I recall, and I started consulting for that firm. That's where I met John [Hollahan], who was the research director for the company.

02-01:26:55
Eardley-Pryor: At Tegal?

02-01:26:56
Bell: At Tegal, yes. Then John and I hit it off, and ended up editing a book on plasma chemistry together.

02-01:27:07
Eardley-Pryor: Had you done any consulting work before this?

02-01:27:09
Bell: No.

02-01:27:10
Eardley-Pryor: How did you know how to set your prices or what the relationship would be?

02-01:27:14
Bell: I didn't know what the relationship would be. I kind of guessed at what the price might be, didn't get refused, so I figured that it was an okay price.

02-01:27:22
Eardley-Pryor: And next time, you can see if you get more.

02-01:27:24
Bell: Yes, right. [laughter]

02-01:27:26
Eardley-Pryor: So you and John Hollahan begin this work explicitly for plasma etching of the photoresist etching. Tell me about the book that you created together. I see

here the title, *Techniques and Applications of Plasma Chemistry*, published in '74. A couple of chapters in there, I think you—

02-01:27:47
Bell: I wrote.

02-01:27:48
Eardley-Pryor: — had a heavy hand on, [like] "The Fundamentals of Plasma Chemistry." Where was that work coming from?

02-01:27:53
Bell: That came solely from me putting together my thoughts about how plasma worked, based on things that I had taught myself while I was a graduate student, plus some of the work done with Kam Kwong and others here in the early days. This was all self-generated.

02-01:28:14
Eardley-Pryor: Another chapter that you had a heavy hand in writing there is titled "Engineering and Economic Aspects of Plasma Chemistry." You had mentioned, back at MIT, the expectation that nuclear energy would make the electrical costs of doing plasma work negligible, but that wasn't the case. Since the seven years from the time when you did your PhD work to writing this chapter, what did you learn about the economic aspects of plasma chemistry?

02-01:28:42
Bell: There were many people publishing about making chemicals of one type or another. If you look carefully, some of the ones who were publishing in engineering journals would cite the kilowatt hours per kilogram of product. Kilowatt hour can translate into dollars or cents, depending on the price of electricity. You just multiply the two together. That told you the price of electricity you had to expend to make a kilogram of that product. When you started then comparing this to the price per kilogram of the product on the open market, you saw that, hey, this is a big number relative to what you can sell the stuff for. So, you knew you were going to be dead in the water unless you brought that number down.

02-01:29:28
Eardley-Pryor: Particularly in the early seventies, as energy costs are rising.

02-01:29:230
Bell: That's right, yes. I took what data was available in the open literature and used it to show how the cost of power got factored into the economics.

02-01:29:45
Eardley-Pryor: How did that change your approach to the research you were doing?

02-01:29:48
Bell: It didn't, really, and I continued working in the plasma area. I started to divert from just gas-phase chemistry to making polymers. This came about because

we hired Mitchel Shen here, who was a polymer chemist, and he and I started talking, and realizing that you could take gases like ethylene, or fluorocarbon gases, and polymerize them. Now, the background here for why you wanted to do this was that people at the Department of Agriculture used to have a laboratory here in Richmond, a USDA lab. I had become familiar with a man named Attila Pavlath, Hungarian, obviously, by name. He was a very clever chemist, who worked on treating wool and cotton—USDA—to make them more water-resistant, in the case of cotton, and oil and dirt-resistant, in the case of both fabrics. He was playing around with plasma chemistry to put very thin coatings, or graftings, on these natural fibers. That looked intriguing.

Mitch Shen joined us at about that time, and so we teamed up to start looking at plasma deposition of polymers. We did a lot of work together with various students. The first one was Hioraki Kobayashi, who came to us from Japan. He was employed by Toray, which is one of Japan's biggest rayon producers. Toray, at the time, had a program for sending their bright young people abroad to get a graduate education. He worked with us, and did very well, then returned to Toray, and I think became a vice president before he retired.

Mitch and I taught ourselves how to make polymer films and coatings, and studied their properties. We got into fluorocarbon coatings, and then the question was how much fluorine do you have relative to the carbon? How can you measure that? About the time we're doing this work in the mid-seventies, X-ray photoelectron spectroscopy (XPS) became available commercially. I think Varian was the first to put out a machine. I don't remember where the first machine was that we used. It was, I think, in the South Bay somewhere. I went down there. I was taught how to operate the machine.

02-01:32:39
Eardley-Pryor: Where's down there?

02-01:32:41
Bell: In the South Bay, and I don't remember the name of the company right off hand I would take our samples down there and actually get fluorine and carbon measurements. XPS is a technique that bombards a surface with X-rays. You eject electrons, and the electrons have an energy that's characteristic of the element from which they came. So you energy-analyze them, and you get an energy spectrum. If you use standards, you can tell whether this is fluorine, carbon, or whatever.

02-01:33:13
Eardley-Pryor: Based on the X-ray bombardment?

02-01:33:15
Bell: Yes. XPS was a very popular technique at the time, and Varian made one of the first commercial machines. We did this early work, and could even identify whether the fluorine was part of a carbon that had three fluorines, one fluorine, or two fluorines, because the chemical shifts could be differented. So

we used XPS to characterize the fluorocarbon coatings that we made. We did a lot of very good, basic science. I think one of our last students in this area was Jim Tibbett, who did a complete chemical engineering analysis of the formation of the polymer, starting from the gas phase because our monomers were always gas-phase species.

02-01:34:07
Eardley-Pryor: What did Jim end up doing with that when he finished here?

02-01:34:10
Bell: Ah, now, that's a good question.

02-01:34:13
Eardley-Pryor: Did he move into industry, perhaps?

02-01:34:14
Bell: He went to industry, and he's done his career in industry. I think he moved into the polymer area, but at the moment, I don't remember where he moved to.

02-01:34:24
Eardley-Pryor: I'm fascinated thinking about your family history, your maternal side, being involved in this industrial cotton manufacture in Russia, and then here you are, on the West Coast of North America, using cutting-edge science to develop different kinds of cotton fabric.

02-01:34:40
Bell: Ysh, although I wasn't connecting the two at all, or thinking of the two, at the time. It was just following opportunities that existed.

02-01:34:50
Eardley-Pryor: When Mitchel Shen was hired here, was he hired in the department of chemistry, or was he chemical engineering?

02-01:34:55
Bell: Chemical engineering.

02-01:34:57
Eardley-Pryor: When you two started working together, how do those kinds of collaborations begin?

02-01:35:02
Bell: It began by the two of us speaking informally and realizing that we had an interest in looking for something new.

02-01:35:10
Eardley-Pryor: Just chatting down the hallway and saying, "What are you working on?" "Oh, what are you working on?"

02-01:35:12
Bell: Yes, or going to coffee, having lunch together—the way things always start. We hit it off. He had no background in plasma chemistry. I had no background in polymer chemistry, but that didn't stop us.

02-01:35:26
Eardley-Pryor: You could teach each other.

02-01:35:27
Bell: Yes, teach each other, right.

02-01:35:29
Eardley-Pryor: So this is through USDA funding, this branch of research. What ended up happening to that strand of research through the seventies?

02-01:35:37
Bell: Eventually, we didn't find enough applications and people who wanted to continue funding it. It became very popular for a while in Japan, and so we knew Japanese people who were working on this subject. There was a Japanese fellow, whose name escapes me right now, who went to the University of Missouri, and became very big. Made his name in this area and published a book on it. But I gave all of that up as I got more and more interested in catalysis. In fact, Jim Tibbett was near the end of the line of that body of research.

02-01:36:16
Eardley-Pryor: I also understand that Mitchell Shen suddenly passed away.

02-01:36:20
Bell: Yes, he passed away. He went to China and became very ill. He had an exploratory operation in China, and they discovered he had liver cancer. It was far enough advanced that it was not treatable. He came back here, and not too long after that, he passed away.

02-01:36:39
Eardley-Pryor: That's a shame. This work that you're doing on cotton polymerization in the seventies—it's hard for me not to picture the fabrics of the seventies, the polyesters. Was there a connection between some of the research and also what was happening and what people were wearing at this time?

02-01:36:56
Bell: Oh, yes, the flashy suits. Not really. Not really. There was interest in the fabric manufacturers in this treatment. Also, there was interest in the manufacturers of polyethylene bags. Polyethylene is water-phobic, hydrophobic, and so in order to print on it, you had to pre-treat the surface. One of the things these polymer manufacturers were interested in is oxidizing the surface enough that you could put ink onto it and it would hold. That actually became a commercial success.

02-01:37:40
Eardley-Pryor: The work that you began doing, the plasma work, seemed so curiosity-driven, almost an intellectual exercise. And as you go, you're finding these applications, plugging them in. Are you actively searching for them, or are they coming to you?

02-01:37:52
Bell: No, people were coming to me. I was not interested in developing processes for the industry. I felt that is really the purview of industry, and they have more people, more money that they can put at it. But I can provide the way of thinking about the problem that they can't afford to do.

02-01:38:12
Eardley-Pryor: The theoretical foundations.

02-01:38:13
Bell: Yes. I've always felt that industry and academe, if they understand each other's goals and drivers, can form a natural partnership, with academe providing the know-how and the know-why, and industry taking that and turning it into a product, or a process.

02-01:38:32
Eardley-Pryor: Before we talk about the catalysis research beginning, I would like to summarize a little bit of how your colleagues were approaching your plasma work. It sounds to me like Charles Tobias really served almost as a mentor figure for you.

02-01:38:45
Bell: He did serve as a mentor figure for me. He was a big supporter of both my own work and the work of others who started to work in the semiconductor applications. He saw the industry growing in the South Bay and knew that there would be an outlet for our students, which, in fact, there was. This was not fully shared by all our colleagues, but enough of them did agree that he could carry the day.

02-01:39:21
Eardley-Pryor: Charles was in support. Who else was in support? Who were some of the ones that were critical?

02-01:39:24
Bell: Gene Petersen was forward-looking, even though he didn't work in these areas. Let me think who else. Bob Merrill, who was here—he was a surface chemist—because he could see how this plasma chemistry applied, and he was supportive. Let me just think of some of the people who were part of the faculty at the time. John Prausnitz sometimes was supportive and sometimes would ask, "Well, what good is this?" So it was kind of back and forth.

02-01:40:02
Eardley-Pryor: And you were finding answers as you went along?

02-01:40:04
Bell: Yes, yes.

02-01:40:05
Eardley-Pryor: The plasma chemistry research, and particularly some of the applications that eventually came into semiconductor industry, was essentially the bulk of the work that enabled you to get tenure?

02-01:40:17
Bell: It was the bulk of the work that enabled me to get tenure, yes.

02-01:40:20
Eardley-Pryor: Tell me about the tenure process. What was that like here? How was that explained to you?

02-01:40:27
Bell: It wasn't very well-explained, to me or to anyone, at the time. There was no formal mentor in the department. So at one point, you're approached by the chair who [says], "It's time to put you up for tenure. Send us a list of all your publications. Give us the names of people we can contact to write letters on your behalf, and teaching evaluations." The standard stuff. "Write a page or so about your research. Summarize that." So you go off and do that.

02-01:41:04
Eardley-Pryor: Who were some of the folks that you requested letters of support from?

02-01:41:09
Bell: That's a good question. I don't remember, to be honest.

02-01:41:16
Eardley-Pryor: Tell me now about the beginning of the work that has become a consistent aspect of your research throughout your career now—the catalysis research. What was your first experience of even approaching catalysis research? When did it first come onto your radar?

02-01:41:34
Bell: That came onto my radar in the early seventies, with Gene Petersen approaching me and saying that he and a couple of his colleagues—I think Bob Merrill and Ted Vermeulen—had some money left over from an EPA [Environmental Protection Agency] grant.

02-01:41:54
Eardley-Pryor: This is in the early seventies?

02-01:41:55
Bell: Yes.

02-01:41:56
Eardley-Pryor: Early EPA.

02-01:41:57
Bell: Right, early EPA. The grant had been to study things in catalysis. They didn't have a productive way to use this money. It was $15,000, not much. They said, "You can have it if you can find a way to legitimize it by saying that you're working on catalysis."

02-01:42:18
Eardley-Pryor: So that was your challenge.

02-01:42:20
Bell: That's my challenge. Don't turn money away. It's a sizable amount of money in that day. I said, "What do I know about catalysis?" Well, virtually nothing. Never worked in the area. But I had, as a graduate student, done these translations of papers from Russian to English for Bill Koch.

02-01:42:40
Eardley-Pryor: Tell me about this.

02-01:42:41
Bell: When we were both graduate students, working for the same research director, Bill was working on ethylene epoxidation, or oxidation, to make ethylene oxide, which is a precursor to glycol, which is used for antifreeze. It's the biggest output for ethylene oxide.

02-01:43:01
Eardley-Pryor: So there's a huge market industry to figure out this process.

02-01:43:02
Bell: Huge market industry.

02-01:43:04
Eardley-Pryor: What was it that Bill was interested in doing?

02-01:43:07
Bell: He wanted to understand the mechanism of the reaction, and as a part of this, he thought that it might be useful to do in-situ infrared spectroscopy—to look at the catalyst with [an] infrared spectrometer and see what species are in the catalyst.

02-01:43:25
Eardley-Pryor: While the reaction is occurring?

02-01:43:26
Bell: Is occurring, right. There had just started to appear books—in the late sixties, early seventies—on doing this kind of work using infrared spectrometers. Bill found three articles by Terenin and coworkers, who were in the Ukraine, and published their work in the *Ukrainian Journal of Chemistry*, which was only available in one language: Russian, not English.

02-01:43:58
Eardley-Pryor: How do you even find something like this in 1966 or '67?

02-01:44:00
Bell: He found it somewhere in the MIT library system. I think what you did is you went to chem abstracts, by hand, found the reference, went to the stacks—foreign journals were in the stacks, as well as the English-language journals—found the article, looked at it, saw the pictures, said, "Yeah, this probably is interesting," and you went and photocopied it. That's what I got, the photocopies. At the time, I was making some money on the side, doing translations to make extra money as a graduate student.

02-01:44:34
Eardley-Pryor: Doing these kind of chemical abstract translations?

02-01:44:36
Bell: No, this was whole articles for an outfit in New York City. It gave me some extra money to have as a graduate student. I did this for Bill for free, as a friendly activity, and that's all I knew about catalysis. But here's money, enough to buy an infrared spectrometer. I know about this material, so I went back and reread the papers, and yes, this is interesting.

02-01:45:08
Eardley-Pryor: The same ones that you had translated?

02-01:45:09
Bell: Yes, and I got—

02-01:45:11
Eardley-Pryor: What did Bill do with that work? You translated it for him.

02-01:45:14
Bell: I translated for him. He could never get the reactors to stop from blowing up, because he would use explosive mixtures. When you heated them up and you weren't careful, you blew up your glass reactor. I don't remember what he did, finally, for his thesis. We sort of parted company after I gave him the translations.

02-01:45:35
Eardley-Pryor: And after he blew them up.

02-01:45:36
Bell: Yes. Well, he didn't blow up my translations, but he blew up his reactors.

02-01:45:42
Eardley-Pryor: So you revisit these translations.

02-01:45:44
Bell: I revisited the translations, and looked at the papers.

02-01:45:46
Eardley-Pryor: After Gene Petersen comes to you and says, "Can you do something in this?"

02-01:45:49
Bell: Yes, yes. I said, "Let's try." Ed Force was recruited to do this work.

02-01:45:58
Eardley-Pryor: Who's Ed Force?

02-01:45:59
Bell: Ed Force was a graduate student. He had worked at Chevron. He had been an undergraduate here at Berkeley, left to work for Chevron several years, and then came back, which is unusual for one of our undergraduates to come back. He was, in fact, older than I was.

02-01:46:18
Eardley-Pryor: How old were you when you made this transition into catalysis?

02-01:46:21
Bell: This is, what, around '72? [I'm] thirty—twenty-nine, thirty, somewhere in there. He started working with me, and our first challenge was to build an infrared chamber, a small cell. We read the literature on what people had done in glass, and we didn't want to do that. We wanted to work in metal. You had to have an infrared transparent window, and you had to seal that against gas from the cell, which you also had to heat. We figured out that there was a material called Kalrez. It's a commercially available fluorocarbon resin, which you could heat up to, I don't know, 250 degrees Celsius, maybe 300 if you pushed it. We purchased some of these O-rings, and used the O-ring to seal the infrared window against the stainless steel flange.

02-01:47:25
Eardley-Pryor: Was this Kalrez—was there a California connection to this?

02-01:47:28
Bell: No, no, no, it's K-A-L. I think it's a DuPont product. So we designed this cell. It was built by the machine shop here. We put it together. It leaked. We fixed it, rebuilt it, and finally got it to work. Then the rest is what ended up in his thesis and the papers that we published.

02-01:47:52
Eardley-Pryor: Nothing blew up this time.

02-01:47:53
Bell: Nothing blew up, no.

02-01:47:55
Eardley-Pryor: Were you able to get the ethylene to oxidize?

02-01:47:57
Bell: Yes, yes. We were able to show that you could get selectivities above the theoretical one predicted by Wolfgang Sachtler, purely on the basis of arguing that you could only use molecular oxygen, and any atomic oxygen you made was going to just combust the product to CO_2 and water.

02-01:48:16
Eardley-Pryor: Step me back a little bit. You publish the research here with Ed Force—the work that becomes his thesis—in the *Journal of Catalysis*. This is your first publication to come out, in the catalytic field, around 1975—a couple different publications that you and Ed work on together. [So] who is the Sachtler fellow you just mentioned?

02-01:48:36
Bell: Sachtler, at the time, was the head of catalysis research for Shell Corporation, located in Amsterdam. He was originally from Germany. Moved after the war to Holland, and was a very prominent figure in the field of catalysis. He later retired from Shell at the mandatory age, came to Northwestern University, and was a faculty member there for many years, until he retired from there. He passed away a few years ago now.

02-01:49:07
Eardley-Pryor: So he's a leading figure in catalysis internationally?

02-01:49:09
Bell: Oh, yes, internationally. Very well-known figure.

02-01:49:12
Eardley-Pryor: What was his challenge for you?

02-01:49:17
Bell: I didn't know how he reacted to these papers until he came to visit here. His intention was to visit Somorjai, whom he knew.

02-01:49:27
Eardley-Pryor: Gábor Somorjai.

02-01:49:28
Bell: Gábor Somorjai. He came with a man whom I knew, Vladimir Ponec, who was at—the University of Leiden. They came together, and Somorjai arranged for them to visit with me, because my interest in ethylene epoxidation.

02-01:49:54
Eardley-Pryor: Had you and Gábor Somorjai began collaboration, because you also—

02-01:49:57
Bell: We were just beginning at the time.

02-01:50:00
Eardley-Pryor: That's a cross-departmental collaboration. Gábor is in Chemistry, and you're here in Chemical Engineering. How did those kind of connections work?

02-01:50:08
Bell: Gábor came to me. He had read these papers, and he was fascinated by the infrared spectroscopy, and the chemical approach.

02-01:50:17
Eardley-Pryor: So it was through your publications that he came to you?

02-01:50:19
Bell: [Yes.] We hadn't met before that, although both of us were here at the time.

02-01:50:24
Eardley-Pryor: And that was the incentive for him to say, "I have Wolfgang Sachtler coming to campus. I'd love for you to chat."

02-01:50:28
Bell: Right. So he arranged for us to visit, and Wolfgang came to my office and started immediately challenging me on my interpretation of the data, and that you could get to these high selectivities. I said, "Well, my logic leads me to these conclusions, and I'm happy to discuss this with you." We went to the board and tied up the better part from eleven to noon. Then the chimes rang, and Ponec, to take the pressure off the situation, said, "I think we have lunch waiting for us at the Faculty Club." So we left, went to the Faculty Club, and he continued over lunch. Then the next visit was with Somorjai, so we parted, and I sighed a sigh of relief.

02-01:51:18
Eardley-Pryor: What was that like? Here's the dean of catalytic research coming.

02-01:51:22
Bell: It was unnerving to be challenged, but I felt that I understood what we had done well enough that I wasn't going to just cave in to authority. Why should I do that? So I stood my ground, in a professional way, which didn't please him.

The next thing I know is, a few months later, I get an invitation to visit his lab in Amsterdam. I said yes, and I was going to go visit Ponec, too, so we connected these things in Amsterdam. Take the little ferry from the Amsterdam port over to the labs. He greets me there and takes me to his office first thing, and I see the office has a conference table, where all his people who had worked on ethylene epoxidation are sitting around the table. I notice many of them have a copy of my paper heavily underlined. That's when I realized that I'm going to get another grilling. So now I got a grilling in the home office, and again stood my ground, until it came time for lunch again.

02-01:52:37
Eardley-Pryor: Saved by lunch.

02-01:52:38
Bell: [laughter] Yes, saved by lunch. It was aggressive, but friendly. We then left, and one of the people in charge of that part of his group, Peter Kilty, pulled me aside and he said, "I know that you have a point, but we can't tell him this, because he's so wedded to his point of view." Typically, I would say, a European point of view: "I have a position I've taken, and I now defend it with all the new work that we do."

02-01:53:14
Eardley-Pryor: Even though his own colleagues had [seen] the light through your work.

02-01:53:18
Bell: Right. I spent the day there, left, and that was that. History has proven that I had a point, because subsequent work done at Union Carbide showed that you could push the selectivity from 67 percent, which was considered the theoretical limit, up to close to 90 and more percent.

02-01:53:39
Eardley-Pryor: There's a lot of room to grow.

02-01:53:40
Bell: Yes, by putting in additives and playing with the silver chemistry.

02-01:53:45
Eardley-Pryor: What did Ed Force do with this work after you had both reached these conclusions and kind of changed the field?

02-01:53:50
Bell: He got his dissertation. He went to work for Stauffer at first. In fact, he was married, and his wife was bugging him to get to making money! So he left, and it took a long while to get the publications finished, because he could only work on the weekends and at nights. But we got them out. He never used this work in his professional career, and then he left Stauffer, went to work for Chevron again, and I think he's now retired. I haven't heard from him in years.

02-01:54:25
Eardley-Pryor: What was it that you took away from this experience of going to Amsterdam, being challenged, standing your ground? What was it that you took from this?

02-01:54:33
Bell: I took from it that if I'm going to stick my neck out, I'm going to get it whacked. But I have a thick neck. I've had this happen also with a guy named Mordecai Shelef, who was one of the lead researchers at Ford Motor Company. That was a little bit later, on the subject of NO reduction over automotive catalysis, which was kind of the next phase I got into as I moved into heterogeneous catalysis research. That came at an ACS [American Chemical Society] meeting in New York City, in front of hundreds of people.

02-01:55:13
Eardley-Pryor: Having to stand your ground again. Industry coming to attack the theoretical frameworks you're building. Well, that sounds to me like this might be a great place to pause, and we can talk about, in the next sessions: your shift into the catalytic nitric oxides work.

02-01:55:26
Bell: Very good.

02-01:55:27
Eardley-Pryor: Thank you, Alex.

Interview 3: February 18, 2019

03-00:00:00
Eardley-Pryor: I am Roger Eardley-Pryor, from UC [University of California] Berkeley's Oral History Center of the Bancroft Library. Today is February 18, 2019, President's Day. We are in the third session of our interview with Alexis T. Bell. Alex, it's great to see you again.

03-00:00:15
Bell: Good to see you, Roger.

03-00:00:16
Eardley-Pryor: We're here in your office at Gilman Hall [on campus at the University of California Berkeley]. Today and in the next few sessions that you and I will share together, we're going to be covering your major research topics throughout your career. We're going to use about three interview sessions to do that. You and I have worked in combination to lay an outline out that you have suggested.

03-00:00:35
Bell: That's correct.

03-00:00:36
Eardley-Pryor: We've organized your research in three major areas, the first being "New Materials and Energy Resources," and we'll begin that topic today. We'll move into discussions of "Multi-Technique Studies in Structure-Property Relations"—everywhere from new experimental methods to catalyst composition and structure. And then we'll also talk about a major innovation in what you do, the "Theoretical Methods." So many people focus mostly on experimentation and catalysis, but you combine that with your theoretical methods and the applications of theory to catalysis.

In framing the discussion for your research career, I do want to make mention that you are such an accomplished and internationally renowned scientist. I just want to drop a few pieces of information here to help frame that.

One is that your scientific publications are extensive—hundreds and hundreds. You have over 50,000 citations in this research, which is increasing at a rate of nearly 5,000 citations a year. You are a member of the National Academy of Engineers, elected in '87; the National Academy of Arts and Sciences, elected in 2007; and the National Academy of Sciences, in 2010. In addition to that, your international reach is outstanding. We've talked a good bit about your Russian immigrant parents and that history, and that's related to your research, too, as an honorary professor of the Siberian branch of the Russian Academy of Sciences. You're identified as one of the "100 Engineers of the Modern Era" by the American Institute of Engineers. And the Chinese Academy of Science selected you as an Einstein Professor in 2013, one of twenty such people chosen from all areas of science internationally.

03-00:02:26

So it is impossible for us to try to summarize your career-worth of research and work at such a global level. Instead, what we'll do in this oral history is to contextualize your research, to try to tell the stories behind your research accomplishments. And one of the ways that you suggested we do this—and I think this is great—is to talk about the funding, the ideas behind the research, the tools that were used, and especially the people that you worked with. So that's where we will begin moving forward as we frame this.

Before we dive into the details of the work itself, I would love to hear you talk about, generally, your philosophy of research—your research philosophy. What can you share and tell us in how you think about doing research as a chemical engineer?

03-00:03:14

Bell: So my thinking about this starts with the fact that I identify myself as an engineer, and a chemical engineer, which means I focus on chemical transformations, which lead to products that people all over the world need—fuels for transportation; polymers; commodity chemicals that are then transformed to other products that we use, such as hand soap and so forth. Therefore, as you think about these products and their production, there are always technical issues that come up that keep the product either from being made or from being made efficiently and economically. And what I like to do is start with an area that seems like it's ripe for investigation and ask, "What are the scientific bottlenecks? Where would more science be helpful to aid people doing this kind of work in industry, to transform initial materials into final products?" I see this also as an excellent area for education for graduate students and postdocs – to do science on something that society needs. Therefore, that's been one of the guiding principles for all of my work throughout my career. And these guiding principles and choice of topics change from time to time, and that's great fun, because this way, not only do the topics evolve, but I get to work on something new, and I get to stimulate young people to work on something new, and it keeps us all lively and happy.

03-00:04:56

Eardley-Pryor: That's how you can maintain such a vigorous research career over the decades. Can you tell me a little bit about how you wrestle with the tensions that are almost inherent in chemical engineering? And by that I mean, the tension between the practical and the intellectual, the applicable and the theoretical—especially because your work is rooted often in these fundamental aspects of theoretical science, and yet chemical engineering came out of such a process-oriented tradition. So can you talk about your tensions with those?

03-00:05:26

Bell: Yes, certainly. I think you have to see the tension looking from two sides. One is the industrial side, where if you work for industry, your supporters and people who pay your salary are looking for something that is profitable at the end of the day—practical and profitable—and if it isn't, the interest level wanes fairly quickly. If you're an academic, on the other hand, I think that one should take the opportunity to look at, what are the fundamental issues? How can the fundamentals of science and engineering be applied to solve a practical problem? And I'll give you some examples as we get into talking about specifics. So this is the guiding principle.

I often have discussions with my friends in industry who tut-tut about the fact that I'm doing such theoretical work or very fundamental work. And I say that each one of us is doing what is appropriate for our institution. If I were at your institution, I would take a different perspective; if you were at my institution, I would hope you would also take a different perspective. So these two cultures need to coexist, and I feel that academe contributes to the practical and the industrial culture by the knowledge it puts into the bank. And I've sometimes used the analogy that what academic professors do, academic researchers do, is put intellectual capital into a bank that the world can draw upon. And if we weren't all doing that, there wouldn't be any capital in the bank, and industrial corporations couldn't make investments using that capital.

03-00:07:18

Eardley-Pryor: That's great. That's a great analogy. Shaking hands through capital that way, of different kinds. Can you tell me a little bit more about your choice of topics? You mentioned certain chemistries being important for society and how that changes over time. Can you talk a little bit generally about what issues you have focused on that you see as important to society?

03-00:07:39

Bell: I've focused throughout my career on environmental protection, and there are a host of issues there, going back several decades, and into the future as well—they change. Society needs fuels for transportation in various forms; that's an ongoing issue. The contemporary issue being recognized more and more is CO_2 emissions—as being environmentally challenging and leading to climate change—it causes one to rethink: where does the carbon come from? How do you reuse carbon so as not to pollute the atmosphere?

As time changes and the needs of society change, there are always chemistries that are relevant, and there are always opportunities to look deeply at these chemistries and to think about, how does one facilitates the chemical reactions? And that's really at the heart of all of my work, one way or another, is facilitating the transformation of chemistry—and chemicals from one form to another.

03-00:08:50

Eardley-Pryor: Can you talk a little bit about how this—you mentioned that this is important, the role that academe plays in shaping the next generation, whether they are academics or industrial practitioners—how your research philosophy relates to the ways that you teach, and the way you choose topics relates to the ways that you instruct the next generation?

03-00:09:11
Bell: With every new graduate student or postdoc with whom I begin working, I have a series of conversations—which don't go to specifics, but start to look at the broad theme that we've chosen to work on, and ask, what is known? What's not known? What are the opportunity areas? And this is often done by my asking the person I'm working with to do a literature search or a survey—and today, with the aid of electronic means, this is very easy to do—and then to digest this literature on their own and make a presentation for me. There's so much literature that I can't keep up with it, especially with the many different topics that I'm dealing with, so for the students, it's a good exercise. Now, they discover along the way that there are many things they don't understand, and I tell them, that's natural. I wouldn't understand it either if I went into a new area.

But together, I feel that we're smart enough to dig through, sort it out, learn what the nomenclature means—which is the first step—and then identify how principles that we know can be used to interpret what we see and what we read. So once that's been done, the next step then is to ask, what are the things that people don't know? What would it be critical to know? And if you were to know the answers to these questions, how would this enable progress to be made? So it then finally boils down to establishing a set of hypotheses about what is happening and what needs to be known. And I very much like hypothesis-driven research, rather than, let's go look and see what happens and maybe we'll see something interesting and then figure it out.

03-00:11:06
Eardley-Pryor: Why do you think the hypothesis approach is important?

03-00:11:09
Bell: I think having a hypothesis means that you have a focus. You've already struggled with the unknown and have a verbal statement of where you might want to go. Now, that hypothesis may be proven wrong; it may be undermined by the facts. And this is perfectly fine, because then you have to sit back and think of another hypothesis. And I've learned, and I'm sure many other people who have done science and engineering have learned, that scientific activities don't tell you what questions to ask. They give you answers, or partial answers, but the questions to ask are part of the human process.

03-00:11:54
Eardley-Pryor: Yeah. They required creativity for that.

03-00:11:56
Bell: It requires creativity. And this is where the human mind and human creativity enter in. Teaching that to young students is important, I think.

03-00:12:06
Eardley-Pryor: I want to drill-in a little bit more in that. Why do you think it's important for students to have that kind of approach in their training when many of them will go out and use chemical engineering as purely a vocational tool? It's an

advancement for them to get a job in industry. Why do you think this hypothesis-driven aspect of your research philosophy is important for their training?

03-00:12:26
Bell: First of all, it sharpens the mind. And it's a technique that can be applied in any context—an industrial context, in your daily life, in your political life—is to say, what is it that is the central issue here at play, and how do I believe the world is working? What are the forces at work here? And it's a good way to approach many difficult problems.

03-00:12:57
Eardley-Pryor: Yeah. Teaching people how to be citizens, in some way, better people.

03-00:13:02
Bell: Exactly. Yes.

03-00:13:04
Eardley-Pryor: The strategy you mentioned about writing a review at the beginning of your research—it seems like, as we move through some of these different research topics, it's something that you have taken on in your research, too—not just assigning that for students, but assigning that for yourself. Tell me a little bit about that.

03-00:13:20
Bell: Yes, I've done this occasionally. It's an enormous amount of work. I've done this in the area of hydrogenation of carbon monoxide to make synthetic fuels. That was in the eighties and early nineties. I've done it subsequently in the later nineties on fundamentals of how chemical reactions proceed, how you discuss the kinetics of chemical reactions theoretically. These days, it's not done right at the beginning of the new effort, because I simply don't have the time to do it. But if I have a student who's up to it, he or she and I will work together to write a review that will be part of their thesis.

03-00:14:08
Eardley-Pryor: Have you seen a difference in the research topics that you've chosen when you have done a review versus times you haven't?

03-00:14:14
Bell: No, not really. I can be as effective in not writing a review and then going into the research topic, or writing it later on when we've spent some years working on the topic.

03-00:14:25
Eardley-Pryor: And I imagine you, for a long time, were editing the Catalysis journal's review section [*Catalysis Reviews*], so you were deeply involved in the review process as an editor.

03-00:14:35
Bell: Right. So that's an interesting thought—that the process of reviewing other people's work, for journals or for proposals, is a way to learn about what's current. And so I typically review one paper a week for one or another journal, and I try to pick papers these days that are of interest to me—because I get more than enough choices in a given week—and then learn from them—the good papers that are being submitted.

03-00:15:08
Eardley-Pryor: That's a way to keep yourself sharp, I imagine.

03-00:15:10
Bell: Yes. And I pass on the references that I see that are relevant to my coworkers.

03-00:15:15
Eardley-Pryor: Beautiful. Are there other things you want to say about your research philosophy before we move to another topic?

03-00:15:21
Bell: No, I think we've done a fairly good job of covering that.

03-00:15:23
Eardley-Pryor: I would love to hear you talk about chemical engineering as a discipline, as it has evolved. In previous discussions that we've recorded, you talked about initial training in unit operations, to a shift in the sixties towards more transport phenomena and continuum sort of work. I've also heard you mention that in the seventies, transport phenomena shifts, in a way, to what some call a molecular approach. I'm wondering if you can—as we begin to discuss your research in the seventies—if you can frame what that means—so, what this shift from the continuum and transport phenomena to a molecular approach was, and why did it happen then?

03-00:16:03
Bell: So the continuum approach assumes that matter is a continuum—like, a glass of water, you see the liquid flow. And one can describe the flow of a glass of water, or water in general, with, for example, viscosity, which represents how easily it flows and passes momentum. Now, a deeper question would be to ask, where does that viscosity arise from? Because it's a colligative property, and in fact, it can be traced back to molecular interactions. So as the field started to look in a more and more molecular fashion at continuum properties, this recognition came in that "Hey, we could predict things from first principles by looking at the molecules making up matter." And this happened in the seventies and eighties more and more, as people in our profession started to realize they could import knowledge from physical chemistry related to the properties of molecules and build this in. And then subsequently, people said, "Oh, we can even do this theoretically, from first principles, knowing just the structure and the composition of molecules, and predict the properties." So there's been a constant evolution of perspective.

03-00:17:27

The context initially was the properties of gases, liquids, and solids, but I'd say since the nineties and really up to the present, there's been more and more emphasis of this similar kind on biological materials, which are many orders of magnitude more complex. People are now starting to think about biological processes in terms of the atoms and molecules that are involved.

03-00:17:53
Eardley-Pryor: Can you talk about why you think this happened in the seventies?

03-00:17:57
Bell: Why it happened? Well, I think what happens in any field is that at some point there is the feeling that the time ripe to bring something else in—some other element from another discipline? And by the seventies, I think, people had started to exhaust the creative thoughts and ideas in the continuum domain and were looking for more challenging things to do, and recognized that yes, if you go to your chemistry cousins, you could learn something from them and import that. This has been a very nice aspect of chemical engineering throughout its development—that it has its own core discipline, but it is constantly importing knowledge from other fields—from physics, from synthetic chemistry, from physical chemistry, from materials science, and onwards and onwards.

03-00:18:53
Eardley-Pryor: Now biology, even.

03-00:18:55
Bell: Biology now, yes. Even concepts from electrical engineering on process control. Yes.

03-00:19:01
Eardley-Pryor: Well, I'm wondering if tools or instrumentation is another triggering point for some of these shifts—and you mentioned the theoretical work—even theorizing first principles rather than simply observing them—and if part of that has to do with the computer revolution. So I'm wondering if tools played a role in this shift to this more molecular approach, let alone the theoretical.

03-00:19:24
Bell: Tools definitely play a role here. As tools come to be available, it enables you to ask deeper questions and look at things in a different perspective. I'll give you an example: the developments in electron microscopy have now evolved to a point where you can look at a subatomic scale—at fractions of an angstrom, and actually see atoms and see molecules and see their shape—and in some cases, recognize that their shapes are more or less the way that we draw the cartoons in organic chemistry. And this is very gratifying—that what your imagination and intuition says is actually visible now. So it allows you to look more deeply at things. There have been various kinds of spectroscopy that have evolved. And I think what engineers and practical people are doing is, when new tools become available, they're mature enough that you can use

them routinely, they'll grab onto them, start using them, and advance their field to yet another level.

03-00:20:36
Eardley-Pryor: So what are some of the tools that you would identify as part of this shift to the molecular? You mentioned electron microscopes.

03-00:20:42
Bell: So early on in my career, I started using infrared spectroscopy, which looks at the vibrations of molecules, and identifying species that are absorbed on surfaces by their infrared fingerprint. A cousin to that is Raman spectroscopy, which is a scattering phenomenon that also tells you about the vibrations of molecules. Later on, together with Jeff [Jeffrey A.] Reimer, I used nuclear magnetic resonance spectroscopy—NMR. And subsequently, with Bruce [C.] Gates's help—who's a friend and a colleague at UC [University of California] Davis—we learned how to use X-ray absorption spectroscopy, working on synchrotrons. There are several around the country, but we started out down at Stanford, and now we've moved on to Argonne [National Laboratory]. And sometimes we use the Advanced Light Source here at Berkeley.

03-00:21:39
Eardley-Pryor: When was it that these tools became things that entered into your work? Were these things that happened all around a similar couple of decades? Or is this something that has evolved over your career?

03-00:21:50
Bell: No, it's been an evolving thing. It evolves. And one gets the sense, from listening to other people talk, as to when the tool has matured to a point where you can use it routinely and it's not a research problem in and of itself to use the tool.

03-00:22:09
Eardley-Pryor: Just to wrap up this a little bit, tell me a little bit more about how biology has factored into this, and how has the biological realm changed the way that chemical engineers can do their work?

03-00:22:22
Bell: The interest in biological processes actually goes back to the seventies, at least here at Berkeley. My colleague, who's passed on now, Charlie [Charles R.] Wilke, was the first to bring it into play. But it wasn't looking at the biology so much as looking at biological processes, such as fermentation, as a chemical process, and learning how to control all aspects of it—the mass transfer of oxygen, the evolution of the ethanol, et cetera. Subsequently, his younger colleagues started to take a more molecular approach to it. Jay [D.] Keasling, is one of the leaders in synthetic biology—in fact, one of the founders of synthetic biology—recognized that you could use biological organisms to manufacture chemicals. But you have to understand how the biological organism functioned and how you built in new DNA into it and caused it to redirect and make things you want rather than what it would do

naturally. So knowing how these principles of biology work and factoring them in with principles of chemistry has led to a use of now biological synthesis as a means to produce very sophisticated materials.

03-00:23:44
Eardley-Pryor: That's great. Let's shift our focus into some more of the details of your career and your work rather than the big picture. And catalysis is the general area in which you have done the majority of your research, we can put it underneath that category. I think one of the things that really stands out in your work is, as we've mentioned, the use of experimental and theoretical tools to really define the nature of the active sites for catalysis, and your work on elementary processes by which these reactants are converted into usable products. So as we talk through the details of these, we can keep the big picture in mind about how relationships between elementary steps will define the activity and selectivity of a catalyst, and how those relationships define the composition and structure of those sites. Is that a fair summary?

03-00:24:41
Bell: Yes, that's fair.

03-00:24:43
Eardley-Pryor: All right. Well, today's topic, that you helped outline for us, is new materials and energy resources. We've identified five major areas, and we'll see what we get through today and what stories come from them. The five subject areas that we'll talk about, just to lay them out here, will be: nitrogen oxide reduction—and that also leads to international collaborations in a really unique way with the Soviet Union. Carbon monoxide and carbon dioxide hydrogenation to hydrocarbons is a second frame in this, but especially talking about the Fischer-Tropsch synthesis and your work on that. A third piece will be zeolite synthesis. A fourth is biomass conversion processes. And then lastly, we'll address electrocatalysis work that you've done most recently, especially with the Joint Center for Artificial Photosynthesis [JCAP].

Before we dive too deep into those specific things, I think a placement might be neat to think about, we are here at Berkeley, and one of the great benefits of doing research here is having Lawrence Berkeley [National] Laboratory [LBNL] on our backdoor. You've maintained a long relationship with LBNL. I have the start date at around 1975 where you became [connected with it]?

03-00:25:57
Bell: That's correct, yes.

03-00:25:58
Eardley-Pryor: What was it that you were doing that pulled you in, in 1975, to the Berkeley Lab?

03-00:26:02
Bell: So I had started working on catalysis prior to that, just at the end of the sixties and into the seventies. And '75 coincided with the first energy crisis. The

Berkeley National Lab was supported by the AEC—Atomic Energy Commission—at the time, but also at this point, the decision was made in Washington to phase that out and convert it into ERDA, the Energy Research Development Administration, which was a unit that lasted only—not very many years—I think less than five years, and then became the Department of Energy [DOE]. So, together with my colleague Gabor Somorjai in chemistry, we realized that this was now becoming an opportunity for new funding in the energy area, and the first calls for proposals came out of ERDA and then later the DOE. So he and I were among the early ones who went to the ERDA-slash-DOE to seek funding for energy conversion—because we saw this as a growth opportunity. And so the general areas that we were both—well, that he was interested, and I also, were first of all synthesis of hydrocarbons from carbon monoxide or CO and hydrogen—what is known as Fischer-Tropsch synthesis. The other was a growing interest in coal conversion, because America then—and now—has large coal reserves, and the thought is, well, if we can't get petroleum from the Far East, maybe we'll use our own resources and liquefy the solid coal to make a petroleum substitute. So this is what got us started in the area of synthetic fuels.

03-00:28:01
Eardley-Pryor: What was the proposal that you and Gabor Somorjai put together?

03-00:28:04
Bell: So we put together one on using synthesis gas, which you can make also from coal—or from natural gas or anything with carbon in it—by steam reforming of the carbonaceous material to make a mixture of hydrogen and CO, and then you start from that and you react them over a metal to make fuels—diesel fuel and gasoline. It's a crude product, but it can be refined. The coal-related work was done with Ted [Theodore] Vermeulen, who was part of our faculty at the time, and Ed [Edward A.] Grens—two other colleagues. And there we decided to pursue coal liquefaction—and coal gasification. So we actually had two parallel programs, one with Somorjai and one with my other colleagues here, and both were funded, and we had students work on both of those. So it was a lot of fun.

03-00:29:06
Eardley-Pryor: How did the ERDA funding come onto your radar? How did you hear about it?

03-00:29:10
Bell: Well, if you're here at Berkeley, you hear about all sorts of opportunities. It's not hard. And keeping your ears open and being aware of things before it's obvious to everybody in the country is important. It's constantly important—and even today. So I think that's one of the virtues of being at Berkeley, is that you hear what's in the wind, and you find ways to couple into this message before everyone else discovers it.

03-00:29:42
Eardley-Pryor: It didn't seem, at the time, that there were a lot of chemical engineers at Berkeley that were working up at Berkeley Labs, though.

03-00:29:48
Bell: There had been—and there are. And this extends from the period of the Second World War. And in fact the reason chemical engineering is at Berkeley is that [Wendell] Latimer, who was dean right at the end of the war, recognized what an important role chemical engineers had played in isotope separation for the Atomic Energy Commission and the atomic weapons program. And he decided that there should be an applied chemistry part of the chemistry department. He hired the first chemical engineers from Shell Development, which was in Emeryville at the time. So that's the history.

03-00:30:30
Eardley-Pryor: And that helped lay the framework for the department here?

03-00:30:31
Bell: That laid the framework for this department, right—and also the association with the [Berkeley] Lab.

03-00:30:36
Eardley-Pryor: Okay, so the department had a deep connection with the Berkeley Lab?

03-00:30:41
Bell: Oh, yes. It had a connection even well before I came to the faculty.

03-00:30:45
Eardley-Pryor: Tell me, if you can, a little bit about how you and Gabor Somorjai came to collaborate. Because when we spoke last, you talked about Wolfgang [M.H.] Sachtler coming to visit campus, and he was coming to meet Gabor, but Gabor said, "You need to talk with Alex as well while you're here," and that led to a whole string of fun events.

03-00:31:04
Bell: Yes. So Gabor made contact with me in the very early seventies—before '75—when he saw the papers that I was publishing on applications of infrared spectroscopy. And it was not something he was doing, but he was intrigued, and the fact that there was somebody in the sister department doing this kind of work led him to come and meet me, and we hit it off and started talking. And this is really characteristic of how many collaborations here at Berkeley get started—you hear that somebody is doing similar work, you invite them out for coffee, you have lunch with them, and off it goes. It's very informal and unstructured.

03-00:31:53
Eardley-Pryor: Was the '75 funding from the ERDA the first funding you two had together?

03-00:31:57
Bell: Yes.

03-00:31:58
Eardley-Pryor: And that relationship lasted through almost a decade and a half from that point on.

03-00:32:01
Bell: Right, yes.

03-00:32:03
Eardley-Pryor: What about your work with Ted Vermeulen? You mentioned that was the second project.

03-00:32:07
Bell: Right.

03-00:32:07
Eardley-Pryor: How did you and Ted begin working together?

03-00:32:09
Bell: Well, we were here—in fact, this was his office many years ago—and again, because the chemical engineering department is basically a small community all on one or two floors, two and a half floors, in this building, we see each other frequently. And the room next door, which is still the faculty lounge, was a place that people gathered at ten o'clock for coffee or at lunch informally, and this is where people talked.

03-00:32:38
Eardley-Pryor: Is that how you and Ted came to cross paths on this?

03-00:32:40
Bell: Yes, yes.

03-00:32:42
Eardley-Pryor: That's great.

03-00:32:43
Bell: Yes. Being in a small department helps, too.

03-00:32:46
Eardley-Pryor: I want to think about, time-wise, big chunks of funding research. In the seventies, the mid-seventies, it seems like the relationship with Lawrence Berkeley Lab was a major factor.

03-00:32:57
Bell: Right.

03-00:32:58
Eardley-Pryor: Other major national endeavors, I'm wondering if your work fit into. Maybe you can help me frame it?

03-00:33:04
Bell: So one of the first areas I worked in was nitric oxide abatement, and this was driven by several things. One is the recognition that L.A. and many urban

centers were suffering from smog, and that the major source of the smog was automobiles. So, what to do about it? Well, nitric oxide, for example—one of the pollutants—is intrinsically unstable relative to nitrogen and oxygen, its component parts. What hinders the reaction is that it has a large activation barrier to break the bonds and rearrange them, and so you need a catalyst to facilitate all of this. And so there was an opportunity—both Ford Motor Company and GM [General Motors] were starting to do work in this direction. The first automotive convertors appeared on cars in, I think, 1972. The Clean Air Act was passed about that time. And so both the DOE and NSF [National Science Foundation] were interested in supporting work in this direction. And so we went out and got support for that kind of work.

03-00:34:18
Eardley-Pryor: Tapping into these big national focuses?

03-00:34:20
Bell: Yes. And it's a theme that lit off in about the early seventies and lasted about a decade or more. There are still people working on it, although it's not as exciting a theme as it used to be.

03-00:34:32
Eardley-Pryor: Why do you think it trailed off, you said, around the mid-eighties or so?

03-00:34:35
Bell: It tailed off largely because the technology became so good that as the states and the feds pushed the requirements down and down into a tiny corner, the technology kept up with it, and now the issues were more not, "Do we have a way to deal with it?", but, "What is the lifetime? Can we make the product cheaper?" For example, rhodium, which was the first element found to be very effective for nitric oxide reduction, would periodically spike in the market and be extremely expensive, and even some companies tried to manipulate the market by buying it up and then selling it. So Ford realized that they could use palladium, also a noble metal but cheaper, and play the game that when rhodium was too high, they'd reformulate and go to palladium, and then when palladium prices started to spike, they'd then go back to rhodium. And so the interest was now more in fine-tuning the properties of the product, making it last longer so you didn't have to replace the muffler, and more and more practical issues, rather than the fundamental issues.

03-00:35:54
Eardley-Pryor: I see. Did you hear, by the way, that Berkeley is experiencing a crisis in people stealing catalytic convertors?

03-00:36:01
Bell: The city of Berkeley?

03-00:36:03
Eardley-Pryor: Yeah. There's a crew of people coming through Oakland and Berkeley.

03-00:36:05
Bell: Oh, that doesn't surprise me. There's about $100 worth of precious metal in a converter.

03-00:36:11
Eardley-Pryor: Yeah, and palladium right now has just spiked to be more expensive than gold, more valuable than gold.

03-00:36:15
Bell: Okay, yes. Yes. So there's incentive, right?

03-00:36:18
Eardley-Pryor: Yeah, it's wild. The *Wall Street Journal* just had an article about that.

03-00:36:21
Bell: No, I hadn't seen that.

03-00:36:22
Eardley-Pryor: Not just Berkeley, but they mentioned Chicago, as well. I think even in London, there's crews going around sawing these things off.

03-00:36:27
Bell: Right, because you can acid-leach—you can leach out the alumina support, and then you have a solution that has dissolved precious metal, which you can then recover.

03-00:36:40
Eardley-Pryor: My gosh, that seems like a heck of a process for people to go through on the black market.

03-00:36:45
Bell: Right. You have to have smart people to know how to do it, too.

03-00:36:48
Eardley-Pryor: It's really advanced. I think also, for the end of the 1990s, I'm wondering, where was the big chunk of money coming from federal research—maybe with connections with the Berkeley Lab or not—that were helping drive some of your work?

03-00:37:01
Bell: So the nineties, I'd say the DOE became the leading source of money. Today that's true, too, in the field of catalysis. There's about, oh, I'm guessing, $40 [million], $45 million a year put into catalysis at the National Labs and academic institutions jointly, and that's a significantly larger amount than, say, the National Science Foundation has, and then an even much smaller amount by the DOD [Department of Defense] agencies—and there, it's only for very specified topics. The Energy Protection Agency—EPA—used to have money for atmospheric protection, but that's long gone.

03-00:37:50
Eardley-Pryor: When did that fade off?

03-00:37:52
Bell: Oh, that must be in the, I think, late eighties.

03-00:37:55
Eardley-Pryor: Why do you think it happened then?

03-00:37:57
Bell: I must say, I don't remember, and I think it had to do with politics.

03-00:38:03
Eardley-Pryor: Did the National Nanotech Initiative that spiked around 2000—that [Bill] Clinton and Bush helped put forward, George W. Bush—did that have any influence on the funding that you were able to do and the research you were able to do?

03-00:38:16
Bell: Which?

03-00:38:17
Eardley-Pryor: The National Nanotechnology Initiative.

03-00:38:19
Bell: Oh, nanotechnology. Yes, it did. And it was a very interesting discussion, because people doing catalysis thought that they were always doing nanotechnology before the buzzword appeared. And we even went around telling people we were doing sub-nano—you know, smaller than nano. And the response was, "Yes, yes, we know that, but that's old nano." So there was this kind of tension. And I participated in several workshops about nanotechnology and open discussions. And those who were from the material sciences and from chemistry who wanted to advance the making of fancy things at the nano scale weren't always taken with catalysis. Now, in the interim, I think that tension has died away, and now it's recognized that catalysis is a part of nanotechnology.

03-00:39:16
Eardley-Pryor: Why do you think that tension was there then?

03-00:39:19
Bell: Something new. And, you know, all the old boys felt that they might crowd out the new boys on the block.

03-00:39:28
Eardley-Pryor: What did you think about the use of that term, "nanotechnology"?

03-00:39:31
Bell: Oh, I think it's oversold. Because while there are products that derive their properties specifically from the fact that the size scale is in the nanometer domain, what is nano spreads such a wide size scale—from, say, a tenth of a nanometer, which is an angstrom, to 100 nanometers—that you go almost to bulk properties on one side and to atomic and molecular properties at the

other. So it's not a highly well-defined thing. But it's a theme that sold, and caught on.

03-00:40:11
Eardley-Pryor: Is it more of a policy term, then?

03-00:40:15
Bell: It's a political term in the scientific domain.

03-00:40:20
Eardley-Pryor: Moving from the 2000s into the 2010s, it seems like, particularly, your research in the Joint Center for Artificial Photosynthesis seems to be a major piece.

03-00:40:30
Bell: Yes.

03-00:40:31
Eardley-Pryor: That, again, is DOE funding, correct?

03-00:40:33
Bell: That's completely DOE-funded. And before the JCAP, there was SERC, it was called—Solar Energy Research Center—SERC, and I participated in that.

03-00:40:50
Eardley-Pryor: Where was that based at?

03-00:40:51
Bell: That was based here, at Lawrence Berkeley Lab. Paul Alivisatos had the insight to see that solar energy conversion and utilization was a coming thing, and he got a number of us organized, and we got a funded center. It was not as large as JCAP, which was—what was it, $50 million—no, $25 million at its inception—$25 million a year—this was more like $5 million, and only centered here, at Berkeley. And that lasted, I think, for about three years, and I got involved with that.

03-00:41:34
Eardley-Pryor: When?

03-00:41:37
Bell: When? Well, now we have to go back in time. So we're in 2018-'19, we're in the ninth year of JCAP, so that takes us back to 2010. This would have been around 2007, give or take a year.

03-00:42:03
Eardley-Pryor: Two thousand seven to 2010 range? In those three years?

03-00:42:04
Bell: Yes, 2007 to 2010. Because as soon as the DOE decided to fund the JCAP hub, of course they phased out the SERC funding—because we couldn't have two things running simultaneously with similar objectives.

03-00:42:20
Eardley-Pryor: Well, once we get into your work in electrocatalysis, we can dive a little bit more into how all of that evolved. That's great. Just also to help frame us with some of this work, in 1976, your personal career, you moved from associate professor to earning full professorship here. I'm wondering what that change did for you. Did it do anything?

03-00:42:42
Bell: Well, more than anything else, it freed me up from worrying about advancing up through these major life crises and transitions. And it freed me up intellectually, and it meant that okay, I'm here permanently. If I do good work, I'll advance in salary. Now I'm free to think about what it is I really want to do.

03-00:43:08
Eardley-Pryor: And this was in '76 that you went through the process?

03-00:43:10
Bell: Yes.

03-00:43:10
Eardley-Pryor: What was that process like? You talked before about the process of getting tenure the first time, but what about the process from associate to full? What does that look like here?

03-00:43:19
Bell: Well, in terms of what is required, it's more or less the same—outside letters, submission of your publications, a review by a departmental ad hoc committee, a review by the chair, the dean, the budget committee, an ad hoc committee of the university—the whole nine yards. It's the same process, actually.

03-00:43:43
Eardley-Pryor: It's extensive.

03-00:43:44
Bell: Yes, it's extensive. And Berkeley has one of the most extensive processes. And it's done at tenure time; associate to full; if people go above scale—above step ten, I think it is now—it's done. And even—there's a step in between, step six and above—because for many faculty, step six is kind of where they peak out.

03-00:44:08
Eardley-Pryor: Super-full professor.

03-00:44:10
Bell: Yes.

03-00:44:11
Eardley-Pryor: With the earning of full professorship, I'm wondering, did other job offers from other institutions ever arise?

03-00:44:19
Bell: No, actually, they didn't, and I never made myself available in the sense that—dropping hints that yes, I'd like to be flirted with. Because I was happy here; I didn't really want to go anywhere. The period right after I stopped being dean was the time where I had lots of search committees and search companies call me and said, would you like to come be a dean or a Vice Chancellor for Research or positions of that type at other universities.

03-00:44:53
Eardley-Pryor: Did you ever entertain those?

03-00:44:54
Bell: I entertained one, at Yale. And I went even for the interview trip, and was one of three finalists. And that was an interesting process.

03-00:45:06
Eardley-Pryor: Tell me about it.

03-00:45:07
Bell: Well, first of all, this is a private institution. It has a good chemical engineering department, but it's not in the top ten. But Yale is a very wealthy institution. One of the things that impressed me most is visiting their libraries. Each one is an architectural treasure in its own right, and the libraries are specialized. There are colleges there that have living arrangements and dining arrangements. So it's more like an English-style university. Very impressive. Very good people there. I had very nice interactions. But they chose someone else, which is fine. And I'm here.

03-00:45:52
Eardley-Pryor: Do you think you would have gone, had you been offered?

03-00:45:54
Bell: Probably not, if I evaluated everything.

03-00:45:58
Eardley-Pryor: Why is it that Berkeley is so important to you that you stayed?

03-00:46:03
Bell: So what has kept me here are the people. My colleagues, first of all, in this department—we always work as a team. There's very little political tension here. Good leadership has helped to maintain that sense of collegiality. Good colleagues in chemistry. And then you're embedded in a first-ranked university. That, plus the Bay Area, California as a whole. You know, why leave a good place?

03-00:46:38
Eardley-Pryor: Indeed. Another piece that's really fascinating with your work, and I think this will move us into your research on nitrous oxides that you had mentioned, is international collaborations. Regardless of the US government's relations,

could you talk about why you think international collaborations happen and why you pursue them?

03-00:46:59
Bell: So I think they're important because they build bridges between people, scientists in different countries. The two major collaborations I've had are with the Soviet Union-slash-Russia and, later, with China. I've not had long-standing collaborations with people in Europe; I've had some short-term collaborations—a very successful one with a professor in Germany. But the ones with Russia and with China have allowed me to present myself and learn about different cultures—in China, particularly, there's a very different culture—and also different political systems, and to establish a common language with these people. Now, over the decades, there are friendships that are established, and we see each other as international friends rather than as members of opposing countries.

03-00:48:04
Eardley-Pryor: We'll get into the Soviet Union-Russia connection, but the China relationships—when did those begin, and how?

03-00:48:12
Bell: So that one started in 1982. There was a thawing of relationships between China and the US. And a man named Kenzi Tamaru, in Japan, knowing about the tensions between Japan and China during the Second World War, he wanted to establish closer relationships between the scientific communities. And he thought it would be a good idea to extend this to the US, so he worked with Tsai Quiri, who was—a prominent professor in Xiamen University and Guo Xiexian of the Dalian Institute of Chemical Physics, and with Michel Boudart, who was at Stanford—to have a trilateral meeting. Each country got to choose its representatives, and so Michel asked me to be a part of the US team. And then, at the last moment, as we were getting ready to go—we were to fly to Hong Kong, the American delegation was to meet there and then go to Beijing—he—and I've forgotten the reason—he withdrew, did not participate, and, instead, he asked me to lead the team. So I said thank you, yes, I'll do that, and we met in Hong Kong and flew on. And I still have at home a copy of the photograph, where we're all lined up there in China for the group shoot.

03-00:49:49
And it was an eye-opener. First of all, Beijing—none of us had been there before, so that was very interesting. Then we went to Xiamen, which is in the south, and had the conference—no, we went to Xiamen and then we flew to Dalian, which is in the north, on the Bohai Sea, and we had the meeting in the hotel where Mao Zedong used to go to for summer vacations—because he could be at the seashore, where the climate is mild. It's a nice, old hotel, and we held the conference there. And the first day that I arrived, there was a tea in the evening. Each of the delegates from Japan and the US was assigned to a table, with lots of Chinese students and a few professors, and the tea was the

least of it. But everybody came with copies of our papers, heavily underlined, and prepared to ask questions. I was amazed, first of all, at how well read the Chinese graduate students were, and how good their English was—it was not too different from getting a Chinese immigrant here in California. We had a very, very lively discussion that evening. So this was the first day of a five-day meeting; the rest involved presentations, the talks, further meals together.

03-00:51:30

And this started a collaboration that lasted quite a few years. It involved—I think it's every second year, either we would travel to one of the three countries, and then we hosted the meetings here—I think it was in '85 or '86—I have forgotten the exact year—that I hosted one of the meetings here—I think it was the second meeting, I hosted here at Berkeley. I used the dorm facilities in the law school to put everybody—it was the cheapest way to get a hotel room—and we had the meeting over in Latimer Hall—the technical meeting.

03-00:52:15

Eardley-Pryor: Tell me about how you structured these collaborations, these interactions. Were they by topic? Were they by similar research problems?

03-00:52:24

Bell: They were largely by a set of topics that were of interest to all three sides. And then the Chinese government arranged to send people over. And some of these people were fairly senior; they were faculty members. So I had two—a woman from Nanking University and that was followed by the former chair of the chemistry department at Fudan University in Shanghai, Gao Ze.

03-00:52:53

Eardley-Pryor: Do you remember who this was?

03-00:52:55

Bell: Let's see. Gao Ze was the woman from Fudan. And now I have to reconstruct the name of the woman from Nanking. That's not coming back to me right away. Ah yes, Yan Qiji.

03-00:53:11

Eardley-Pryor: Would this focus on catalysis research, or was it—

03-00:53:13

Bell: We were all focused on catalysis, yes. That was the only requirement. But they could do anything. And these two women were sponsored by the Chinese government, so the only burden to me was the cost of the research work. And that worked out very well. And then we saw each other subsequently when we traveled to China.

03-00:53:34

Eardley-Pryor: What were the topics that you worked on together?

03-00:53:37
Bell: One of the topics was using molybdenum nitride, which at the time was of interest to me as a substitute for platinum—so molybdenum is a relatively inexpensive metal; nitride has properties that are similar to platinum. And there was kind of a fad at the time to look at carbides of tungsten and molybdenum and nitrides to use for hydrocarbon processing. Now, unfortunately, even though Exxon Mobil got into the act, you can never make these things as stable and keep them alive long enough to take advantage of them, so that interest in industry died.

03-00:54:21
Eardley-Pryor: Did the Chinese take it up in a different way?

03-00:54:23
Bell: No, not really. They eventually turned to other things. The Chinese have been very clever in looking at the literature, and in the early days, doing the same thing—trying to do it as well; that was the first benchmark—and then in their industrial areas, they would go one better and develop technologies which, you could see, the origins were in European or US chemistry.

03-00:54:52
Eardley-Pryor: Can you think of an example?

03-00:54:54
Bell: So an example is their processes that they use today to make polyolefins, or ethylene and propylene principally. They start with coal, because they have that there; they gasify the coal, make synthesis gas; then convert that with known technology to make methanol; and then the methanol is converted to olefins and water. The Chinese like this because it uses an indigenous raw material—they don't have to pay for imported petroleum. And it allowed them to develop this technology, and I think they have now up to thirty-five of these plants. The technology for going from methanol to olefins was actually developed and patented by UOP [Universal Oil Products] here in the US, in Illinois, but it was not practical, and so UOP put it on the shelf. What the Chinese did is, fiddled with the catalyst composition, made it stable, made it operable under industrial conditions, and then designed and built plants.

03-00:54:54
Eardley-Pryor: So they did make it operable, they made it practical.

03-00:56:07
Bell: They made it operable, yes. And the man who led that team at the Dalian Institute of Chemical Physics, Professor [Zhongmin] Liu, is now the director of that institute in the subsequent years, and one of his most recent graduate student, Liang Qi, is arriving Wednesday, the twentieth, to become a postdoc with me for three years.

03-00:56:38
Eardley-Pryor: What kind of work do you think you'll pursue together?

03-00:56:39
Bell: We'll work together on zeolites, which are what they use for their methanol to olefins project, but we won't work on that aspect of the chemistry; we'll work on something else.

03-00:56:53
Eardley-Pryor: That's exciting. In the early days of this collaboration with China—you mentioned '82 through '85 being really the start of things—was it mostly one-way, the research relationship?

03-00:57:09
Bell: Yes, it was mostly the Chinese learning from us. Yes. They were really hard-working and well read, but they didn't have a lot of new things to offer us.

03-00:57:22
Eardley-Pryor: When did you think that transition happened?

03-00:57:22
Bell: Well, that probably happened more like the late nineties, 2000. And today, China is making huge investments in their universities, modernizing them. Everywhere you go, you see brand-new equipment—and sometimes, we Americans drool, because there's more equipment in one place than we would readily put our hands on. Increasingly, the utilization of this equipment is not routine, but to do clever things. So there are areas where we definitely want to see what's happening in China and keep our eyes open.

03-00:58:00
Eardley-Pryor: Aside from the olefins you mentioned, what else? Where are some of the other areas that you look to the Chinese?

03-00:58:06
Bell: Well, in electrocatalysis, which they've picked up also. Now, not all of it is innovative and taking us in the right direction, but there's certainly a lot of it, and there are some goodies to be picked over and used.

03-00:58:27
Eardley-Pryor: How long did you maintain leadership of the American side?

03-00:58:31
Bell: I maintained leadership of the trilateral meetings until I helped convert this into the—what is it called—Asian Pacific Catalysis Society [Asia-Pacific Association of Catalysis Societies]—APCAT]. And this happened because first Korea wanted to join in, and so we had them come as observers, but not full participants—Korea and then, let's see, who else? Taiwan. And eventually Australia wanted to get in on the game. After a while, it became clear that we shouldn't keep it as a trilateral meeting. And it was getting harder and harder to maintain the enthusiasm of the Americans to come to these things—because after the novelty has worn off, there had to be something else to motivate people to attend. While there was a little resistance on the Chinese side, especially by the older members—the founders from the Chinese side.

However, eventually, I convinced them that it was going to be in everybody's interest to open it up to the Asian Pacific rim.

03-00:59:40
Eardley-Pryor: How did you do that?

03-00:59:40
Bell: Talking. Just sitting down quietly and being persistent. David Trimm, who was from Sydney, at the time, University of Sydney, was the first president of that organization. So, in the long run, APCAT took over the trilateral meetings and it continues to this day. In fact, I'm going to Bangkok for the next meeting as an invited speaker.

03-01:00:13
Eardley-Pryor: When is that?

03-01:00:14
Bell: That's in August.

03-01:00:16
Eardley-Pryor: That sounds great. You mentioned that this was initially a trilateral relationship. What was the connection with the Japanese that you've seen?

03-01:00:23
Bell: Well, this really was Kenzi Tamaru's brainchild. He's now in his nineties; he was a distinguished professor in chemistry at the University of Tokyo at the time, and he was the leading person in catalysis in his country. And he had—rightfully so—bad feelings about what Japan had done to China during the Second World War and wanted to make amends. So the idea for the trilateral meetings was personally driven. I give him a lot of credit for that.

03-01:01:01
Eardley-Pryor: Did you have much relationship with the Japanese catalysis researchers?

03-01:01:05
Bell: I have had, going back to about the same period—the eighties. But somehow, the Japanese travel to the US fell off with time. You don't see as many Japanese at American Chemical Society meetings or American Institute of Chemical Engineers meetings. And I'd say that the leading people who I have known through most of my career, have retired at this point—they have to retire at sixty or sixty-five, depending on the university. So most of them are retired, and the younger generation isn't as interesting in catalysis as the Chinese are. The Chinese have taken over. And there are many more of them.

03-01:01:56
Eardley-Pryor: That's fascinating. Do you think for the Japanese, it's less looking towards the US for the model, and maybe they're going to attend Chinese conferences?

03-01:02:03
Bell: I have not traveled to Japan in a long while to know exactly what has happened.

03-01:02:12
Eardley-Pryor: Tell me, if you can, some of your impressions of being in China for that first time. This is the early 1980s; they've just recently made their transition to become more of a capitalist-communist system. What were your impressions of just being in the country?

03-01:02:27
Bell: Well, you definitely felt odd going out on the street.

03-01:02:30
Eardley-Pryor: What do you mean? Why?

03-01:02:32
Bell: In the sense that people were not dressed in Western clothes—mostly. And especially women. And as a Westerner, you were a curiosity. Everybody would come around you and look at you and want to touch you [laughter] and see if you're real.

03-01:02:51
Eardley-Pryor: Really?

03-01:02:51
Bell: Yes, yes. And then driving out of Beijing, you could see occasional camels pulling carts. Certainly, donkeys. The rural countryside was nothing like the city, and the city didn't look like a modern Asian city as it does today.

03-01:03:11
Eardley-Pryor: What did it look like?

03-01:03:14
Bell: It looked like a very rural Asian area: small huts, lots of dirt streets, villages. People would dry their tea by the roadside because of the wind of the trucks going by—that was really odd. You'd see also women squatting down selling tea—you know, with a little balance on a stick. What was clear was that food was becoming available. If you'd go in the markets, there was an abundance of stuff—of every variety—vegetables, seafood, and so forth. So, yes, it was interesting.

03-01:04:04
Eardley-Pryor: I think that's fascinating to think about how has that changed since? Because you've continued visiting China over the years.

03-01:04:08
Bell: Yes, I've continued visiting, and now I go more frequently. Well, now the cities have become ultra-modern—and in fact you might say in some areas, they're more modern than our cities because everything is recently built. The Beijing airport is a fantastic place—very efficient, very effective. I think

they're even building something newer, or are going to build something newer, soon. The rail system works very well—high-speed rail works very well. Internal flights are on time—very modern—well, they're mostly US airplanes—Boeings—so they're very comfortable. The Chinese people are very hospitable—at least the ones I deal with—the university and industry people. So I feel very much at home, even though I don't speak a word of Chinese.

03-01:05:07
Eardley-Pryor: Have you been able to pinpoint a time where you saw that shift, from these rural, underdeveloped even urban centers to this ultra-modern society?

03-01:05:18
Bell: It's been gradual. I wasn't there for many years to watch the whole transition, but I think that's been gradual, and I'd say largely maybe the late nineties, 2000 and onwards—the last twenty years, thirty years—

03-01:05:33
Eardley-Pryor: Where you could see a difference?

03-01:05:34
Bell: Yes, where you could definitely see a difference. Yes.

03-01:05:37
Eardley-Pryor: Would that correlate, as well, with the changes in Chinese knowledge and offerings in catalysis?

03-01:05:47
Bell: Well, first of all, it correlates, I think, more with the freeing up of the Chinese society to be a capitalist economy in a communist political system, because that drove everybody's entrepreneurship and willingness to take risks, if you could make money—and certainly many people have made lots of money. The government recognition that science and technology were going to help the economy led the government to put money into institutes and, more recently, universities—that was the sequence in which it went.

03-01:06:32
Eardley-Pryor: One of the things I've heard talked about for American versus Chinese styles of doing science, is that the American model is more of that independent identity that America likes to think of itself as.

03-01:06:44
Bell: Very much so.

03-01:06:45
Eardley-Pryor: Whereas the Chinese, the stereotype I've heard used is the, perhaps, Confucian influence, but the more hierarchical structure, where you don't challenge a person in a point of authority. Would you say that that's about right?

03-01:06:59
Bell: Yes, that's about right. And it's changing slowly, but it is right. Certainly, the very first time I came and I would give a lecture, afterwards my host would ask if there were any questions, and there would be deadly silence—until one of the professors asked a question, and then students would eventually get the courage to ask a question. Now, thirty-plus years later, that's not the issue at all. Everybody feels free to pepper you with questions when you're finished. And the knowledge of spoken English is fairly good; otherwise, the questions wouldn't be there. So that's a big transition.

03-01:07:44
Now, if you ask, how are the research groups run, within the university, and even within institutes, there's a top person who's the section leader or the lab leader; there are what I would call associate professor-level people associated with that individual; and then there are junior people further down. So there's a clear pecking order. Let me give you an illustration One of the things I did for the Chinese Academy of Sciences, was to lead an international team of 23 scholar to do a review of the whole Dalian Institute of Chemical Physics (DICP). We spent three days in Dalian looking at all aspects of their activities. One of the things I did was to go to a young professor's office in order to learn what he was doing. And I would ask, "Why do you do that?" You know, because I wanted to hear the motivation. He said, "Well, professor X, who's my boss, my supervisor, suggested that these would be good themes to work on." And I said, "Well, that's nice. But what if you don't agree with professor X, or that these are exactly the themes that you want to work on?" And he said, "It won't contribute to my career." So it was clearly—you know, the pass-down of thoughts of what to do, rather than encouraging younger colleagues to think—within the context of their program—to think creatively on their own. My more recent visits show that this approach is changing, but it is happening very slowly. Cultural norms and expectations are well embedded and change extremely slowly.

03-01:09:26
Eardley-Pryor: How did your observation of that shape the way that you completed your review?

03-01:09:33
Bell: Well, we pointed this out in the review.

03-01:09:35
Eardley-Pryor: You did?

03-01:09:35
Bell: Yes. And the review was very candid. At the end of the three-day period, I had to give an oral report to the vice president for the Chinese Academy of Sciences, Jinghai Li. He is a chemical engineer and I got to know him relatively well because he was on my editorial board as an editor for *Chemical Engineering Science* when I was the editor-in-chief. During my oral summary, I was very candid about what the group had found.

03-01:10:17
Eardley-Pryor: How did he take it?

03-01:10:18
Bell: Oh, he took it extremely well. Yes. And one of the things I emphasized was the over-involvement with the scientific index and citation ratings. Everybody would tell you what their personal rating was and what journals they were publishing in, and the whole committee felt that this was overdone.

03-01:10:36
Eardley-Pryor: Why? Why do you think it was overdone?

03-01:10:41
Bell: The Chinese put so much emphasis on it because their salaries are connected to it.

03-01:10:49
Eardley-Pryor: I assume that you think that's not great for the science. Why do you think that's the case?

03-01:10:54
Bell: The background is that the Chinese, when they wanted to raise the level of their science, encouraged people to publish their work in the most competitive journals. Okay, so there's some logic to that—that means that your work has to be good enough for the journal. But then to make it go more so, there were bonuses to your salary for every article published in *Nature*—in a *Nature* journal, or *Science*, or so forth. So, as you might imagine, the reward system drove behavior. Unfortunately, the behavior is now risen to the point where there is a kind of formulaic ways to get a paper in. As a reviewer, I see this in some of the papers I get. And it's somewhat annoying, because, in many cases, the quality of science isn't there, but the style is very aggressive—references to first time demonstration, unique results, fantastic performance—and aimed at selling the results. In my opinion this is not helpful for the advancement of science.

03-01:12:05
I think Jinghai Li recognized this already then, six years ago, and said it was unfortunate, but it was something that had caught on and was very hard to shake out.

03-01:12:21
Eardley-Pryor: Yeah, a new cultural change that needs to happen now.

03-01:12:24
Bell: Right.

03-01:12:26
Eardley-Pryor: With these international collaborations, which are just remarkable, I'm wondering if you can talk a little bit about the role of politics in doing science? There's, especially now amidst the [Donald J.] Trump administration,

the idea that science is somehow apolitical, that we can think about science as being a nonpolitical process and activity, and I wonder what your thoughts are about that. Is science something that goes beyond politics, or are politics embedded in science?

03-01:12:58
Bell: Well, it's hard to escape politics, because if you go to the question of what's funded, that's a political decision as much as it is a scientific decision. How should science be done? It should be done apolitically.

03-01:13:16
Eardley-Pryor: Can it be done apolitically?

03-01:13:18
Bell: Yes, if you have funding to do the work. [laughter] In that sense, once you have the funding, there's nothing political pulling on you—other than the politics of science, in some respects, but not the politics of public policy or government. So you do the science with the idea that you want to have the greatest clarity. Now, sometimes creating new clarity challenges old perceptions, and that has to be broken down. That's one of the hardest things you do in science, is getting people to let go of the previously perceived notion of how things work—as it does in any cultural change, in any respect. Politics also enters into the attitudes towards people doing science and engineering.

03-01:14:17
Eardley-Pryor: Tell me what you mean by that—or give me an example.

03-01:14:21
Bell: They are viewed as elitists who are only interested in their own thing, or are they viewed as people who are well educated and are trying to solve problems of need to society? Those would be the extremes, right? And how much respect is given to somebody when he or she says they're a scientist?

03-01:14:48
Eardley-Pryor: Or even the role of "he" versus "she" as a scientist. I imagine that politics are wrapped in that.

03-01:14:52
Bell: Well, there's that—the gender politics—but I'm going to leave that aside. In the US today, it depends very much who you're speaking with. Around Berkeley, I'd say you'd be more likely than not to be respected; if you go out into the farm country in Iowa, you may not be so well respected.

03-01:15:15
Eardley-Pryor: Have you had those experiences yourself?

03-01:15:18
Bell: No, not really. I explain what I do to people on an airplane, occasionally, if they ask, and I do it in such a way that we get through that subject fairly

quickly because I don't want to be peppered for three hours or five hours with questions. But no, I've not had personal negative experiences. However, the present federal administration is clearly skeptical about scientists and, I would say, has the view that scientists is defend their own interests and not the perceived public interests.

03-01:16:00
Eardley-Pryor: From what I'm hearing you say, politics are embedded in the practice of science. But I also heard you say that science could be apolitical. How could you do apolitical science?

03-01:16:12
Bell: How could you do? Well, it's hard.

03-01:16:14
Eardley-Pryor: Or can you?

03-01:16:15
Bell: Oh, can you? Okay.

03-01:16:15
Eardley-Pryor: I'm really struggling to think that you can.

03-01:16:17
Bell: So, okay. There's another level of politics, which is within the system. At any given time, there are certain themes that are fashionable; certain ways of looking at things that are fashionable. If you support them, that helped to sustain the fashion; if you're pushing against them or showing that they're wrong, you don't accept the kind words of the people who are supporting the alternative. I think that's human and part of being, living in a society. So how do you do apolitical science in that context?

03-01:17:00
Eardley-Pryor: Can you?

03-01:17:01
Bell: Well, you can, only if you're, first of all, conscious of what the politics are, and the societal context within which you do your science. You have to be unafraid of the consequences of who thinks what about your science if you do X or Y or Z—so you have to have that personal sense of confidence and freedom to go and say what you think.

03-01:17:34
Eardley-Pryor: Before we dive into what became your collaborations with Soviet scientists around a topic that, in the seventies, became increasingly interested in by politicians but [also by] the public in general—the nitrous oxide reduction—let's take a little break before we dive into that work.

03-01:17:50
Bell: Okay, good.

[Break in recording]

03-01:17:53
Eardley-Pryor: So, Alex, in the mid-1970s, you began a new wing of your research on nitrogen oxides, or NO_x, and the reduction of these. Can you talk about how that work began?

03-01:18:06
Bell: Yes. That began at a time when there was increasing concern about nitric oxide emissions in urban centers—principally in California and Los Angeles, but also here in the Bay Area. So nitric oxides, as emitted from automobiles, are NO, nitric oxide, and once that gets in the atmosphere, it makes NO_2, nitrogen dioxide, and that product will interact with hydrocarbons to make partially oxidizes hydrocarbons and nitrates, and this makes what is called PAN, which is a molecule which is very harmful to the eyes—causes the eyes to sting—and it creates smog, the brown stuff that you see in the sky, and not great to breathe. So as California became more and more involved in this, it became clear that something has to be done, and the best way to handle this problem is to reduce the nitric oxides to nitrogen and oxygen, or nitrogen and carbon dioxide, CO_2, by using the unburned fuel in the exhaust of an automobile.

03-01:19:22
So, research at Ford Motor Company and GM started more or less at this time, and the federal government started putting in money to this research, as well. We got involved in this area, because it's a nice way to start looking at catalysis with very simple molecules. My first work was done on reacting with NO with carbon monoxide, which is another product of combustion, and that will make N_2 and CO_2—very simple products. Together with a number of graduate students at that time, we started asking, can we understand what is adsorbed on the catalyst, by doing in situ—meaning under operating conditions—infrared spectroscopy, and then looking at the kinetics—the rates at which these products are formed—and asking, what can we learn about the mechanism, the steps by which reactants are converted to products? And this turned out very well, because you could use simple transition metals as catalysts—principally, rhodium, palladium, sometimes platinum—and make very good scientific studies out of this.

03-01:20:48
And my principal contribution to this area was using in situ infrared spectroscopy. We were one of the earlier adopters of this technology, and we built our own cells for maintaining a catalyst in an environment that is doing the reduction—and analyzing the infrared spectra, as well as seeing the emissions and cataloguing how effective the catalyst was.

03-01:21:16
Eardley-Pryor: Well, this is great. Let's unpack all of that, because there's a ton in there. First off, who's "we"?

03-01:21:22
Bell: Who's "we"?

03-01:21:23
Eardley-Pryor: Yeah, you said "we" were able to begin this work.

03-01:21:25
Bell: Okay, so the graduate students who were working with me at the time—and I do have to consult some notes here—so one of the first ones was a man named D'Arcy Lorimer; he's probably the second or third of my graduate students. Another one was Jack [W.] London, who later went on and studied blood flow in the heart at the University of Pennsylvania.

03-01:21:54
Eardley-Pryor: That's an interesting transition.

03-01:21:56
Bell: Yes. It had nothing to do—but it was an opportunity, and he went back to the East Coast, where he's from. Bill [William C.] Hecker, who ended up being—a professor at Brigham Young University. Nutan [K.] Pande, who left here and went to DuPont. Artie [Arthur A.] Chin, who worked on aspects of this and ended up at Exxon Mobil. And then I had a couple of Russian postdocs, one of whom stands out is Anatoli [A.] Davydov, from the Boreskov Institute of Catalysis.

03-01:22:34
Eardley-Pryor: Great. We'll get into those collaborations as this unfolds. This group that you put together, or eventually came together, that you just listed—where did you get your first waves of funding?

03-01:22:47
Bell: Well, I believe the first wave of funding was actually from the National Science Foundation for this work.

03-01:22:53
Eardley-Pryor: And you had already started work on catalysis, and this just seemed like, "This is an opportunity?" What made you leap into this area?

03-01:23:01
Bell: Oh, it was clear that automotive converters were going to be implemented eventually in automobiles—in fact, in '72, they were, the first implementation—and that this was a timely area for involvement. Molecules are simple, so you can understand the chemistry more readily than if you had to work with very complex systems.

03-01:23:27
Eardley-Pryor: My understanding was that the US car market, by '75, required a two-way catalytic converter.

03-01:23:32
Bell: That's right.

03-01:23:33
Eardley-Pryor: But it wasn't until 1981 for the requirement to make it the three-way [catalytic converter] that includes this nitrous oxide reduction.

03-01:23:37
Bell: That's right, yes. So, two-way is that you can combust any hydrocarbons and carbon monoxide to CO_2 and water; three-way means that you were converting the NO as well as the other two pollutants. And the trick is to get all three of them down to meet the federal and state requirements.

03-01:24:00
Eardley-Pryor: And to do all of those things in one device.

03-01:24:02
Bell: And do it all in one device, yes.

03-01:24:04
Eardley-Pryor: That's an impressive feat. So the money came from the NSF. I'm thinking about, where on campus? You had told me before, your first lab was not in Gilman Hall but over in Lewis Hall.

03-01:24:15
Bell: It was in Lewis Hall.

03-01:24:16
Eardley-Pryor: Is that where you were continuing to do your work?

03-01:24:17
Bell: Yes, this is where we started our work on catalysis. And we continued doing the work on this, and also on other work I'll talk about on Fischer-Tropsch synthesis, until Bob [Robert G.] Bergman came from Caltech [California Institute of Technology], and he needed laboratories, and that whole suite of laboratories that I was a part of were renovated.

03-01:24:41
Eardley-Pryor: And where did you go from there?

03-01:24:42
Bell: And so then I was moved to—let's see, it's the basement of Hildebrand Hall. And I had labs there for quite a while.

03-01:24:53
Eardley-Pryor: When did that transition happen, when renovations forced you into Hildebrand?

03-01:24:58
Bell: Let's see—let me think. It would have been, I think, the early eighties that I moved to Hildebrand Hall. I had two labs side-by-side there. And that worked fine.

03-01:25:11
Eardley-Pryor: What was the layout like? If you could describe the space for me—just what was the experience of being there?

03-01:25:14
Bell: In the new labs?

03-01:25:16
Eardley-Pryor: Mm-hmm.

03-01:25:16
Bell: Well, first of all, it was air conditioned, so in the summertime you didn't bake from the Western sun—because Lewis Hall had not been renovated since its construction in the late forties. It had more modern hoods, which is good. It was also designed for work with hydrogen from people from Giauque Hall, and so it had a slightly canted ceiling, so the hydrogen would all go towards a vent in case there was a leak and be vented before it could catch fire. So we took advantage of that.

03-01:25:57
Eardley-Pryor: How so?

03-01:25:58
Bell: Well, we took advantage of the fact that if you had a leak of CO or NO and you had a very good ventilation system, it would clear out of the room.

03-01:26:10
Eardley-Pryor: Did you notice, as the transition to this new space happened, was there a transition that happened in your research that you were doing around that time, as well?

03-01:26:17
Bell: Not really. That was also a time when I was getting more and more involved in catalysis and less and less in the original research in plasma chemistry. In fact, by the time we moved there—this would have been the early eighties—we had more or less stopped doing the plasma chemistry, which was largely done in Lewis Hall.

03-01:26:38
Eardley-Pryor: One of the things we talked about at the beginning of this session was your research philosophy, and you had told me that sunsetting aspects of your work is a part of your philosophy.

03-01:26:48
Bell: That's right.

03-01:26:49
Eardley-Pryor: Tell me a little bit about that. Why do you sunset things purposefully—as you did, perhaps, with the plasma work?

03-01:26:56
Bell: So there are two aspects to this. One is that after working in an area for ten years or more, you feel that you've made most of the contributions that you can think of making. You also ask, are there opportunities to do other things on this topic if there are new tools available? And sometimes I'll continue working in an area if new tools or new ways of looking at the problem become available. But then the other driver is that new opportunities to do new things come along, and these seem exciting, and I like to try new things. So rather than continuing to polish the doorknob to a higher and higher gloss, I like to open new doors. And this means that with a finite set of resources and abilities of my own, I have to switch. And I do this roughly on the time scale of every six years—maybe take 20 percent of my work and phase that out and start something new.

03-01:28:04
Eardley-Pryor: How did you develop that—every six years or so?

03-01:28:07
Bell: It's just innate to my nature that I don't want to go stale—even if I'm very good at something. And I find that I'm most creative when I'm entering into a new area. It's easiest to motivate students and get them excited and get myself excited at the same time, and together we break new ground.

03-01:28:31
Eardley-Pryor: With the research on NO_x that you were doing in the seventies, you just said that in situ infrared spectroscopy was a new tool that you were able to apply to this. Tell me about how you used this instrument, how did you obtain it—how did this come onto your radar?

03-01:28:49
Bell: So, two things were instrumental. One is getting the funding for the spectrometer. And this came by chance. In fact, one of the reasons I got into catalysis is that one of my colleagues, Gene [Eugene E.] Petersen, who together with two other colleagues had had money from an EPA grant, which was ending, told me that they had money set aside for yet another fourth person who had left the department, and they could give it to me—$15,000—if I did something in the area of catalysis. So I took that money and bought a spectrometer.

03-01:29:28
Eardley-Pryor: That's where the tool came from?

03-01:29:30
Bell: That's the first tool.

03-01:29:31
Eardley-Pryor: That's where the instrument came from.

03-01:29:31
Bell: Yes. Otherwise, I wouldn't have had the money. And I used that instrument both to study the epoxidation of ethylene, which was the very first study, and subsequently the nitric oxide reduction. So, that gave me the instrument. The cells were not commercially available, so using ideas taken from both the American and the Russian [scientific] literature, we designed our cells and had them built in the machine shop. And that was a good experience for us. In fact, subsequently, we published the design as a paper so others could use it, and it was picked up and widely used.

03-01:30:20
And these were little cells that you could put in the palm of your hand, made of stainless steel, that had a very thin area where you could put a wafer. What you did is, you took silica or alumina as the support, put your precious metal on it, and then put this powder into a press and pressed down with hundreds to a thousand PSI—pounds per square inch—of pressure, and then you got a little self-sustaining wafer that's a fraction of a millimeter thick. And you handled this thing very carefully, because they were brittle. And you mounted it in the cell, and then you could put an infrared beam right through the center of the thing. And then the cell had windows of calcium chloride or sodium chloride—that's more water-sensitive—and they're infrared transparent, so you could peer through this thing while it's being heated to several hundred degrees C. We used a gas chromatograph to analyze the gas products—a device that separates the mixture into individual components and then detects each one.

03-01:31:30
And so we built these cells ourselves by trial and error, getting all of the bits and pieces right, and went to work.

03-01:31:40
Eardley-Pryor: So that's how you were able to do the in situ piece of it?

03-01:31:41
Bell: This is how we did the in situ work, yes.

03-01:31:44
Eardley-Pryor: I didn't know that the gas chromatograph also played a role. So this is not just IR, but also—

03-01:31:49
Bell: So gas chromatographs had just come into being commercially available when I finished graduate school—so that would have been '67. Late sixties, they became commercially available. And the art of separating things was the packing in the column—it's a powder that you have to put. And there wasn't a lot of experience in separating NO and its various cousins from each other—there was more experience in separating hydrocarbons and this kind of thing for the oil industry. So we had to play around with what was available commercially, packing the columns—which we did ourselves by taking a

piece of stainless steel tubing, going to the stairwell, and putting the powder through a tiny funnel into the thing and tapping this ten-foot column down on the stairs to make sure it packed right, and then you would coil it up carefully and then put it into the machine.

03-01:32:55
Eardley-Pryor: I love hearing how tactile and physical the process is.

03-01:32:59
Bell: Right. So that was one of the things we did. The other thing we did, because of the era in which we were doing it, was how you collected the data. So in that period, what was typical is that you had a recorder with a pen that drew the results on a piece of paper that was constantly moving under the pen. Well, when you're finished, how do you quantify? Take this paper, cut it off, and you put it down, and you either cut out the paper and weighed it for each peak—and then you looked at the distribution and you knew how to associate the weight of that piece of paper with a certain concentration—or you used a device called a planimeter, which goes back to Thomas Jefferson—invention—of tracing out the perimeter, and there's a little set of wheels on the side that calculates the area from the trace—but that's also very tedious.

03-01:34:02

So about the time we were doing this, the first analog-to-digital (A-to-D) converters came out. So D'Arcy Lorimer, one of my graduate students, was a whiz at electronics. He bought A-to-D converter, wired it up with a little power supply, and we took a digital output. Now, where do you put that? Because you don't have personal computers. So we put it to a Teletype. And the Teletype churned out a thin, pink paper tape, which spewed onto the floor, with the data.

So now the question is, you have the data; how do you read the data? So you cut off the paper tape; you carefully remembered which end was the front and which was back; you went to another Teletype reader which was connected up to the College of Chemistry computer—there was one in the whole college—and you read the paper tape back in. That was written onto a big Winchester disk, which was about this big around, and digitally stored on a magnetic medium, and read it into a computer.

03-01:35:16

Now, that's fine, but you have to have a program that interprets all of the data. So I developed, with my students, a little algorithm for looking at the data, detecting when the derivative goes up faster than the background noise—and that's the start of the peak—and then then there are ways of calculating the area. And then you do the same thing at the back end of the peak, and you record where it turns around—the second derivative. And so we put out our own digital mapping of the data and integration of the data. A few years later, you could buy these things commercially. We beat them—never commercialized it, but we used it internally.

03-01:36:01
Eardley-Pryor: Had you ever done any work like that before—programming?

03-01:36:04
Bell: No. [Well,] I had done programming using Fortran programming in graduate school, but I was not a whiz at that. What I do is, I'm very able to capitalize on the abilities of other people when I know what I want to do. So my graduate student had more ability in programming than I did, and so he did all of that.

03-01:36:27
Eardley-Pryor: That's a fascinating process, and for just this one aspect of your research.

03-01:36:32
Bell: Yes, yes. When there's something we want to do and you can't buy it or borrow it, you have to do it yourself. And we've done this many times. And it's a good learning process for everybody.

03-01:36:48
Eardley-Pryor: While you were doing this work on the nitrogen oxides—the NO_x—how were you choosing which noble metals you were going to be exploring the catalysis with?

03-01:36:58
Bell: So this is partly from reading the literature—you knew that the metal had to be chosen so that it would adsorb both the NO and the CO—so there was enough known about that from the physical chemical literature. Then you want the NO to actually fall apart into its component parts—into nitrogen atoms and oxygen atoms. The oxygen atoms react with the CO to make CO_2, and the nitrogen atoms either find each other and make N_2 or, less desired, they find another NO and they make N_2O, which is nitrous oxide. Why is that not so good? Because nitrous oxide is also a greenhouse gas, and it's what we call laughing gas, used by the dentists—or it was. And so part of this game was to figure out which processes occur, and how do you steer it towards making nitrogen.

03-01:38:00
Eardley-Pryor: But choosing which of these metals to do our experiments on—how did you go about figuring out what—

03-01:38:07
Bell: Well, it's a small subset of metals which would meet the bill of adsorbing both—the late transition metals, as they're called. So there's platinum, rhodium, palladium, ruthenium.

03-01:38:19
Eardley-Pryor: So you knew that those were the only ones you really could work with, so—

03-01:38:21
Bell: Yes, right. And we looked at all of them. And then you're asking, well, which one gives you the right set of products at the end?

03-01:38:30
Eardley-Pryor: I have a note from a report in the early eighties that you also had encouraging results with something called titania as a promoter for rhodium.

03-01:38:41
Bell: Yes, titania is used as a promoter, but not so much in this context as it is for CO hydrogenation, where also you need to break the carbon-oxygen bond in that case. But that's tougher to do, and so you need a promoter to facilitate. We'll talk about that.

03-01:39:00
Eardley-Pryor: I see. But the NO_x don't necessarily need the promoters.

03-01:39:01
Bell: But not for NO_x, no.

03-01:39:04
Eardley-Pryor: So eventually this work, in addition to sending all of these students onto their postdoctoral careers, also led to some fascinating international collaborations. Can you tell me about how this developed, and what they were?

03-01:39:18
Bell: Yes. So in the early—I think it was '72, [Richard M.] Nixon decided to open up relations with the Soviet Union. And it was decided that science would be a politically neutral—or more or less neutral—area to do this in. And so the National Science Foundation, from the American side, was given the mandate to set this up—the Soviet Academy of Sciences, from the Soviet side. John [D.] Baldeschwieler, who was at Caltech at the time in chemistry, was the leader from the American side. Georgii Konstantinovich Boreskov, who was the director of the Boreskov Institute of Catalysis, was the leader from the Soviet side.

03-01:40:08
Eardley-Pryor: Where was that based at?

03-01:40:09
Bell: That's right outside of Novosibirsk. Novosibirsk is exactly halfway across the country, in the middle of Siberia. And the institute is located in a city called Akademgorodok, which means "little academy town," thirty kilometers outside of the center of Novosibirsk, which is a big metropolis.

03-01:40:33
Eardley-Pryor: Can you tell me a little bit about the background, the history, of this catalysis town?

03-01:40:37
Bell: Yes. Akademgorodok was founded after World War II—actually, it grew up in the early fifties, for the following reason—and why there. During World War II, the Germans had bombed and destroyed most of Soviet industrial capacity, which was on the European side—close, not far from Germany. And

so the Russians—the Soviets—literally dismantled factories and plants for building tanks and cannon and aircraft, and they transported them across the Urals by rail and set them up in Siberia, knowing it was too far away for the Germans to get over there—and in the middle of winter, they're not going to get there anyway. And so they rebuilt all their capacity there, and then used it very effectively to close out the war. So that was why that region was chosen. And subsequently, then, a decision was made to set up a series of what eventually became twenty-five academy institutes and a university in that same town. It was put outside of the city to give it some independence. In a very nice location. I've been there many times. And so that's where the institute [Boreskov Institute of Catalysis] was located.

03-01:42:08

So Baldeschwieler and Boreskov got together, and they decided that then the theme for the collaboration would be catalysis.

03-01:42:18

Eardley-Pryor: Why do you think they chose that then?

03-01:42:21

Bell: Well, Boreskov was the head of the Institute of Catalysis, so it made sense. And he suggested that the two parties—the two sides—work on automotive emissions reduction, because this was completely apolitical—it didn't have to do with the making of jet fuel or anything like that which had military implications. So this was the setup. There was one visit before the one I went on which I think happened in '72—the inaugural visit. I was not part of that.

03-01:42:55

And then I was contacted by a guy named Vladimir Haensel, who was the vice president for research at UOP [Universal Oil Products] in Des Plaines. And the background there is not obvious, but he was born in Moscow. His father was a professor of economics. So he grew up in Russia, and lived there after the revolution. And then at one point, his father arranged to take the family—the son and the wife—out of the country and have a European vacation. And the father knew he was taking the family out for good, but he didn't tell anybody. So everything was left behind. They emigrated, and then eventually, Val resettled in the US. And he went to work for Universal Oil Products—he had studied at Northwestern University—and rose to become a vice president, very prominent. So he was a natural person to select, because he was a native Russian speaker. And so he invited me to join him and a man named Joe [Joseph W.] Hightower, from Rice University in Texas.

03-01:42:55

So the three of us went over to Moscow, did a little sightseeing in Moscow, and then flew to Novosibirsk, were received by Boreskov himself. And we had dinner at his cottage—and between courses in dinner, played badminton in his backyard. And then Boreskov says, "So what's the program for the next day?"—you know, towards the end of the evening, and we had had quite a bit to drink during the evening. And Val said, "Why don't the two young men," Hightower and I, "give a talk?" And he said, "Of course, Alex will give his talk in Russian"—which I had never done in my life. So each of us went back to the hotel, and I sweated the night out figuring out what I'm going to talk about. Well, I had a copy of an article with me on epoxidation, which we talked about earlier, and I knew it was a topic of interest to the Soviets, but I had no slides. "No problem," they said. "We'll photograph the graphics and make the slides for you by tomorrow morning." Okay, but now I don't know the terminology. So I sat there—you know, no computer to look up words—sat there struggling with how I'm going to explain this. And the next day, I gave a forty-five-minute talk in Russian. I was drenched in sweat by the time I finished, but I got it across. And it was clearly understood, because I was peppered with questions afterwards. So that was my first exposure to doing a talk in Russian, and first visit to the institute.

03-01:46:12
Eardley-Pryor: That's so wild. So how did you even—you and Hightower—how did you get this connection with the gentleman at [UOP]?

03-01:46:19
Bell: He knew both of us. He was the one who connected us. I didn't know Hightower well. I knew his name.

03-01:46:24
Eardley-Pryor: Well, how did that relationship happen for you, then? How did you know the person that was at UOP [Vladimir Haensel]?

03-01:46:32
Bell: Well, I didn't know him either. He had heard about me, and he knew that I was a Russian speaker. Because that wasn't generally known in the community. And this was my first contact with him. So it was great. We had a great time together. And he had a wonderful sense of humor. On the way back, we stopped to visit Red Square, and we were walking around speaking English, and a group of schoolgirls surrounded us, saying, "You speak English?" And they had notebooks. And I said yes. So we chatted with them. And then Haensel turned to them and started speaking Russian, and I did, too. And by the time the little girls left, he turns to Hightower, with his usual sense of humor, and he says, "Joe, how come you don't understand what they're talking about? Even the children here speak Russian."

03-01:47:26
Eardley-Pryor: That's great. So Dr. Hightower didn't know Russian?

03-01:47:28
Bell: No, no.

03-01:47:30
Eardley-Pryor: He just knew catalysis?

03-01:47:31
Bell: Yes, he knew catalysis. Yes.

03-01:47:33
Eardley-Pryor: Tell me about your first experience of what it was like going to the Soviet Union. This was your first trip in, correct?

03-01:47:39
Bell: It was my first trip in. Of course, growing up in a Russian household, I knew a lot from my mother, who had lived in Moscow, and whose father and grandfather owned personal property in the middle of Moscow, in the Arbat region. So I went in a day in advance of the other two to go find my mother's house. And in New York City, where I stopped before I flew over, you couldn't buy a map of Moscow. So I knew the address, but you couldn't buy a map of Moscow. So a relative of my mother's xeroxed an 1890s map of Moscow from a book he had, and he showed me where the house was. And he said, "Well, it's likely that in the old part of the city, the names of the streets haven't changed, so if you can get yourself oriented, you'll find the place." So I had that. And on the way in, we flew to Vienna, and in Vienna, I actually was able to buy a map of Moscow. So between the old one and the new one, I figured it out and went on my own.

03-01:48:58
Eardley-Pryor: What was it like being there? You had heard these stories as a kid, but Moscow was very different, I imagine.

03-01:49:03
Bell: A very different place in 1974. No foreign cars—only the local production.

03-01:49:16
Eardley-Pryor: Little Skodas going around?

03-01:49:18
Bell: Yes. Uh-huh. And some Czech cars. People were very suspicious. I got around because I could read the street signs and I can speak and ask for directions, so I wasn't intimidated. But it's a very different place from New York or San Francisco or the Bay Area.

03-01:49:39
Eardley-Pryor: In what ways?

03-01:49:40
Bell: Well, much less in the shops. A much more drab-looking place. It didn't look at all the way Moscow does today, which is a very modern, European city, in the center. I went to Red Square on my own the first time and looked around and—

03-01:50:06
Eardley-Pryor: What were your impressions?

03-01:50:07
Bell: Well, it was like, Wow, this is what I've been hearing all my young life about. And I'd always wanted to go, and this was the first opportunity, so I was really excited about this.

03-01:50:20
Eardley-Pryor: Was it a challenge to get in there?

03-01:50:22
Bell: No. Because it was an official visit, I could get a visa. And I remember, I submitted the paperwork to the consulate here in San Francisco, and then I had to go over for an interview. And the consul general came out and interviewed me, and he said, "So, why are you going?" I said, "Well, you have it there. I'm invited by the Soviet government for a scientific exchange." And he said, "Is this your first time?" And I said yes. This interview was going on in Russian. And he said, "How come you speak Russian so well?" So I told him about my parents. And he asked whether I had any living relatives over there. I said no. And so I didn't know where this conversation was going, but at the end of the interview, he said, "Fine. We'll give you the visa. And give my regards to Moscow." So that was my introduction to the whole visa process.

03-01:51:19
Eardley-Pryor: What was it like getting around once you were there? Did you have trouble going as an individual, as a foreigner? Were there people following you?

03-01:51:28
Bell: No, no, no. I stayed at the Metropol Hotel, and, you know, just walked out the door. I didn't have a guide or somebody from Intourist. I didn't need one, or want one. So I did two days on my own, then. And then the other folks came in, and immediately we had people from the institutes in Moscow as our guides and friends, and we spent some time doing that. And then we flew over to Novosibirsk and spent, I think, three days there, and then flew back.

03-01:52:03
Eardley-Pryor: What was the feeling of seeing your family's old property—if you discovered where it was using these two maps?

03-01:52:08
Bell: Oh, it was an immense sense of pride and connecting to things. An uncle of mine who lived in Paris had been over on business—a technical show. He was in the area of digital electronics—telephone communications—and so he led a French group over there. And he found the building himself, and he introduced himself to the current owners and even took them on a guided tour of the interior.

03-01:52:42
Eardley-Pryor: Because he remembered being there?

03-01:52:42
Bell: Yes, he remembered where he lived and where his room was, my mother's room. Everything had changed, but he could remember the building. And he said that was quite a trip for him. I couldn't do this. In fact, on several occasions, my wife and I tried to get inside, and people wouldn't let us. So I've only seen the exterior and the hallway. So anyway, it was quite an experience going over there the first time. And I loved it, because you're surrounded by people speaking the language, and that felt comfortable.

03-01:53:20
Eardley-Pryor: What was the feeling of being in a planned society versus California capitalism that you had come from?

03-01:53:27
Bell: Well, it's quite different. The first thing that impressed me—if you go into any store, it wouldn't be like going into a Lucky's or a supermarket here in the US, where you went with your cart and you put everything in and you went to the cashier. You went into a typical store, where they had different products. You lined up for the deli, and you got a chit; you had to go pay for that quantity. Then, you returned with a stamp on the chit, and you gave it, and you got your product. Okay, now you put it in a bag that everybody carried around with them. Then you went to the cheese counter, and then you went to the bread counter. And everything was handled separately, and you had to pay for each item separately. Very inefficient. So that's one thing that struck you.

03-01:54:27

The other thing is, if you went to a restaurant—which I did on, not on that occasion, but a subsequent one, with a fellow from Yale—and you tried to see if they have a free table, the immediate answer was no. But if you provide a little money, the answer was yes. So that's different from the US.

When we went out to the institute, one thing that struck us was that chemicals that you could order from Aldrich or any other chemical house in the US were not readily available; only certain things were available from Soviet sources. And so Soviet scientists were extremely clever in making what they needed from scratch, in the old-fashioned way—and purifying it. Very slow, tedious, donkey-work, but they were good at it. Hardware like chromatographs were built at the institute. The first computers were built at the Atomic Energy Institute, which was nearby. And they were big, clunky things, but they worked. And then clever people hooked them up for digital data acquisition. And so forth. So it was clearly decades behind in terms of hardware. But people still did good work, because they were clever.

03-01:56:00
Eardley-Pryor: Tell me more about the experience of actually being at the institute. You flew out to Siberia, in the middle of the country. What was the flight experience like?

03-01:56:09
Bell: So the flight experience was normal until near the end. We're coming in in daytime, and we're coming down, and all of the sudden the airplane takes a sudden dip and moves towards the runway. We never knew what exactly was going on, but we had this sense that the pilot was over the airport but not quite lined up with the runway coming down, and when he broke through the clouds he could see the runway—he said, "Whoops! I have to make a slight maneuver over here." So we got off the plane and we're looking at it, and it was an old—I think it was a Tupolev 125 or something like that. And you walked towards the front in the plane and you notice the nose isn't completely covered—it looks like it's a bombardier's port—it has glass on the bottom part of it. So we figured these were dual-purpose aircraft—they could be repurposed for bombing runs if you weren't going to be flying for Aeroflot.

03-01:57:15
Eardley-Pryor: Wow. The experience of being on the ground at the institute—how was that different from Moscow? I mean, here you are at this very science-oriented space.

03-01:57:24
Bell: Well, okay. So Akademgorodok then, and even now, is a small town—I don't know what the population is—and it's in the middle of a birch forest. So that's the first thing that strikes you. And everywhere you look there are birches. And it's fairly level.

03-01:57:42
Eardley-Pryor: And you were there in the summertime, I'm assuming—or at least not winter?

03-01:57:44
Bell: Let's see—yes, we were in the summertime. Yes. And it's quite green. Nearby, within walking distance, about a mile away, is what's called the Ob Sea, but it's actually a dammed up river which is used to make hydroelectricity—and I think, at the time, was the world's largest man-made lake—of freshwater. So that's impressive. And it's used in the summertime to go swimming and have picnics and so forth—boating. The institute itself is a kind of drab-looking set of brick buildings. And I have photographs from that original time, and I have contemporary photographs, and the main building is the same. Inside, it's been renovated somewhat. And you go inside, and you have to pass—there's a turnstile and you have to show your pass—otherwise, the women who's sitting there doesn't let you through. Very officious, in that respect. And then on the inside, there's a wide—much wider than necessary—staircase that goes up on both sides and up to the second floor. And this is something like out of the nineteenth century or earlier twentieth century in terms of architecture and styling—nothing like what you would expect. Wooden floors everywhere, some of which were well worn and creaky. Laboratories that have still wooden hoods—which, of course, are flammable.

03-01:59:28
Eardley-Pryor: And if I remember right, you had wooden hoods initially in your Lewis Hall lab?

03-01:59:30
Bell: Yes, I had wooden hoods here. So, yes, right. Which were an original installation in Lewis Hall, from the mid-forties. So this is contemporaneous construction. And equipment which is all clearly handmade and built on-site—they had good machinists and clever people. But nothing—no equivalent of Varian equipment or Beckman spectrometers. Lots of glassware. People had lots of equipment made of glass, and many people knew how to blow glass themselves—which was true here, too, of most of the chemists when I came. That's a lost art now.

03-02:00:13
Eardley-Pryor: What were the things you were most excited to learn from your Russian colleagues?

03-02:00:20
Bell: Not so much science. I didn't learn any new science when I was there. I was excited to see what they were able to do that I would consider good science with how little was available. And it made me appreciate and recognize how resourceful they were. They wanted to do science, they were dedicated to it, and they did whatever was necessary.

And this harks back to a little bit later, when I had a fellow named [Vladimir L.] Kuznitsov, who was also from that institute—he was here as a postdoc for a year. And my graduate students used to tease him about being so ardently socialist—it was still before the collapse of the Soviet Union. And he had a good sense of humor. And he was a good cartoonist. He put up a cartoon by where he sat, by his desk, which showed a Soviet rocket on a wagon being pulled by a horse, and underneath he wrote in English—it said, "Crude, but effective." [laughter] And that catches the spirit.

03-02:01:33
Eardley-Pryor: That's great. Tell me about some of the research. You've mentioned this in the context of your work on NO_x, but the talk you gave was more about your plasma work?

03-02:01:47
Bell: No, the talk I gave was about ethylene epoxidation, it's called—it's the oxidation of ethylene to make ethylene epoxide.

03-02:01:56
Eardley-Pryor: Oh, this is the work you did with Mitchel Shen?

03-02:01:58
Bell: No, no, no.

03-02:01:59
Eardley-Pryor: Oh, different?

03-02:01:59
Bell: This is work that I did with Ed Force originally, my graduate student. That was one of the first things we did in catalysis. And since they knew about it and I knew that groups there in Russia had worked on it, I chose that as the subject for the talk.

03-02:02:17
Eardley-Pryor: I see. But you went under the guise of doing work on nitrogen oxides, correct?

03-02:02:23
Bell: Well, yes, that became the theme, but at that point it was not yet declared the theme. This was still in the getting-to-know-you phase.

03-02:02:35
Eardley-Pryor: I see. Do you remember what Dr. Hightower presented on?

03-02:02:39
Bell: I don't.

03-02:02:40
Eardley-Pryor: You were probably just too worried about your own presentation!

03-02:02:41
Bell: Yes, I was so worried about my own presentation. I don't remember what he talked about.

03-02:02:47
Eardley-Pryor: How did those collaborations evolve over time? Where did they go?

03-02:02:51
Bell: So we had to write proposals as to what we wanted to do. The NSF funded—gave us money. We then hooked up with people in the Soviet Union who came over as postdocs, and we paid them from the grant. And there were a small number of people who came from the US and went over there. So I had one—actually, I think she did initially her work with me, and then she went over there for a year. And that was an eye-opener for her, because she's an American from UCLA [University of California Los Angeles] and knew no Russian. And she found it hard.

03-02:03:35
Eardley-Pryor: Do you remember her name?

03-02:03:36
Bell: No, I'd have to reconstruct it now. It's too long ago.

03-02:03:39
Eardley-Pryor: We can add it in later. What did she have to say about her experiences in the Soviet Union?

03-02:03:44
Bell: Well, she was a good soul. She didn't complain when she was there. She liked the food. She liked the people. Everybody likes the people, I have to say, because the Russians are very outgoing and friendly, and invited these American postdocs to their homes. So that worked very well. And there was only one person who didn't enjoy her experience—a woman named Kathy [Kathleen C.] Taylor, and she was from General Motors—at that time, a young member of the General Motors research staff. When she went over, she expected, I think, more deference than she was given, and that made her miffed. And the Soviets weren't particularly happy with that. And so the director used to refer to her as "the unfortunate Miss Taylor." [laughter] She didn't quite get into the spirit of things, you know? But if people did, they were very well treated.

03-02:04:51
Eardley-Pryor: What were the experiences for the Russians who—the Soviets, even—who came here and you worked with?

03-02:04:55
Bell: Coming here? Well, it was an eye-opener for them, too, because this was the first time outside of the Soviet Union for each one of them.

03-02:05:02
Eardley-Pryor: What did they have to say about being here?

03-02:05:05
Bell: Well, they liked the fact that everybody was open here, too, and friendly to them. They liked the fact that anything you wanted to do in science was essentially possible—you didn't have to make your chemical reagents on your own, and you could buy a cylinder of gas or premixed gases and have them delivered within a week. All of that was very nice. What they didn't like was the absence of any support staff. The Soviet Union, much like Europe, had groups. The group had its own technicians and its own specialists who would come and repair equipment if it didn't work, or glassblowers who would build you something. We don't have that here. We have—and have had—our own glass shops, machine shops, electronics shop. You would go there, but then you're in a queue to get things done.

03-02:06:04
Eardley-Pryor: As opposed to having one specifically for your work?

03-02:06:05
Bell: For your group, yes—dedicated to your group, knowing your equipment. Yes. And that's still true, and it's one of the maybe downsides of the American system, that each faculty member is on their own bottom.

03-02:06:21
Eardley-Pryor: Could you see similarities—or differences, perhaps—in Soviet science versus American science?

03-02:06:30
Bell: In the end, no. In the way in which things are presented and talked about, yes, significant differences. There was not the kind of sharpness and clarity that you have in scientific presentations in English. And I think this is partly the nature of the language—English, for a variety of reasons, is very concise in its descriptions of things, and precise. And probably this comes out British tradition, scientific tradition, of when you write something up, you don't waste a lot of words and dance around the subject. This is not so true in Soviet writing of that time—there was more embellishment and working up to the topic. And so sometimes I would read papers and I wasn't quite clear where things were going—or I'd have to read the page two or three times.

03-02:07:35
Eardley-Pryor: But has that changed over time?

03-02:07:36
Bell: Yes, it's gotten much more similar to our style.

03-02:07:39
Eardley-Pryor: Taken more of the American style, the English style?

03-02:07:40
Bell: Yes. The other thing that was noticeable is that all the figures and tables were either typed on a typewriter or hand-drawn, and then photographed with a thirty-five millimeter camera and then developed more or less—some were not so good in developing black-and-white photographs—and so the stuff was hard to read. Even if they had typed words in English, it was still hard to read. And the presentations were, for the large part, kind of sloppy—not concise, not to the point. And a lot of argumentation between the presenter and the people in the audience in the midst of the presentation—so sometimes somebody would say, "I don't think this is right"—you know, get up and start arguing with the presenter and not let him finish his presentation. So that's very awkward.

03-02:08:41
Eardley-Pryor: You have developed the skill set throughout your career to the point where you can give technical lectures in Russian now, as these collaborations have continued over the decades. I'm wondering if you mediate your presentations when you speak in Russian to whatever their style happens to be. Is it more artistic, in a sense—there's more of a build-up, there's more of talking around? Have you taken on, when you do presentations in Russian, that style?

03-02:09:09
Bell: No, no. I stick to an American style. And I can get my points across more clearly this way. And it's well suited to the slides I have—I'm not making special slides for giving a talk in Russian. And in fact, I've been complimented on the fact that everything is very well organized, very clear. They can follow the theme from the beginning to the end. And I know that I got my point across, because I get very good questions.

03-02:09:43
Eardley-Pryor: Why do you think that the Russian language itself lends itself to more of this sort of superfluous or superficial—maybe that's not the right word—more of the roundabout way of getting at a topic?

03-02:09:56
Bell: That's an interesting question. I think it has to do partly with Russian culture and literary style. Science comes into Russia not so late—it's with [Mikhail] Lomonosov in, what is it, the middle of the eighteenth century? He was a self-taught chemist and the founder of Moscow State University. So it's there from the 1700s onwards. But largely it started to play more and more of a role in the late nineteenth century, twentieth century. Now, how do people speak? I think this is reflective of the culture—what's the style. And if nothing is driving it to change, well, it won't change. And if you reflect on that, the French are more like the Russians in that respect—a lot of flowery language, and I like to say that the French enjoy listening to themselves as much as communicating something to you. I think Brits and Americans have a more businesslike approach—you know, let's get to the point.

03-02:11:19
So a difference that you would also see is, if you go to a Soviet—or even today to a Russian—institute, you're greeted by the director, who has you come into his office and sit you down. He'll tell his young lady, "Bring us some tea and some biscuits." If you're better known, he'll ask for some cognac, and you'll have cognac with your tea and biscuits before you get down to business. Now, this also has a—part of it is an Oriental style. So Russia is only partially Western; the other influence is coming from the East. And so there's a lot of Eastern traditions that are so well integrated and blended that you don't see where one takes off and the other one takes over. And I think that's part of it also.

03-02:12:18
Eardley-Pryor: Earlier you had mentioned collaborations—when speaking about international collaborations—with the Chinese, and the Russians here, as you've talked about. You mentioned one person in Germany. I didn't follow up on that then. Who was that person?

03-02:12:31
Bell: Oh, Fred Keil—[Frerich J.] Keil.

03-02:12:35
Eardley-Pryor: What kind of work did you do together?

03-02:12:36
Bell: He does theoretical work. He was educated as a physicist. He's now recently retired—maybe three or four years ago—retired from University of Hamburg. And he was a physicist, worked in industry—chemical industry—I don't quite recall how he did that—and then he got into the university, but he got into the chemical engineering department. And he's good friends with my colleague

John [M.] Prausnitz, who's originally from Germany. So they get together. And this guy has taken his physics background and turned it to chemical kinetics, to transport phenomena in porous media, and so forth. And so John was the one who introduced us to each other, on one of Fred's trips to the US. We hit it off immediately. At that time, both of us were working on the simulation of diffusion and reaction in zeolites. Our joint efforts began with Fred sending a couple of his graduate students to work with me. Each one of them did a year of their three-year graduate work working with me. And we published together quite a few papers—maybe half a dozen papers. That was very good, but eventually Fred retired, so he didn't have graduate students to send me anymore.

03-02:14:06
Eardley-Pryor: When I had the chance to speak with John Prausnitz in preparation for speaking with you, Alex, he had mentioned one of the advantages that you have is that you can read not just what's in the English literature and understand what the topics of interest are in there, but you can also read the Russian literature of science. How much did those components—especially early, before there as easy translations—how much did that influence your work?

03-02:14:33
Bell: Well, other than the very beginning work, not at all, to be honest. The beginning work, I may have told you, was doing these translations from the Russian literature for—

03-02:14:44
Eardley-Pryor: For Bill Koch.

03-02:14:45
Bell: Yes, Bill Koch.

03-02:14:45
Eardley-Pryor: You did tell that story, yes.

03-02:14:47
Bell: And that piqued my interest in spectroscopy. But really, I didn't draw that much from the Russian—or Soviet—literature. And now, actually, there's very little of it available—not available; it's all available—but of interest, and what good work is being done there is published in the US journals. So I don't need to read it.

03-02:15:15
Eardley-Pryor: Going back to the work on nitrogen oxide reduction for car catalysis, you had mentioned that at some point a person named Mordecai Shelef at an ACS—an American Chemical Society meeting—challenged you over some of your research findings. Can you tell that story? When was this?

03-02:15:36
Bell: Oh, yes. This encounter was at an American Chemical Society, and I now would have to reconstruct exactly when, but it was early in my career. There was a controversy that Shelef was a part of. A Hungarian man named [Frigyes] Solymosi was the other one, and they were always arguing back and forth about the formation of something called an isocyanate. So an isocyanate has a metal at the bottom, nitrogen, carbon, and oxygen, and it is formed as a byproduct during the reduction of NO with CO—nitric oxide with carbon monoxide. We had observed it, too, and we were assigning a certain band to it. And Shelef, who is originally from Israel worked for Ford—very good scientist at Ford in this area—couldn't keep his seat and popped up—and he was sitting in the first row—popped up and started peppering me with questions during my talk.

03-02:16:45
Eardley-Pryor: Like he was a Russian. [laughter]

03-02:16:47
Bell: Yes, right. Well, the Israelis have a similar style, [laughter] and very confrontational. And I didn't take very well to this, because he was interrupting my talk. I didn't think it was very courteous. And I wasn't about to be buffaloed by him, even though he was considerably older than I was. So we argued about what was going on. Eventually, I started to—as I do with all such situations—started to give a litany of experimental proof that I have. And eventually, he sat down and left me alone. But there was a moment where I could tell the audience was wondering, which way is this going to go?

03-02:17:30
Eardley-Pryor: Wow. What were you thinking in that moment?

03-02:17:33
Bell: Well, I was thinking that he's trying to embarrass me—consciously—or show off that I don't know anything and he's the expert. I've been in these situations before, and I don't like to be pushed around. So politely, I countered with the facts. That seemed to win the day, and he left me alone after that. Actually, we ended up subsequently at various meetings, and we came to respect each other. He's now retired.

03-02:18:07
Eardley-Pryor: Let's take a little break here before we move into our next research topic.

03-02:18:10
Bell: Okay, fine.

[Break in recording]

03-02:18:13
Eardley-Pryor: All right, Alex. So tell me, how did you transition out of the work on NO_x? How did this work sunset for you?

03-02:18:21
Bell: So part of it was realizing that I had done what I thought was interesting with the tools that I had available. The work did continue. There were some good people at GM who continued this kind of work, until GM phased that part of their research out. And even today, you'll find people in the academic world working on the subject, but I don't think the research is exciting any more.

03-02:18:55
Eardley-Pryor: At what point did you realize that—where you just said, "I'm done with it?"

03-02:18:58
Bell: Well, you look at what is being published by others, and you ask yourself, what more can I contribute with things that I have available? And there wasn't very much. I'd say maybe the one new theme that has been picked up is the effects of hydrogen on promoting nitric oxide decomposition by hydrogen attacking the nitrogen end and facilitating the dropping off of the oxygen—but then there has to be hydrogen present in the stream for that to happen. So I let that eventually fade and got involved in other things.

03-02:19:40
Eardley-Pryor: I'm trying to just put a time frame on things. When do you think you started shifting away from the NO_x work?

03-02:19:46
Bell: Oh, gosh. I'd have to look at my publications, but I think this happened somewhere in the eighties probably.

03-02:19:54
Eardley-Pryor: Did any of that have to do with transitions in funding? The seventies is such an environmental decade, and the eighties often—the Reagan revolution puts a stop to a lot of that.

03-02:20:01
Bell: Yes. I think it also had to do with the fact that in the mid-seventies and onwards, a lot of funding became available for alternative energy, and I felt that that was a more up-and-coming theme. Nitric oxide was always going to be important. The last part of the nitric oxide work we did was on reactions of ammonia with NO. And this is specific to something called SCR—selective catalytic reduction. On the back end of every power plant making electricity is a unit that is as big as a barn—literally—into which is fed small amounts of ammonia that reacts with the NO to form nitrogen. And this is so that the NO formed in the power plant in the combustion of coal or natural gas doesn't get out into the atmosphere.

03-02:21:01
And the reason we did this work had another Berkeley connection. There was a fellow here named Louie [L. Louis] Hegedus, and he started his graduate work a few years after I started my career here, even though he's older than I am. He was a Hungarian refugee and worked first in Germany for Daimler-Benz. Came over here for a year; he worked for Chevron. Charles [W.]

Tobias, who was the man who hired me, facilitated Louie's coming over to Berkeley. And Louie worked for a colleague of mine, Gene Petersen. We became friends because we were roughly the same age, both working late at night, and, you know, the same kind of sense of humor and spirit. He also helped me with the development of the technology for recording data from a gas chromatograph, and picked it up from me, as well.

03-02:22:05

So he went on to work on nitric oxide abatement at General Motors, his first position. And then he left General Motors and he went as a research administrator at W.R. Grace, on the East Coast. I became his consultant there. And one of the things that W.R. Grace was interested in was this SCR technology. This is what piqued my interest, and we had some support from W.R. Grace, so we pursued this effort for a while. But then that ended, as well, when Grace became less and less interested.

03-02:22:45
Eardley-Pryor: I don't know about W.R. Grace. What kind of work are they known for?

03-02:22:49
Bell: W.R. Grace was one of the big zeolite producers. They're also better known for their production of asbestos, which they did during World War II, and then they were sued for all this asbestos insulation they put around old Navy boats and buildings and so forth.

03-02:23:12
Eardley-Pryor: I see. Are zeolites involved in the process that you're talking about, on the back end of the energy plants?

03-02:23:18
Bell: No, no. There are no zeolites here. There are other kinds of supports—alumina supports.

03-02:23:24
Eardley-Pryor: It's essentially like a catalytic converter, but of massive scale?

03-02:23:27
Bell: Yes, on a massive scale. They have what are called monoliths. So these are brick-like structures that have channels—triangular channels—in them, and the air just whizzes through there. And you need a very large surface area, because you have huge amounts of air that you're treating. So I have a photograph somewhere in my slide collection of a person on the ground in front of one of these things that is literally as big as a barn.

03-02:23:53
Eardley-Pryor: Can you talk a little bit about the differences in research for a publicly funded effort—something like an NSF or DOE grant—versus working as a consultant for a privately funded research effort? What are the differences?

03-02:24:06
Bell: Yes, yes. So as a consultant, I consult on the technology that is needed by the company. I try to address the interests of the company that I'm working for, but I bring to bear all my scientific knowledge in doing so and making suggestions. What I really enjoy is sitting around the table with maybe half a dozen to a dozen people, brainstorming about what might be done and what should be pursued—for, you know, an hour or more—and then taking what you've put on the board in the way of Post-its or handwritten notes and prioritizing this into a research program. So I've found that where people are willing to engage in this type of exchange, it can be very fruitful.

03-02:24:56
Eardley-Pryor: What are the challenges of working for the privatized environment versus publicly funded?

03-02:25:01
Bell: Well, the challenges as a consultant are, first of all, understanding the technology and listening carefully to what people tell you are the problems they're facing. And then, having a way to latch onto that, take what you know, and give back. This takes a lot of careful listening and dialogue to get people to understand what you're telling them.

03-02:25:28
Eardley-Pryor: And that's different than, say, a publicly funded project? Because it sounds to me like they'd be both involved—

03-02:25:33
Bell: Well, okay. So if you're talking about a privately funded research program, that has a different aspect. So now the company comes and says, we have an interest in a certain area. I like to turn it around and say, yes, I understand the area; here's what I have to offer. And it will not be technology development; it will be development of science that enables the technology to work. Now, if a company is willing to buy that and fund me, well, we have a happy partnership. But I never will work on technology development.

03-02:26:08
Eardley-Pryor: Why?

03-02:26:09
Bell: Because I don't think that this is intellectually very stimulating. And that maybe is an arrogant thing to say, but—because the technology is needed—but it's not the best way to educate graduate students and postdocs.

03-02:26:25
Eardley-Pryor: That's a part of that difference you talked about earlier, of the academe versus industry.

03-02:26:31
Bell: Right. Yes.

03-02:26:32
Eardley-Pryor: As a way to set the stage for the next topic of research, I want to make mention of a College of Chemistry newsletter that I read—this is [the newsletter titled] *Dimensions*—and in December of 1984, there was a really nice write-up on the occasion of you winning the Paul H. Emmett Award, which you accepted in '85—in March of '85—for work in outstanding catalysis for people under the age of forty-five. And in 1984, there was a description of your research. I think it paints a nice picture for where you were at in '84, at least.

At the time, it said, you had fifteen graduate students in your research group, and you were doing a lot of work on hydrogenation of carbon monoxide to produce hydrocarbons and oxygenated products, which we'll discuss. Some of these studies emphasized reaction pathways and the influence of catalyst composition and structure on these elementary reactions that are shaping the distribution of these.

It also mentioned that you had started two new research projects at the Berkeley Lab's Center for Advanced Materials: one was identifying molecular species involved in the nucleation of zeolite synthesis, and then the second one that was mentioned was catalysis over transition metal compounds, especially carbides and nitrides. So that seems to me that some of the work that we will talk about was just really kind of forming in that early-to-mid-eighties period.

03-02:28:00
Bell: That's right. That's a very good statement.

03-02:28:03
Eardley-Pryor: But the work on hydrogenation of carbon monoxide is essentially some of the work that you had done that won you the Paul H. Emmett Award?

03-02:28:11
Bell: That's right, yes.

03-02:28:12
Eardley-Pryor: So let's talk a little bit about that work. From my understanding, the hydrogenation work that you're doing—of carbon monoxide and carbon dioxide into hydrocarbons—is essentially playing around with the Fischer-Tropsch synthesis.

03-02:28:27
Bell: Exactly.

03-02:28:28
Eardley-Pryor: Am I saying that right?

03-02:28:29
Bell: Fischer-Tropsch, yes.

03-02:28:30
Eardley-Pryor: Fischer-Tropsch synthesis—FTS. Can you tell me a little bit about what that is, and what your entry point was into it?

03-02:28:38
Bell: Sure. Fischer-Tropsch chemistry is not a new chemistry. It dates back to Germany in the post-World War I, before World War II period, where Fischer and Tropsch discovered that they could make hydrocarbons—synthetic petroleum—by reacting CO and hydrogen. And that product mix would be derived for them, in Germany, by gasifying coal, because Germany has a lot of coal. And Germany at the time did not have petroleum resources. In fact, this is one of the motivations for Hitler's regime going into the Caucasus in Russia and other parts of the world—Iran—where they might find petroleum. Anyway, so this was developed, and in fact used towards the end of World War II to provide fuel for the German army. The plants were dismantled; much of the technology was brought to the US. And Emmett, in fact, was one of the people who went over to Germany with the Army Corps of Engineers to dismantle the plants and interview the people who ran them and find out how this was all done, and brought it back to the States. And so in the US, there already was a tradition of investigating this area of chemistry.

03-02:30:15

The reason I got interested in it in the mid-seventies—so a decade before we were talking about—was that this was one of the ways that you can think of either taking US coal or other sources—maybe methane—and converting it into a liquid fuel. So if the Arab powers in the Middle East were not going to provide as much petroleum as we would like to have, we would use original sources—material here.

So I started work in this area, again, with the interest of understanding what is going on the surface of the catalyst. And this involved looking at the carbon monoxide, which has a very clear fingerprint. You could look at how strongly the CO was adsorbed. We thought that we could see the hydrocarbon whiskers growing off the catalyst surface because they would have a different fingerprint, which we were able to observe—and look at the dynamics of that. Then, along the way, I teamed up with Jeff Reimer, who is now our department chair, who is an expert in NMR spectroscopy, and we did C-13 NMR spectroscopy on these things, and could actually identify which carbon is attached to the metal, which one's above that, which one's above that, and then all the way to the end—because they all have somewhat different chemical shifts, which means they have fingerprints that you can identify.

03-02:31:56
Eardley-Pryor: So you were using iso—?

03-02:31:58
Bell: Isotopically labelled carbon monoxide.

03-02:32:01
Eardley-Pryor: Wow.

03-02:32:02
Bell: Yes. C-13.

03-02:32:03
Eardley-Pryor: Essentially, radiotracers.

03-02:32:05
Bell: It's not radioactive, but it is an isotype that is particularly sensitive for NMR. So rather than working with the small abundance of natural C-13, we enriched the material.

03-02:32:22
Eardley-Pryor: When did you and Jeff begin the NMR work together on this topic?

03-02:32:26
Bell: Oh, exactly when?

03-02:32:27
Eardley-Pryor: I'm just thinking time-wise—you began this work in the mid-seventies; when does Jeff join and when do you start collaborating?

03-02:32:33
Bell: Okay, yes. I think Jeff joined in—he was the first hire that I made when I was department chair, so that was '81 to '91. So that would have been the early eighties that we did this work, shortly after he arrived.

03-02:32:48
Eardley-Pryor: Oh, that's great. Was that part of your interest in bringing him into the department?

03-02:32:53
Bell: His expertise in NMR was one of the reasons, yes. And just very good references and overall abilities, yes. So, yes, we teamed up to do science together, and it was very fruitful. But that was one of several techniques. We used isotopic tracers, then, to also look at the dynamics of chain growth. Because one of the experiments we developed was an ability to switch from ordinary CO, which has a 12-carbon label, to a C-13 carbon-hydrogen mixture with the same composition, in situ. So you made a step function change in gas composition, but the catalyst didn't respond instantaneously. And the products took a number of minutes to respond.

And the way we looked at the products represents another example of having to find the technique that would do the job, because you couldn't buy it. We wanted to look at the fraction of the hydrocarbons that had C-13 labelling. Now, this is very hard to do if you use a mass spectrometer, because the electrons in the mass spectrometer crack each hydrocarbon into lots of little pieces, and what you see are the signatures of these pieces. And when you add carbon-13, for each carbon-13 you have, you'll have slightly one higher mass number than you would have had if it were carbon-12. So that makes it very hard to interpret.

03-02:34:32

So the idea that we developed here was to burn the hydrocarbons as they come out of a gas chromatograph and turn them into CO_2. So that now—you know, mass 44 for ordinary CO_2, mass 45 for the C-13-labeled CO_2—could follow just two masses. And looking at the ratio, you'd see the fraction of C-13 that was in that product—so the fractional isotopic labeling. And that changes with time.

03-02:35:13

So we set up an experiment where we would follow how things changed with time, in real time. And this required not only having a chromatograph, but then you had to have a combustor that did this very quickly. So we used a very fine capillary tube of glass, through which the graduate student had to thread a platinum wire—now, it turns out to be hard, because you can't get the platinum wire to be free of kinks, so all of the kinks had to be squished—and the wire very carefully threaded through capillary. And then we fed a stream of the gas from the chromatograph, plus a little stream of oxygen, through a T. And at the other end of the capillary was a mass spectrometer, which was rapidly switching between the two masses. This arrangement worked beautifully. And we used it carry out a series of experiments looking at the dynamics of how these hydrocarbons are produced. A postdoc in my group then worked out the dynamics and we used his results to get the rate coefficients for all the elementary processes.

03-02:36:35

So this was a really unique contribution, because it required analytical technology, and also a way to solve the mathematics.

03-02:36:43

Eardley-Pryor: And what came out of the realizations from it? What did you learn?

03-02:36:46

Bell: We learned how the rates of termination differ from the rates of propagation of the chain. This is very much a polymerization scheme, where you're adding a bead at a certain time, like polymerization, but you're also terminating the chains so they make stable products.

We also did a related experiment in which we looked at—so some of the products that you make are olefins—in fact, most of the products you make are olefins, which are unsaturated hydrocarbons. So you have a pair of carbon bonds with a double bond between them, rather than fully saturated with hydrogen. And the question we raised is, is it possible for the olefins to feed back and reincorporate into the growing chain? And the way we figured this out is, we took C-13-labeled CO and unlabeled ethylene, propylene, and butylene—so, C_2, C_3, C_4 olefins—and fed those in. And we could see distinct changes in the product distribution when you added the olefin. And you could tell how much was added, because it was not labeled—it was an inverse labeling experiment. So this worked out very nicely, too, and we published a series of papers on that subject.

03-02:38:15

So it's an example of inventing the technology to look at the products, and inventing the experimental protocol that gives an answer to the question you wanted to pose.

03-02:38:29

Eardley-Pryor: Why do you think the theoretical piece, that you had the postdoc contribute to—what did that add to the project?

03-02:38:35

Bell: So that allowed us to quantify everything. So very often, you get experimental results as a function of time or a function of change of some other variable, and you want to know, how does that relate to fundamental rate processes? And you can put together, in this case, a continuum rate expression, which we solved by Laplace transforms—that's a mathematical technique for solving the differential equations—got this in closed form, and then we could plot out how it should happen and adjusted the parameters in the solution to fit the data. So this is how it goes.

03-02:39:13

Eardley-Pryor: That's pretty fascinating work. The construction of the instruments, where you're putting these chromatographs on right after your mass spec and then putting in the last piece onto it—how did you do that on campus? Was that again working with the machine shops, glassblowers?

03-02:39:33

Bell: No, no, this was actually working with a graduate student. We knew the kinetics of combustion, so we figured out how long the glass tube had to be in order to completely combust this little bit of hydrocarbon – we put in an excess of oxygen to make sure it all combusted, and off we went.

03-02:39:56

Eardley-Pryor: That's great. I see that you began this work in the mid-to-late seventies, as you said, and then this evolved through the eighties. And from the nineties to the present day, you're still involved in this work. My understanding is that from the nineties forward, the pathways by which carbon monoxide and hydrogen are converted into what I see as homologous series of hydrocarbons. Why is the homologous nature important here, in this more recent work, from the nineties on?

03-02:40:30

Bell: Okay, so the fact that it forms a homologous series is not important. It is a consequence of the chemistry. Industry doesn't want to make a lot of very light products—methane, ethane, propane, butane—because they're gases; you can't blend them into gasoline. It doesn't want things heavier than maybe C_{15} or so—15 carbon atoms—because they forms waxes—good for fixing your skis if you're a cross-country skier, but not any other purpose. So what industry does is, it tries to fix the front end with promoters and the back end by clipping it—you can hydrocrack the waxy product in a separate process and fold it into the middle. This is how you make diesel fuel.

03-02:41:31
Eardley-Pryor: And so essentially, if I'm hearing you right, it's a form of recycling from the end product and just putting it back in?

03-02:41:36
Bell: Yes. You recycle the end product, blend it with the stuff—the hard cut—that is good, and now you have a synthetic diesel. So what you want to do is, put as much of the carbon into the heavier products. Because the things that are in the wax range you can cut; the things in the light range you can't use, other than for burning—or recycling to reform that to CO and hydrogen, but that's wasteful. So you use a promoter. And that led us into working with Somorjai, and then on our own, on promoter chemistry.

03-02:42:17
Eardley-Pryor: So you went back to working with Somorjai, then?

03-02:42:19
Bell: Actually, we worked with Somorjai in parallel at that time. And this is where the titania that you mentioned earlier came in. So in the early eighties, and for nearly a decade, I worked with Exxon (later ExxonMobil) as a consultant in this very area. And it was known that by either using titania as a support materials, which we eventually figured out were promoters, or putting it in as an intentional promoter, you could shift the product distribution in the desired direction. Now, this was all known empirically, meaning, you do the experiment, it works out the way you like, but no rhyme or reason as to why it is this way. And despite our efforts and the efforts of many other people, it was not known why this worked—only speculation.

So there was kind of a hiatus to our work in the late eighties to nineties on Fischer-Tropsch synthesis, because we kind of pretty much used up everything we knew how. In fact, at one of the DOE reviews, I was asked by a reviewer, "So what else can you learn that you haven't learned?" And I was a little pressed for things to say in response that was legitimate.

03-02:43:49

So we gave it up—retired that effort—and then in the mid-2000s, picked it up again, mainly because we now had some tools that would allow us to look at the effects of the promoter. And the tools had to do with state-of-the-art electron microscopy. So I'm not an electron microscopist, but together with a German postdoc, Sebastian Werner, and Greg [Gregory R.] Johnson, a graduate student, we took this up. They both had to learn how to do electron spectroscopy, so they read up on this. And we started writing proposals to the National Center on Electron Microscopy at LBNL. And after three tries, we got our proposal approved.

And so what they did is, put in a certain amount of promoter—manganese oxide, in this case, was the first one we did—and using a microscope which is a scanning transmission electron microscope—a STEM—that's equipped to look at the X-rays emitted by the electrons hitting the material, we could identify which elements we were looking at. Not only that, you can make a map of the elements, so you have an image—an elemental image. And the detector on this particular microscope had a very high resolution, so we could actually see the little spot of promoter and where it sits relative to the cobalt, which is the catalyst. And the question is, is it sitting over here on the side, and if so, how does it work? Or is it partially covering the cobalt? So the hypothesis had always been in the cartoons and the literature that it's partially covering the metal, but nobody had seen it. We were the first to see it, by using this advanced electron microscopy technique.

03-02:45:54

What's more, then we wanted to ask, how much of the cobalt is covered? Can we quantify that? And it turns out that that's not easy. So we had to develop what is called a correlation analysis of, where do manganese and cobalt coexist? And we did this by taking the image, which is digitized, and doing a pixel by pixel analysis. The pixels are color-coded—red and looking at the color intensity. It's not unlike doing image analysis on a video. Sebastian did this first, and then Greg, picked it up. They developed wonderful software for doing this, which was new for both of them. They had never done any software analysis on images before. And here is, again, the human touch. Sebastian's girlfriend, who later became his wife, was here in astronomy as a graduate student, and over dinner, she told him about how astrophysicists used to tell whether two stars are overlapping. He used exactly the same technology, but developed his own way of massaging the data.

03-02:47:20

In this way, we discovered that manganese oxides wets cobalt oxide very effectively; then you reduce the cobalt oxide to cobalt metal; the manganese goes from Mn_2O_3 to MnO, so it's partially reduced. We could tell this by doing X-ray analysis. And we could tell where things were sitting relative to each other. We then worked with other promoter oxides, like titania and zirconia, and discovered that they don't wet the cobalt, so you have to use a lot more of the stuff to get it where you want it. A lot of it is on the support doing nothing for you.

So this was kind of taking advantage of modern tools, being creative with developing software. The software ended up being freeware that the National

Center for Electron Microscopy now offers to anybody for image analysis. And that was great.

03-02:48:19
Eardley-Pryor: Wow. So you were able to then increase the efficiencies of the catalysis?

03-02:48:25
Bell: So we could tell, using now this new knowledge, how to increase the efficiency. And we discovered that a concept that I had developed with Somorjai—namely, that the Lewis acidity of the metal in the promoter was important—I had postulated this, and we kind of crudely showed that that was important; we could actually quantify that now with this new tool. And we showed that manganese oxide isn't the best Lewis acid—zirconia is better—but it wets the metal, and therefore you can get as much bang for your buck, but with a less effective promoter, but one that sits where you want it. So these are things that the industry didn't know.

03-02:49:12
Eardley-Pryor: And it took taking this fundamental-level approach to it?

03-02:49:14
Bell: Yes. Yes, right.

03-02:49:16
Eardley-Pryor: Talk to me about the decision to make the software publicly available, rather than try to spin it off into some sort of privately held licensure agreement.

03-02:49:23
Bell: Well, we published a paper describing what the software does. And since the software is not—we couldn't patent it, because it wasn't unique to us—we were adapting something from the open literature—we decided, we'll make it available for anybody at the center to use. So NCEM liked it, as a contribution to their capabilities. So, why not? We couldn't have made money off it, anyway.

03-02:49:58
Eardley-Pryor: The making-money piece seems to be—some scientists, especially since the 1980s, when that became more readily available to patent research and spin off side companies—that doesn't seem to be something that you have put much effort into.

03-02:50:14
Bell: I've never wanted to do that.

03-02:50:16
Eardley-Pryor: Why?

03-02:50:17
Bell: Well, because I know from looking at colleagues who have done it, that it's a tremendous diversion of time and effort. Either you say you want to become a

successful businessman, and then you give up what you're doing—you know, you leave university and go on to Microsoft or Google or whatever and devote your life to that—or you say, I like doing what I do, my craft, and being an educator, and you devote yourself to that. And I have to say that the university doesn't pay badly when you get up in the ranks, so I can't complain.

03-02:50:54
Eardley-Pryor: One of the things that came out of some of the work that I saw since the nineties was the realization about this secondary hydrogenation process—rather than a primary product—is where a number of alkanes are produced.

03-02:51:08
Bell: Right.

03-02:51:08
Eardley-Pryor: Can you tell me about that research, and what that realization was?

03-02:51:12
Bell: Yes. So the conventional thinking was that Fischer-Tropsch produced alkanes and olefins, and the proportion of each was a function of the composition of the metal. And that was quite reasonable, with what was available in the way of experimental data. And everybody quantified and interpreted their data this way. What we discovered, by changing what's called the space velocity—how fast the gas moves across the catalyst—is that the proportion of olefin and paraffin changed.

Now, it turns out that there are two things going on. The slower you pass the gas over it, the more the olefin has a chance to be hydrogenated and turn into a paraffin, or to reincorporate into the chain. And we saw evidence of both of these things happening. In fact, without the promoter, it's only the first—the olefins hydrogenates and goes to the paraffin. But the proportion of the material having the same number of carbon atoms stays the same, so the olefin and paraffins are just trading places. And we concluded that most of the paraffin comes from the olefin reabsorbing somewhere else—not where it was grown—and it's a secondary process. The other secondary process which happens when you have a promoter is the olefin gets reincorporated and it builds into the chain. So by choosing your experiments correctly, you can make these deductions.

03-02:53:08
Eardley-Pryor: So if I'm hearing this correctly, part of it was slowing the process down, and then also being able to observe what was happening during that.

03-02:53:14
Bell: Yes. Right, right.

03-02:53:18
Eardley-Pryor: That's a big realization, to be able to see that you can have these sort of secondary processes and save a bunch of money from your process.

03-02:53:24
Bell: Yes. Right. Yes, yes. And you can reshape your product distribution.

03-02:53:31
Eardley-Pryor: By moving it more slowly?

03-02:53:33
Bell: Well, you're not going to use that criterion to decide how fast you move it, because you want to use up all your CO—and that's really dictating. Then, if you can afford to take out the olefins and recycle them to the front end, you can do this chain-building. I've had a discussion with BASF recently—a big German manufacturer—about whether they want to do this. Now, for reasons that have nothing to do with the science, they thought it was too much trouble to do the recycle, so they haven't pursued it. But they do recognize that this is an option.

03-02:54:11
Eardley-Pryor: It could be done, it's just whether it's economically sensible?

03-02:54:12
Bell: It's economical to do, yes. And very often in industry, things that are technically feasible and may be the smartest thing to do aren't the ones that are done, because they're not economical.

03-02:54:24
Eardley-Pryor: Going back to the beginning of your work on hydrogenation towards hydrocarbons—the context, of course, is the energy crisis, which you've mentioned a number of times. But I haven't heard what your experience of the oil embargo was for you personally. What are your memories of that?

03-02:54:41
Bell: Oh, higher gas prices. Because I don't drive very far—I've never driven very far to get to work—I never experienced having to stay in a line for hours to get gas. I buy gas maybe once a month—that's the amount of driving I do. So personally, it didn't mean too much to me, other than the price of gas.

03-02:55:04
Eardley-Pryor: You just saw that, more than anything, it was more of a research opportunity?

03-02:55:07
Bell: Yes. Yes, yes. And it was, I have to say also, at a time when the effects on the climate of burning fossil energy was not evident. It might have been evident to some people, but it certainly wasn't part of the heart of what we do.

03-02:55:29
Eardley-Pryor: Yeah, I don't think even most scientists had any clue about global warming per se.

03-02:55:33
Bell: Yes, that's right.

03-02:55:33
Eardley-Pryor: When did that come onto your radar—climate change and global warming?

03-02:55:37
Bell: Oh, probably ten years—a little more than ten years ago, fifteen years ago.

03-02:55:43
Eardley-Pryor: What was the occasion?

03-02:55:46
Bell: Just doing general reading. Yes.

03-02:55:49
Eardley-Pryor: I'm thinking back in my head—the [Al] Gore documentary, *An Inconvenient Truth*, makes a big splash culturally in the US, and that's around 2006, 2007, and that sounds to me like around the time where you're—

03-02:56:00
Bell: It's about the time, yes. Twelve years ago. Right. Yes. There's a nice sequel called [*An Inconvenient Sequel*]—have you seen it?

03-02:56:08
Eardley-Pryor: I have, I have.

03-02:56:09
Bell: Yes, I have, too.

03-02:56:10
Eardley-Pryor: It's good. It's [Al Gore] saying, "Yeah, I was right the first time, and it's getting worse."

03-02:56:15
Bell: And it is getting worse. And there was just a piece in the *New York Times*, in the review of the week's news, just this Sunday, on this subject.

03-02:56:28
Eardley-Pryor: The funding for Fischer-Tropsch research certainly booms in the seventies, in the midst of this energy crisis. Can you talk to me a little bit about peaks and valleys in research funding on this topic?

03-02:56:39
Bell: Yes. So this topic, actually, because this has been around so long, has gone up and down several times. There was interest in it in, I think, the fifties, after the Second World War. Then that died. Then it came back in the mid-seventies. It's come back again as one is looking at alternative energy sources besides petroleum—except that don't talk to me about using coal to make this product, because that has even more of a CO_2 footprint. Now, the one place in the world that is doing this very aggressively is China, because China has huge coal reserves but does not have substantial reserves of petroleum. And so they have built Fischer-Tropsch plants for making liquids. They also have plants that roast their low-rank coal to drive off some volatiles that they can then re-

form. And then they use the so-called cleaned-up coal, which is higher rank, to gasify and make syngas and make methanol and Fischer-Tropsch synthesis material.

03-02:57:56
Eardley-Pryor: Now, is the reason the Chinese are able to do that have to do with their lower standards of environmental regulation?

03-02:58:02
Bell: That's an interesting question. So the first driver is the need to develop the Chinese economy—and that's a legitimate need—and raise the living standard of the whole country, which has risen dramatically. In the process of doing it, they've had a big CO_2 footprint, which has now well overtaken that of the US. So now we're the second biggest CO_2 generator. And I think China may be 50 percent or higher than we are. We've slowed down, actually, but they're still growing. But China now talks about being an environmentally responsible world partner, which is wonderful. And they're trying to wean themselves off of coal for electricity. However, it's a hard sell, because they've got a lot of coal, and it's cheap, and the cheapest way to make electricity, right? And you have something like four million miners—a noticeable part of the population—that you can't put out of work right away. Therefore, China is interested in nuclear energy as an alternative, solar, wind. Part of the problem with solar and wind is that the Chinese grid isn't flexible enough to deliver the power from the north, where it's generated, to the south, where it's needed. So it's an evolving story in China. But I have to give them credit for working on the problem nationally.

03-02:59:36
Eardley-Pryor: The peaks and valleys of the research in Fischer-Tropsch: what do you think is driving that in the American context? At least in your experience, where you got in in the peak, in the seventies, and you've seen it [change].

03-02:59:48
Bell: Right, right. So it goes up when people think that "Oh, there's an opportunity here"—you know, to fill in a need. And it goes down when either petroleum becomes cheap again—we can go back to doing what we were always doing, and we know how to do that well—or there's other political reasons.

03-03:00:10
Eardley-Pryor: So what I'm hearing you say is, the research funding is tied in a lot of ways to the cost of petroleum.

03-03:00:16
Bell: Yes. Yes. It's related. Not one to one, but it is related, yes. And then there was a period in the late eighties where the funding for catalysis research was starting to plateau and actually in real dollars go down.

03-03:00:35
Eardley-Pryor: Why was that happening then?

03-03:00:37
Bell: Well, the industry was laying off people and closing corporate labs. Exxon closed its corporate lab—well, they didn't close it; they shrunk it by a half. That's very significant. And other companies were not doing so much fundamental work anymore, trying to raise their profitability. So the Department of Energy came to the notion, well, they're not investing; why should we?

03-03:01:06
Eardley-Pryor: To me, it's almost, it would be an opposite reaction.

03-03:01:10
Bell: You would think.

03-03:01:11
Eardley-Pryor: If industry isn't relying on itself for fundamental research, it would lean on the university, so DOE would give more money for that.

03-03:01:16
Bell: Right. Yes, yes. Nobody's coming to us and saying, do more. So this was actually a time where, with Michel Boudart's encouragement, I took the initiative to write one of the first reports—we did this through the National Research Council [NRC]—on why the country needs research in catalysis. It's called *Catalysis Looks to the Future*. And it took me quite a while to get the NRC to agree to do the report, because they said, nobody is asking for this. The DOE isn't coming to us asking for this report. And we have to raise money to pay for staff and the publication and the committee work. So it took me the better part of three years to convince them that yes, we do need this report, and get NSF and DOE support—you know, bits and pieces. And we got this off the ground, and the report was published in '92.

It was a very interesting effort. Very good people participated in it. I sent copies to every congressman, at my own expense. And every senator, at my own expense. And the staff of the committees—House and Senate committees. And several of us who did the study went to Washington and gave presentations. And it had almost no effect. It was very disappointing. Except that the Chinese picked it up, translated it—and I have somewhere on my bookshelf a Chinese version of the report—and used it.

03-03:02:58
Eardley-Pryor: They invested in catalysis at that point?

03-03:02:59
Bell: Yes. And so did the Europeans.

03-03:03:02
Eardley-Pryor: Why do you think it didn't have the cachet in the United States that you hoped it would?

03-03:03:06
Bell: It didn't sound sexy and new, to be blunt.

03-03:03:10
Eardley-Pryor: What was, instead, the governmental focus in the early nineties?

03-03:03:13
Bell: Well, this was about the period where nanotechnology was starting to come. So everybody's looking for, how do we make something new through science and technology that will open up new job opportunities? Saying that you're going to create a new technology, new jobs, will sell. There's no doubt about it. But there are other drivers besides making lots of money.

03-03:03:42
Eardley-Pryor: And I'm also thinking, in the early nineties, the Cold War shift—the government's reducing its Cold War main focus, and that would include science funding in some ways.

03-03:03:51
Bell: Yes, that's right. Right. So this is where politics gets involved in shaping and directing what gets funded.

03-03:04:00
Eardley-Pryor: Well, take me back to this report, because that's a fascinating role that you played in trying to promote your field. How did you massage the National Research Council into finally agreeing to fund the creation of the report? How did you get that coalition together to make the report happen?

03-03:04:17
Bell: Well, it involved talking to some people at the NRC—I had already done some work with the NRC, so I had some people to talk to—and convincing them that this is important. Getting some key people like Boudart and others, senior people, more senior than I was, to talk about it. And eventually, we coaxed them into it.

03-03:04:41
Eardley-Pryor: What were the arguments that you made in that to say why catalysis needs to be promoted more?

03-03:04:48
Bell: What were our arguments? Our arguments were that look, the modern economy depends on fuel, chemicals, pharmaceuticals—and air quality protection at that time was the big thing. And you can trace the ability to do each of these four things to catalysts. If you didn't have the catalyst, you wouldn't have the products. You wouldn't have the clean air—the automobile converter was the prime example. And that future societies will require this to keep going, and to be better off. And we're far from squeezing the optimal selectivity out of a catalyst. Activity is adequate, but selectivity means I'm making the desired product and not making byproducts and wasting my reactant. So, more science devoted to that would help.

03-03:05:49

And one of the pushbacks is, well, what's changed? What suddenly appeared that makes investing in this worthwhile, as opposed to something else? And that's a hard sell. There are new tools that have come along at different periods of time, and we're using them all the time, but unlike many things, catalysis has advanced because a lot of people keep working at it and making incremental changes which add up to huge changes. So a nice example is the catalyst that industry has developed for taking sulfur out of petroleum. First there were none. And then there were some, and it took out, I don't know, 40, 50 percent. That was considered very good. But then the standards kept falling and falling and falling, and people had to develop better and better catalysts. So ExxonMobil is one of the leaders in this thing. And their folks show plots showing that it takes decades before you get to the point where we are today. But if the company didn't invest over the decades, then we wouldn't have what we have.

03-03:07:00
Eardley-Pryor: And we'd have a lot more acid rain.

03-03:07:02
Bell: Yes. That theme can be carried over to many areas that we'll talk about.

03-03:07:09
Eardley-Pryor: I want to ask another question about tools that allow some of these incremental changes to happen over time. A new tool allows a new way of understanding, as you've told stories of. In what ways were technologies—getting these new types of instrumentation—a challenge to doing your research programs? These things cost a lot of money.

03-03:07:30
Bell: They do.

03-03:07:30
Eardley-Pryor: And they may not be proven, necessarily, because you're at the cutting edge.

03-03:07:33
Bell: Right. So this is a constant challenge. At any time during my career, I never have had enough money to just say, oh, I'll take out $100,000, $200,000, go buy the tool and, you know, and off I go. So sometimes you partner with other people to get a grant for a new NMR spectrometer. A whole group of people have to put that in, because these things are anywhere from half a million to three-quarters of a million dollars—you know, the modern ones. Other times, you partner with somebody who has the instrument already and is willing to do science with you. The National Center for Electron Microscopy is a good example. We had to teach ourselves how to do X-ray absorption spectroscopy—never done it before. And simply with Bruce Gates's help—and a postdoc who was with him at the time, who went on our first campaigns down to Stanford with us and spent two or three days with us, helped us learn the ropes. And then that gets passed on to the student generations. But it's

really hard, because once you develop expertise, if you're not able to bring somebody else in to pick it up before that person leaves, you're stuck. Because I have no resident experts. And that happens periodically.

03-03:08:59
Eardley-Pryor: Is that part of recruiting postdocs and recruiting graduate students?

03-03:09:02
Bell: No, I can always recruit postdocs. I'd have more than I could handle, if I wanted to. It's having the money to pay for them. And that's been—it's never been lavish. It's been better sometimes than others, and you're always running at the ragged edge—or at least I find myself running at the ragged edge of what can be done.

03-03:09:26
Eardley-Pryor: Because you could always do more.

03-03:09:28
Bell: Yes.

03-03:09:29
Eardley-Pryor: And wanting to do more. Well, this seems like a good point for us to take a break, and we'll continue our research discussions as we move forward.

03-03:09:37
Bell: Okay, good.

Interview 4: March 11, 2019

04-00:00:00
Eardley-Pryor: Today is March 11, 2019. We're continuing with interview session four with Alexis T. Bell. Alex, we're here in your office on [University of California] Berkeley's campus. I am Roger Eardley-Pryor, from the Oral History Center.

Last time you and I met, we discussed your research initially. And what we covered last time was nitrogen oxides reduction, and we began discussion of carbon hydrogenation via Fischer-Tropsch synthesis. What I'd like to do today, as we discussed, is continue discussion of your work through hydrogenation, while still sticking to funding, ideas, tools, and people as our themes throughout—but using as our launching point, your work making methanol from syngas. How did that work begin, and what stories do you remember from doing that work?

04-00:00:54
Bell: Right. So this is a continuation of the work that we were doing earlier on converting CO, carbon monoxide, and hydrogen into fuels. And we had at this point fairly well exhausted what we could do with the tools available on making hydrocarbons, so a natural place to turn, then, was to make methanol, which is in itself a fuel. Also, in the mid-seventies, Mobil had developed a process for taking methanol to gasoline and diesel fuel, and later even olefins, so it was a natural intermediate to work on. The challenge here is to make this molecule at lower temperatures so that you can get higher conversions, because since it's an exothermic reaction, the higher the temperature, the lower the equilibrium conversation. So we wanted to look for more active catalysts.

04-00:01:55
Eardley-Pryor: So the catalysts are what allow you to do this work at the lower temperatures?

04-00:01:58
Bell: At a lower temperature, right, with the same productivity. So what we turned to was looking at supports and promoters, and one that looked very appealing was zirconia. This choice was based on some early work done in the Japanese literature that stimulated us. So we picked this up and started looking at copper on zirconia, different phases of zirconia, monoclinic and tetragonal, and also promoting copper on silica with small amounts of zirconia. And in fact this turned out very, very well.

What we learned along the way was something that was not known: that zirconia not only acts as a promoter; it actually acts as a cocatalyst, because a lot of the chemistry is happening on the zirconia, facilitated by the copper. So imagine small what we call nanoparticles of copper sitting on a support of this oxide, zirconium oxide, and the carbon monoxide actually preferentially adsorbs on the zirconia and not on the copper, unlike what happens when you have just copper as the catalyst. What happens on the copper is adsorption of hydrogen, and the hydrogen then spills over onto the zirconia and starts to hydrogenate the CO. And we could see the intermediates of that process by doing in situ infrared spectroscopy—it's one of the many tools that we developed for looking at catalysts while they're doing their work.

04-00:03:44

So we were able to follow the dynamics of the spillover; we were able to follow the dynamics of the hydrogenation of CO; we were able to identify the species called methoxide, which is CH_3O, on the zirconia as the last precursor to making methanol.

And in fact these catalysts are a bit more active—somewhat more active, maybe a factor of two or three—than the commercial copper, zinc oxide, and alumina catalysts that were available at that time. And while there were starting to appear patents from both the US and Japan, nobody was running to switch over their commercial catalysts to these new ones, for a variety of economic reasons. So this was very interesting science, but it didn't switch the methanol production industry.

04-00:04:38

Eardley-Pryor: So when you say "we" were doing this work and "we" were taking ideas from the Japanese literature, who is the "we" that you're working with?

04-00:04:44

Bell: The graduate students who were working with me, and I have to look at my list—Ian [A.] Fisher was the first one to do this work, and then Michael [D.] Rhodes, and others who followed him. Kostya [Konstantin A.] Pokrovski was a Russian student who worked on this—I think he was the last of the three to do this work.

04-00:05:09

Eardley-Pryor: So when you and your graduate students began thinking about this process, what was the impetus for it? Was there a batch of funding that you were able to capture to do this work?

04-00:05:16

Bell: No, this was sustained by our Department of Energy [DOE] funding throughout this period—this is in the 1980s, early nineties. And it was kind of a natural thing to pursue. The kind of funding we had was always looking to support fundamental work as opposed to applied work, so it fit in very naturally in our process.

04-00:05:43

Eardley-Pryor: When you had mentioned the fundamental versus the practical applications of it, the practical applications, you said, were economically unfeasible. Why was that?

04-00:05:53
Bell: Well, it costs a lot to build a process for making catalysts. One doesn't switch out one catalyst for another unless you've had very extensive testing of the new catalyst for its activity, its stability, and so forth. And these are not the types of studies that we would do here at the university; this is better suited for industry. So once again, what we're doing is populating the open literature with ideas that industry either does or doesn't pick up on and use at some point, but we don't feel an obligation to convert these things into a process.

04-00:06:34
Eardley-Pryor: Yes, you're looking for the knowledge, the fundamental knowledge.

04-00:06:35
Bell: We're looking for the knowledge, right.

04-00:06:38
Eardley-Pryor: I'm fascinated that the Japanese literature was so forward-thinking on this that you were able to build off of it, to take some of their ideas and build from it.

04-00:06:47
Bell: We took the empirical observations that were reported in the Japanese literature and a couple of Japanese patents, but there was no physical interpretation of the empirical results. So as is often with our work which focuses on the fundamentals, we will take an industrial process or modification of an industrial process and identify the fundamental reasons that it works the way it does. And if we're successful, then we will also point in the directions in which you could make the process better.

04-00:07:20
Eardley-Pryor: I see. Was the Japanese literature written in English, or did you have Japanese students?

04-00:07:25
Bell: It was all in English—it was all in translation—so we didn't have to have somebody who was a native Japanese speaker.

04-00:07:31
Eardley-Pryor: I see. I'm thinking about how you are able to pull from the Russian literature even when it is in Russian—and also looking at the Japanese literature. It's just such an array that you're pulling from to do your work.

04-00:07:42
Bell: Right. So this is typical. We will look at the literature that's specific to our problem area, catalysis, look to different national sources for ideas, but also, often you find that reading related literatures—for example, in the areas of physics, physical chemistry, ceramics, materials science—can provide ideas that wouldn't have come out of just looking at the narrow perspective of catalysis.

04-00:08:12
Eardley-Pryor: That's wonderful.

04-00:08:15
Bell: So we pursued this—first hydrocarbon synthesis, then alcohol synthesis. In the early eighties, Heinz Heinemann, who had just retired from Mobil, came to Berkeley. He had been the director of catalysis research at Mobil and was a well-established figure in the field of catalysis. And Gabor Somorjai invited him to join the Lawrence Berkeley [National] Laboratory [LBNL] here as both an advisor and a principal investigator. So together with Heinz, knowing his industrial background, we went into two directions. One was to start simulating actual reactors that produce Fischer-Tropsch products. And the reason for that is we had a new program that was developing at this time with Heinz's help and Gabor's help called the Center for Advanced Materials, CAM. And under that program, since it was DOE-funded, we had to have themes that were orthogonal from what we were doing with our core DOE program. This is an issue whenever you're working with one agency and you have multiple directions or multiple lines of funding. You have to keep them definable one from another.

04-00:09:47
Eardley-Pryor: So when I had spoken to Gabor about his collaboration with you, he had made mention that materials science research from DOE had to be separate from catalysis research.

04-00:09:56
Bell: That's very much so, yes.

04-00:09:57
Eardley-Pryor: Is that the case that you're talking about here?

04-00:09:59
Bell: That's still the case today. These are two groups within the Department of Energy—Materials Science Division, Chemical Sciences Division—which fund research. Materials Science Division PIs are told you can work on materials, but don't do anything in catalysis, don't do any chemical reactions, look at properties and at best gas or liquid-solid interactions, but not chemical reactions. And the opposite is true in the chemical sciences—we have the purview of all of catalysis.

04-00:10:35
Eardley-Pryor: Well, I can understand why they would want that from a bureaucratic standpoint. But as a scientist working on these issues, what do you think of it?

04-00:10:42
Bell: I don't think it's a great idea, because science and engineering borrow from various areas, and they cross areas fairly freely. And I'll give you an example of that later—it's something that has come up right now in future research plans that we have, where we want to cross boundaries and we find that we have to tread carefully.

04-00:11:03
Eardley-Pryor: Because of the funding streams?

04-00:11:04
Bell: Yes, because of the funding and resources.

04-00:11:07
Eardley-Pryor: Take me back. You were talking about your work with Heinz Heinemann, when Gabor Somorjai had brought Heinz to campus after he retired from Mobil. How did you and Heinz first come together to collaborate?

04-00:11:18
Bell: Gabor introduced us, and we hit it off. I had known Heinz as a senior figure in our field. We hit it off. We saw each other socially after a while, as well as professionally. And we enjoyed each other's company until Heinz passed away at the age of ninety-three.

04-00:11:39
Eardley-Pryor: That's a long, productive life.

04-00:11:40
Bell: A long, very successful career. Right.

04-00:11:42
Eardley-Pryor: And as a founding editor for *Catalysis Reviews*, which—

04-00:11:46
Bell: Which he then handed over to me—and which I've been editing for over thirty years now.

04-00:11:50
Eardley-Pryor: That is a long-lasting collaboration that moves even beyond his lifetime.

04-00:11:53
Bell: That's right, yes.

04-00:11:55
Eardley-Pryor: Tell me about some of your memories of Heinz himself, of the man.

04-00:11:58
Bell: He had a very broad perspective on catalysis. He clearly saw it as a technology that had and found applications in industry—he had spent his whole career in industry—and so in contrast to myself, he was always interested in how a new catalyst or a modification could be used to produce products. He had been instrumental at Mobil in making sure that zeolite-based catalysts were used for the methanol-to-gasoline program that New Zealand put into place and had overseen a number of other developments while he was there—until he retired. So when he came to Berkeley, he brings this background in industrial catalysis.

04-00:12:56

And so I did a couple of things. I had him teach some lectures in my course on catalysis—graduate course—here in the department. And then we found ways to collaborate, first in this area of chemical reaction engineering, which involves the interplay between heat, mass transfer, and catalysis in the design of a reactor. Now, this is a topic was not totally new to me; I had engaged in this in the course of looking at plasma chemical reactors—and we talked about that earlier—but the context was different here. And the very interesting thing is that about this time, it became clearer that Fischer-Tropsch catalysis is a very exothermic reaction—that means it puts out a lot of heat—and if you don't control that heat by getting rid of it, you burn out your catalyst or your reactor.

So several people around the world, including in Germany, had found that what's called a slurry bubble column reactor would do the job. So envision a pipe anywhere from two inches to a foot across, filled with this Fischer-Tropsch wax—the product itself was the slurrying agent—particles of catalyst that are on the scale of microns to millimeters—closer to maybe a tenth of a millimeter, 100 microns—and then this mixture is fluidized, kept in suspension, by bubbles of gas coming from the bottom of the column. So basically you have something that looks like liquid shoe polish, black shoe polish, with bubbles coming through it. And this is operating at about 250 degrees Celsius.

04-00:15:00

So our task was to describe the mass and heat transfer properties of this system. And with David Stern, one of my graduate students at the time, and Heinz, we developed a working model, which we also compared against laboratory results we had here. Heinz was also instrumental in getting us data from Mobil, who were running a pilot plant, also under DOE support. So we got their pilot plant data and we were able to emulate their pilot plant data, which gave better validation of our model.

04-00:15:42

Eardley-Pryor: Tell me more about the model. Was the model a simulation? Was it built actually physically?

04-00:15:47

Bell: The model was a simulation. A computer code that described the interplay between kinetics, mass transfer, and heat transfer along the height of the reactor. And we had to put in quite a bit of detail about the mass transfer, how the mass transfer depended on the properties of the liquid, how the mass transfer inside the particles came into play with external mass transfer from the liquid to the particles, and at what point you become mass transfer limited, and how all these effects influenced the distribution of products—because we were trying to make something that looks like a diesel fuel, and if you don't do things right, you'll make a much lighter product and you'll waste the carbon, so to speak. So that was a good learning exercise for us.

04-00:16:44
Eardley-Pryor: Unpack for me, if you would, how a simulation like that gets developed. I'm thinking this work is happening—you're first meeting Heinz in the late seventies, early eighties? And the work that you, Heinz, and David Stern do is in the eighties.

04-00:16:57
Bell: Yes. Mm-hmm.

04-00:16:58
Eardley-Pryor: So I'm thinking it's the dawn of the desktop computer revolution, and you're creating these very complex situations, I would think ad hoc, from your own baseline code? Tell me about how the model works.

04-00:17:12
Bell: We developed the codes from scratch in Fortran. And they were based on the principles of heat and mass conservation, conservation of momentum. So we knew how to write the differential equations, and then we recast these into difference equations which we could solve on the computer. Now, this wasn't done on a desktop computer; we used a mainframe computer.

04-00:17:40
Eardley-Pryor: And tell me about where you did this work.

04-00:17:42
Bell: It was done here on campus.

04-00:17:44
Eardley-Pryor: Was the mainframe in the building of Gilman Hall?

04-00:17:46
Bell: No, the mainframe was where Evans Hall is right now.

04-00:17:49
Eardley-Pryor: What did it look like in the early eighties, this mainframe?

04-00:17:52
Bell: You huge steel cabinets filled with electronics. And you took your deck of cards down there and ran the cards.

04-00:18:03
Eardley-Pryor: So this was still punch cards?

04-00:18:04
Bell: Yes, punch cards. Right.

04-00:18:05
Eardley-Pryor: Great. And was David's role in this essentially helping with the computer programming?

04-00:18:11
Bell: He did all the computer programming. He also built a smaller version of this reactor for testing.

04-00:18:22
Eardley-Pryor: Like a physical testing model?

04-00:18:24
Bell: Yes, we had a physical model.

04-00:18:26
Eardley-Pryor: So it was both a simulation and a physical model?

04-00:18:28
Bell: Right, right. We needed something that we could compare the results against and test our assumptions, put it into the model. So this worked very well. It taught me something else, something new—and a very complex interplay between the effects of mass transfer, which alter the hydrogen-to-CO concentration at the catalyst surface, which in turn influenced the product distribution. And we got all of that both qualitatively and quantitatively correctly.

04-00:19:01
Eardley-Pryor: And when Heinz was able to bring in the pilot plant data through his Mobil connections, how did that shape the way you were thinking about the work that you had already done with the simulation and model?

04-00:19:12
Bell: Well, first of all, I had never seen the pilot plant, so I actually flew out to Mobil in New Jersey and walked up the staircase and saw this thing. It was oh, about a story and a half tall, and much more complicated than what we had in the laboratory here—much bigger—it was about a foot across. And the kinds of data that were obtained were not that different from what we had. They had better temperature sensing and distribution along the height of the column, but otherwise, in terms of product distribution—that was measured at the end of the column by disengaging the gaseous products from the liquid, and then analyzing them with a gas chromatograph.

So yes, that was an interesting effort, and it brought me in contact with very good people at Mobil. One of them was Vern [W.] Weekman, who was a chemical engineer who was in charge of the effort there.

04-00:20:17
Eardley-Pryor: You mentioned Heinz's approach coming from industry. He had more of his [experience], you had said, with thoughts on products. Whereas you're thinking about the fundamental issues: the science, the knowledge base, and the theoretical aspects that go into that. Tell me about how you two came together, for your strengths, to work together on a project.

04-00:20:39
Bell: Right. So Heinz was a great manager—not a sophisticated scientist per se—a great manager and had a deep understanding of what was important. So his role was to sit in our discussions and ask, what would be the consequences if you got this right? What would it enable us to do? Where could you go with this tool once you have it? And remarkably, these are not the questions that are always asked by an academic. And so that was a good counterpoint to the kinds of things that I would ask, which had more to do with the specifics of the model. So this worked extremely well. And as I say, we came to be not only partners in research, but also friends – our two families came to meet periodically, too, over dinner.

04-00:21:41
Eardley-Pryor: And you had told me that Heinz had grown up in Princeton?

04-00:21:45
Bell: Actually, I misspoke. He grew up in Berlin and came to the US, I think, in 1938.

04-00:21:54
Eardley-Pryor: Oh, in the wake of his dissertation being rejected in Germany, he went to Switzerland?

04-00:21:56
Bell: Right, that's right. He went to Switzerland, got his dissertation accepted there, and then started to realize that Europe was probably not a friendly place for Jews in the long term. So he came to the US and spent the rest of his career here.

04-00:22:10
Eardley-Pryor: I see.

04-00:22:15
Bell: Yes. Go ahead.

04-00:22:16
Eardley-Pryor: Well, I was going to say, let's back to the work of making methanol from syngas that veered into our discussion of Heinz Heinemann and your collaborations with him. I have a note that the methanol from syngas work was also related to some sort of BP [British Petroleum] funding and work that you did with Enrique Iglesia?

04-00:22:33
Bell: No, that came later. The interaction with Enrique Iglesia, my colleague here, and some of the work at BP, that started in 2000.

04-00:22:50
Eardley-Pryor: Oh, I see. So the work that you did with methanol from syngas was really rooted in the Center for Advanced Materials up at the Berkeley Lab through DOE?

04-00:22:57
Bell: Well, it started with the DOE-funded core program, and then there was a piece of it—the practical piece—that was in the Center for Advanced Materials. And then when that funding stopped, we continued with the core funding. Iglesia came here, I think, in 1992 or 1993.

04-00:23:19
Eardley-Pryor: In the early nineties then?

04-00:23:21
Bell: Yes, early nineties. And I got him into the core catalysis program at LBNL. And then he and I collaborated for quite a few years together on oxidation of alkanes to alkenes—it was something called oxidative dehydrogenation [ODH].

04-00:23:47
Eardley-Pryor: All right. Well, before we get to that, I do want to also return to another topic that you had brought up—that was structure-function research, and what kinds of tools and approaches you were doing around structure-function work.

04-00:23:59
Bell: So starting almost with day one in my research on catalysis, I realized that you have to have all the eyes possible to look at a catalyst and figure out what's going on—and you can think about this as triangulating from different perspectives. So the first tool that we developed was in situ infrared spectroscopy with Ed Force. And then Bob [Robert F.] Hicks, much later, refined the cells, and we published a paper, in fact, on that. Then the next tool that came into play was Raman spectroscopy.

04-00:24:39
Eardley-Pryor: What is Raman spectroscopy?

04-00:24:41
Bell: Raman spectroscopy is a scattering technique. You take visible laser light, scatter it from a solid surface, and the scattered light has information about the vibrations of the molecules at the surface. If you now analyze the frequency of that scattered light and throw away the principal component, which is the frequency of the visible light, then off to the side you see these vibrations.

04-00:25:12
Eardley-Pryor: All right. So this is a scattering, a diffraction kind of methodology?

04-00:25:16
Bell: Right. It's a complement to infrared spectroscopy in the sense that it's a vibrational spectroscopy, but the selection rules are complementary to those of infrared spectroscopy, which is an absorption spectroscopy—different physics.

04-00:25:31
Eardley-Pryor: So tell me about how you came to start using Raman spectroscopy in your labs.

04-00:25:36
Bell: So I came to that having spent a six-month sabbatical period at ExxonMobil. So this is, again, an example of how contact with industry has been very helpful. In fact, I think it wasn't ExxonMobil then; it was just Exxon. And one of the people I contacted there was Shirley Chan—she was doing Raman spectroscopy. And so she taught me what she knew. And when I got back to Berkeley, I wangled enough money to get a spectrometer and then emulated what she had been doing, and that really took off.

04-00:26:27
Eardley-Pryor: That's great. So where does funding come from for this kind of instrumentation?

04-00:26:31
Bell: Well, that came also from my core DOE program. It was in a day when every year there was a call for capital equipment, and the division had enough money that it could parse it out to people who had a real need. Unfortunately, that's long disappeared, so you get your operating money but no equipment money.

04-00:26:55
Eardley-Pryor: Well then today, when you do need some sort of new instrument, how do you find funding for those things?

04-00:27:00
Bell: Well, you have to start a new program or you have to get instrument support—there are competitions for larger instruments.

04-00:27:11
Eardley-Pryor: Through this DOE funding at Berkeley Labs?

04-00:27:12
Bell: Yes. Well, DOE, from NSF [National Science Foundation]—various things. But most of the new instruments I've gotten in the more recent years have been by starting non-DOE programs.

04-00:27:23
Eardley-Pryor: Entirely new programs. But this time, when you're doing this structure-function work—

04-00:27:27
Bell: Yes, this was early enough that I could get the instrumentation.

04-00:27:32
Eardley-Pryor: Your partnerships through the LBNL seem to have been incredibly fruitful for helping open up doors and collaborations for your work.

04-00:27:39
Bell: They were, yes. Right, right. They were, and they still are. Yes.

04-00:27:42
Eardley-Pryor: Is that something that you think is typical or unique for your role here within the department?

04-00:27:49
Bell: Well, it's a laboratory that has people from many different areas working in the same division, so you're going to encounter materials scientists, chemists, chemical engineers, physicists. And if you're open to learning from them, it's a great place to pick up new things. So I've taken advantage of it.

04-00:28:12
Eardley-Pryor: Are there other people in chemical engineering who have done similar paths, or do you think you're the one that sort of leads the way on that?

04-00:28:17
Bell: I probably have done this more than most. It's just because I'm curious and I get frustrated when I'm limited, so if I can't buy the toy myself, I'll go see who has one and take advantage of it. And in the Lawrence Berkeley Laboratory, the principal tool I've taken advantage of—well, there are two. One is the superb electron microscopy capabilities we have in the National Center for Electron Microscopy, known as NCEM, where they have atomic resolution microscopes.

And in fact, related to this work on Fischer-Tropsch synthesis in its most recent manifestation, which is now coming into the 2010s, Greg [Gregory R.] Johnson and I decided we wanted to see where promoters sit relative to the catalyst. Prior to this, Gabor and I had looked at taking thin films of rhodium and decorating them with titania and other metal oxides and seeing the effect. However, in that case, we couldn't see where the titania was. We could tell it's there by doing something called X-ray photoelectron spectroscopy and Auger spectroscopy, but we couldn't actually see the little patches. With Greg Johnson, we were starting to look at little cobalt nanoparticles sitting on silica. While you could see cobalt particles with transmission electron micrographs, but you couldn't tell whether the oxide was there or not because the atomic number of the metal in the oxide is very close to that of cobalt, so you didn't have any phase contrast – everything looked the same gray.

04-00:30:24

So at about the time we were trying to do this, the center had acquired new detectors for their scanning transmission electron microscope (STEM) which would detect and analyze the X-rays generated by the electron as it went through the sample. And the X-rays have energies that are characteristic of the element from which they were generated, so you could generate an elemental map for cobalt, you could do one for manganese—one of the promoters we looked at—or zirconia or titania and see how well these elemental maps overlap. Once we got the micrographs the question was, how do you interpret the raw data?

So Greg and a postdoc at the time, Sebastian Werner, developed the software for doing that. And it was one of these fortuitous things. Sebastian's girlfriend was across the street studying astrophysics as a PhD student, and she told him over dinner the kind of software that's used to distinguish whether one star is in front of another or not. And Sebastian, being a clever guy, said, "Ah-ha! I'll go read that." And then he, from scratch, wrote the software for analyzing these images—STEM images.

04-00:31:57
Eardley-Pryor: Based off his girlfriend's use of similar kind of ideas in astronomy?

04-00:32:00
Bell: Yes, right. So this is how one thing builds one thing on another. And the net result is that we developed this image analysis software, which we used very effectively to tell what fraction of the cobalt is covered by the metal oxide and tell what is the ratio of metal to cobalt. And we could compare this also with elemental analysis, and that agreed very well. And so the software was used not only for our work, but it eventually ended up being public software in the NSEM library. So we were very fortunate this way.

04-00:32:43
Eardley-Pryor: So other scholars can come and use the same software?

04-00:32:44
Bell: Right. So this is how we just merged into something totally new: we had to write a proposal to get the NSEM time; we had to write our own software, because they didn't have anything like this; and it paid off for everybody.

04-00:33:00
Eardley-Pryor: But all of this came from NSEM's having the scanning electron microscopes that are able to use X-rays in order to get the mapping [to be] elemental?

04-00:33:09
Bell: Right. And the spatial resolution analysis of the X-rays had come down to twenty nanometers—a few nanometers—better than twenty nanometers—so that we could see images which were relevant to the scale of our problem.

04-00:33:26
Eardley-Pryor: That's wonderful. And this is essentially using X-ray absorption spectroscopy?

04-00:33:31
Bell: This is X-ray-emitted spectroscopy.

04-00:33:33
Eardley-Pryor: Not the absorption?

04-00:33:34
Bell: No. I'll get to the absorption—that's another technique we've used. So in the 1980s, we started doing this at the Stanford Synchrotron Radiation Lab, known as SSRL. And I may or may not have said this before, but Bruce [C.] Gates was instrumental in getting us started. He had a permanent Russian postdoc who helped us do the first work there. And we learned how to do X-ray absorption spectroscopy and used two parts of the spectrum. The lower-energy part is called the XANES—X-ray absorption near edge spectroscopy—and gives us information about oxidation states and coordination numbers; the latter part, which is the ring-down, is the EXAFS portion—Extended X-ray Absorption Fine Structure—which you analyze by taking a Fourier transform of the structure. And that gives you a radial distribution function, or something very close to it, that tells you who the nearest neighbor atoms are, and you can simulate that and find out the coordination number and how close they are.

So we taught ourselves how to use that. We built a cell for doing this in situ. And we did a lot, and continue to do a lot of work with this technique.

04-00:35:04
Eardley-Pryor: When you began using this technique—because you said this was in the eighties that you and Bruce were able to start working down at Stanford?

04-00:35:09
Bell: Yes.

04-00:35:09
Eardley-Pryor: Tell me the story about how that all came to be, with this postdoc, the Russian postdoc.

04-00:35:16
Bell: Well, the postdoc was the facilitator. His name is [Oleg S.] Alexeev. He's now at the University of South Carolina as a permanent—I think he's a research professor there. That came about because EXAFS and X-ray absorption spectroscopy, as it's known in general, was becoming something that more and more people were doing to get information. And I knew that it would be useful and I wanted to add it to our toolkit.

04-00:35:50
Eardley-Pryor: And that tool was not available here at Berkeley?

04-00:35:53
Bell: It was not available at Berkeley, and nobody else was doing it at Berkeley at the time.

04-00:35:57
Eardley-Pryor: And it was not available where Bruce is at, in [University of California] Davis, either?

04-00:36:00
Bell: No, Bruce was using it routinely.

04-00:36:02
Eardley-Pryor: But not at Davis?

04-00:36:04
Bell: At the Stanford Synchrotron Radiation Laboratory (SSRL).

04-00:36:05
Eardley-Pryor: Oh, okay.

04-00:36:06
Bell: No, no, he was using it at SSRL. Yes. And I knew about his work and had read about it, and I wanted to get started, but starting on something as complicated as this just on your own would have been much more difficult than if we'd had some help.

04-00:36:20
Eardley-Pryor: And the X-ray work that you were fascinated with wanting to get involved in, is that what brought you and Bruce together?

04-00:36:27
Bell: No, we didn't do this work together. We didn't actually collaborate on this work. But I got time allocated at SSRL on a proposal that I wrote, and then we needed somebody who could guide the team, so this fellow agreed to do it. And I went on the first couple of tours with the students and postdocs and we worked down there.

04-00:36:54
Eardley-Pryor: I see. What was the first time that you and Bruce Gates came across one another?

04-00:37:00
Bell: Oh, let's see. That I have to think about. I guess I knew him when he was still at the University of Delaware. Prior to that he was at Chevron for a while, but I don't think I knew him at that time. So we had probably met at a Catalysis Society meeting. We're roughly the same age—he's actually a little older than I am, but roughly the same age. And so we hit it off. Bruce helped me get started on the EXAFS work. And we continued to see each other at meetings and have similar interests, so it's been a very nice friendship and association.

04-00:37:44
Eardley-Pryor: I love hearing the connections between how people are helping facilitate the science and access to tools and opportunities together.

04-00:37:50
Bell: Oh, yes. Yes, that's right. Yes.

04-00:37:53
Eardley-Pryor: Are there other tools and approaches you want to discuss with relation to structure-function research?

04-00:37:58
Bell: Sure. There's NMR, nuclear magnetic resonance spectroscopy, and that I started to do with Jeff [Jeffrey A.] Reimer, my colleague now—and he's now chair of our department—not long after I hired him as an assistant professor. He is a graduate of Caltech [California Institute of Technology] and had been, I think, at IBM prior to coming here. And he's an NMR expert, and so we teamed up to look at the carbonaceous species that are formed on Fischer-Tropsch catalysts.

04-00:38:35
Eardley-Pryor: I believe you talked about this—and they had to put that wire through the long tubing in order to get this process started?

04-00:38:40
Bell: Oh, now that's separate. That we did on my own in my own lab.

04-00:38:45
Eardley-Pryor: Oh, I see.

04-00:38:45
Bell: The work with Jeff was aimed at looking at the carbon species—so if you fed C-13-labeled carbon monoxide, you could see the whiskers of these hydrocarbons growing off the surface of ruthenium. And the resolution was good enough that we could tell the chemical shift of a carbon that's just bonded to the metal, one that's just above it, a CH_2 above that, and then finally the methyl group at the top. And so by counting the relative areas, we could tell how long the whiskers were. So we published a couple of papers on that subject.

04-00:39:26
Eardley-Pryor: That's wonderful.

04-00:39:28
Bell: So that's NMR spectroscopy. Another technique, which we developed here but only used once with a fellow named Jim [James A.] Baker, who was a master's student, was what I call swiping the cookie dough to taste it before you bake the cookies. So here's the idea. You're going from reactants to products, and there's an intermediate—that's the cookie dough. And you want to know what that intermediate is before it gets to the final product. Unfortunately, that intermediate is present in very, very small quantities, so it turns out that spectroscopies can't sense it. But if you can come in with a chemical that is not one made naturally by the process and swipe that intermediate and take something off that is distinguishable, then you have indirect proof that intermediate exists. So what we wanted to look for are called methylene units—CH_2 units—bounded to the metal.

04-00:40:43

And over a conversation at the faculty club with one of my chemistry colleagues, Earl [L.] Muetterties—he had come from DuPont and was here many years until he passed away—I told him what I was doing and he said, "Have you thought about using chemical interception?" So this is where I say the finger in the cookie dough approach. And I had not, but we talked about how it might be done. And he suggested that we use cyclohexene—so this is a six-membered carbon ring with one double-bond, and he knew that the double-bond would react with the CH_2 to make a three-membered ring on the side of a six-membered ring—a very unusual product known as norcarane. And in fact, we tried out his idea. It required condensing the products and then doing very careful gas chromatography and mass spectrometry to identify this product. And it worked out beautifully. And then we went on to purchase some fluorene-labeled cyclohexene so we could tell on the mass spectrometer that you had added a CH_2 unit to something that had fluorene on it—this idea worked and we were able to see a methyl group attached to the perflourinated cyclohexane.

04-00:42:17
Eardley-Pryor: And what came from that work?

04-00:42:19
Bell: We published a couple of papers. Jim left here—he didn't pass his qualifying exam—went, I think, to University of Oregon and got a PhD there. So he went on to have a good career. And then I couldn't convince anybody else to undertake this, because it's fairly arduous chemistry. So I think this might have been the first and last time the technique was practiced. But it proved the point.

04-00:42:46
Eardley-Pryor: I'm fascinated to think about all of these new instrumental techniques that you're using, some of which you were using here on campus with your students, and how your lab space for different research projects changes and evolves over time. Can you talk a little bit about that? You had mentioned your first lab on campus with the wooden hoods, and you had moved to another spot on campus.

04-00:43:04
Bell: Right. So I moved to Hildebrand Hall in the basement. When Bob [Robert G.] Bergman was coming to Berkeley, the College wanted to renovate a part of the floor in Lewis [Hall], where I was—the second floor. And so I moved out, and I forgot who was down the hall from me also moved out, and we got new lab space. And the floor was renovated for Bergman. So that was the first move. Then I needed more space, and the College couldn't find it here on campus, so I had the opportunity to go to Building 66 at LBNL. So I went there for the better part of a decade.

04-00:43:48
Eardley-Pryor: And when do you think you moved up to that spot?

04-00:43:52
Bell: Let's see. We'll work backwards. I left there in '97, so it was about '87 that I went up there. And it was beautiful lab space, with a view of the bay from the windows in the lab. The only inconvenience is that you had to ride the bus to get up to it, and that was not the greatest experience for the students—and parking up there was, as always, very tough. So I stayed there until I came to the present labs, which are in Tan Hall. And that was opened up in '97 when I was dean and I was responsible for overseeing the construction of that building. So I allotted myself a nice suite of labs, and they were fitted out to the needs of my group. And that's where we've been ever since.

04-00:44:47
Eardley-Pryor: That's wonderful. And as you make these transitions to these new spots, does the instrumentation come with you?

04-00:44:53
Bell: The instrumentation came with me. When you make these moves, you have to do a lot of planning in advance, so you lose as little time as possible. We never lost more than maybe two, three months of productive time—every time we made a move.

04-00:45:09
Eardley-Pryor: What are your different thoughts on these different locations? You mentioned LBNL being a beautiful view, but Tan Hall being something you got to create to your own specifications. What are your different thoughts on doing the work in these spots?

04-00:45:21
Bell: So I needed more hood space than I could have at LBNL, and we built the hoods into the building from the start, so that was very helpful. The amount of floor space—I have something like 3,000 square feet here in Tan Hall, which is more than enough for me right now. So that's how you work, you know? The instrumentation is mostly tabletop and floor-stand, so it's not exceedingly large. It's not hard to move.

04-00:45:55
Eardley-Pryor: Are there other approaches or tools you would like to discuss with relation to your structure-function research?

04-00:46:02
Bell: No. These are the principle tools: IR, Raman spectroscopy—oh! Ultraviolet visible spectroscopy. That's not a particularly sophisticated tool, but it's very informative about coordination—that we have in the lab. Let's see. IR, Raman, UV vis. We've used also vacuum-based surface science techniques—not in my lab, but in other locations. So X-ray photoelectron spectroscopy, Auger electron spectroscopy—some of that was done with Gabor, and then with facilities that are in the molecular foundry at LBNL. Electron microscopy we've talked about. X-ray absorption spectroscopy. And then after that goes theory, but that's a whole story in its own right.

04-00:47:02
Eardley-Pryor: And we'll get to that.

04-00:47:03
Bell: Yes, we'll get to that later.

04-00:47:03
Eardley-Pryor: We'll get to that maybe next time. Well, I'd like to transition, if you're ready for it, to your work on zeolite synthesis and work around zeolites in general.

04-00:47:13
Bell: Sure. So that takes us back to the eighties, when Heinz was here. One of his major contributions to Mobil had been developing zeolites there and finding applications for them in the petroleum processing area, and then in the methanol-to-gasoline area.

04-00:47:38
Eardley-Pryor: Is it Heinz who introduced you to thinking about including zeolites into your research?

04-00:47:43
Bell: Yes. He was instrumental in telling me about their virtues and their strengths. Prior to that I had not worked with zeolites. So I thought that an interesting place to start would be to look at how they're made, and in particular what elementary particles come together to make these beautiful crystalline, microporous materials. And since I'd been working with Jeff on NMR spectroscopy and I had a student join my group, Alon McCormick, who was interested, we decided to do silicon-29 NMR spectroscopy and aluminum-23.

04-00:48:31
Eardley-Pryor: Now, why did you choose those?

04-00:48:34
Bell: These are elements that are NMR sensitive and will show up—in the case of silicon, different forms of silicates that are formed. And it was known that the way zeolites are formed is, you dissolve silica, SiO_2, in base—something like sodium hydroxide or a tetraalkylammonium hydroxide. And then you add an aluminum source—it could be aluminum wire, it could be an aluminate—aluminum sulfate. And these form a gel. And then you cook this gel, and over time, it nucleates crystals. And then you can use up most of the silica and alumina in making these aluminosilicates, which are microporous. And it's known from the recipes that if you have so much water or so much base, some structure-directing agent, that you'll make specific zeolites.

04-00:49:33
Eardley-Pryor: So you knew the process around how to get these things generally?

04-00:49:38
Bell: Right.

04-00:49:39
Eardley-Pryor: And so you went with that?

04-00:49:40
Bell: So we knew there were recipes for making them, and they were practiced industrially, but at the time there was very little knowledge about how does it happen. So we thought that NMR might teach us this, and maybe we could identify what are called secondary building units—these are little oligomers of silicate from which it looks like you could assemble the zeolite like a Lego set. So we identified these dimers, tetramers, hexamers by NMR spectroscopy. And sure enough, they're there.

Then we could even do some more sophisticated experiments—they're called spin polarization experiments—where you flip the spin in one entity and you look how it interacts with another over time. So you can measure the dynamics, so we did that. We looked at the aluminum NMR and how that interacts with the silicon by doing polarization exchange experiments. And probably the most sophisticated one we did was to look at how what's called a structure-directing agent, which is a soluble organic precursor that's positively charged—so it's a cation—organizes the silica around it, so it shapes what you make. And that we could do with proton-silicon cross-polarization and look at the dynamics and know when the structure-forming entity was close enough to the silica that they were interacting, because it's sensitive on the angstrom scale. So we did all of that ourselves, and figured out how to interpret the dynamics and get out time and rate coefficients.

04-00:51:38
Eardley-Pryor: Well, I was going to ask, why do you think zeolites are important? I'm thinking about what kind of question would Heinz Heinemann ask about this—of your work?

04-00:51:43
Bell: Sure, sure. So the reason that these are particularly important in catalysis is they're crystalline materials that have holes not much larger than molecules—most molecules. So they can act as molecular sieves: little things can go in, but larger ones won't. By the size and shape, they can also be directing the selectivity. So there's a molecule called para-xylene, which is benzene with two opposing methyl groups, but ortho- and meta-xylene that have these groups closer to each other are not as desirable for making polymers—you use the para-xylene in polymer manufacture. And so the pores actually enable the undesired products to rearrange until they can pop out—they have a profile that's skinny enough that they can leave the zeolite, and the other ones just tumble around and rearrange until they do pop out. That's the classic example.

04-00:52:54
Eardley-Pryor: So zeolites, it sounds to me, are used in creating the process, in getting a process to move forward, to get to an endpoint?

04-00:53:00
Bell: That's right. Yes. And you can make them so that they have acid centers—Brønsted acid centers—in them. And these protons catalyze the reaction, but the way they work depends on the shape of the cavity in which the chemical reaction is occurring.

04-00:53:20
Eardley-Pryor: So again, the structure is essential here.

04-00:53:22
Bell: Right—is important. And then you can replace the protons with metal cations and do other kinds of chemistry. So we started by looking at how the zeolites are made, we identified these secondary building units, but much to our dismay, we discovered that the zeolites don't grow based on having the right population of secondary building units; they grew much more promiscuously, and mostly from isolated silicate units that just keep adding until you make a nucleus that then is the forming agent for—the rest of the zeolite grows around this nucleus. So we squeezed out as much as we could with NMR, and then we went on to do other things with zeolites and other materials.

04-00:54:13
Eardley-Pryor: Now, when you say "we," who are you talking about doing work with?

04-00:54:16
Bell: So this was principally Alon McCormick, and a couple of other students who followed him.

04-00:54:22
Eardley-Pryor: And how did you and Alon come to work together?

04-00:54:25
Bell: Well, he joined my group as a PhD student. I was brand new to the zeolite area, and I said, "Would you like to work on this?" And he said, "Sure." So we both taught ourselves how to do silicon-29 NMR and went to work.

04-00:54:40
Eardley-Pryor: And where did funding come for this work?

04-00:54:42
Bell: This came from the Center for Advanced Materials, CAM.

04-00:54:47
Eardley-Pryor: Okay, so this is another part of the work you were doing at CAM.

04-00:54:50
Bell: Yes, right. Yes.

04-00:54:51
Eardley-Pryor: Great. I have a note that some of the zeolite work you did over your career, which runs from the late eighties through the present, also had some funding from Chevron Energy Technology.

04-00:55:02
Bell: That's right. So that started, let's see, twelve years ago now. I was instrumental in getting that funding for Iglesia, [Alexander] Katz, and myself—the three of us are supported by this funding. And the way it started is, I went to Chevron. We had always had good contacts with the people there and we knew each other, but there was no support or actual collaboration. I offered to give an overview of our capabilities and interests and hit a resonant tone and was asked to submit a proposal, which we did—the three of us—and that got us started. So the grant has been running—every three years we get a renewal, and we just got renewed for another three years starting in '19.

04-00:56:04
Eardley-Pryor: That work that you had mentioned, by this point in 2012, with Iglesia, Katz, and yourself: how did you and Iglesia and Katz come together to work on projects together?

04-00:56:13
Bell: So let's see. Iglesia was here first. Katz was hired somewhere around 2000—no, before 2000—1990s, late nineties—and had an interest in silicate chemistry and more towards the synthetic parts of making catalysts. And so we're the three people in the department who had an interest in various aspects of catalysis.

04-00:56:43
Eardley-Pryor: And did these things come up over meetings at the faculty lounge or—?

04-00:56:47
Bell: No, I think it came up more informally by, you know, hallway conversations and my going to other people's offices and talking about what are they were interested in.

04-00:56:58
Eardley-Pryor: It's always interesting to me, hearing how people come together to do their work. I also have a note that some of the work you did around zeolites, particularly with composition and structure, was also with [T.] Don Tilley?

04-00:57:11
Bell: No, not in the zeolite area. We worked on metal oxides—supported metal oxides.

04-00:57:18
Eardley-Pryor: Oh, I see. That's the dispersed vanadia work.

04-00:57:20
Bell: Right. And I've also worked in this area with Enrique Iglesia. So the prototypical example is, you take silica—amorphous silica—as a support. It has nice, high surface area—hundreds of square meters to 1,000 square meters per gram. And then you can chemically graft onto its surface vanadia, molybdena, tungstena, various species. We've done a lot of work on asking, what's the organization of this overlayer? Is it isolated metal-oxo units, or do

they form dimers, do they form oligomers? Can you get a complete conformal mapping or coding of this material? And so with Don it was mostly taking advantage of his expertise in organic chemistry and making precursors. With Enrique and myself, it was more characterization of the things that we deposited.

04-00:58:30
Eardley-Pryor: Okay. Well, take me back. Because your work with Enrique overlaps both the zeolite work as well as the oxidative dehydrogenation research. So, back to your work with Dr. Iglesia on zeolites. What was it that you two brought together?

04-00:58:48
Bell: So on zeolites, we never really worked together. We worked only together on the dispersed metal oxides. He has had, and continues to have, an interest in zeolites—not unlike my own, but looking at some other reactions. So the place where we overlapped was that we were both supported by BP and we were doing things with zeolites, but we were working independently at that point.

04-00:59:16
Eardley-Pryor: Oh, I see. Okay. And that's where I'm seeing these overlaps and getting confused about where funding is coming from and what projects you're working on.

04-00:59:22
Bell: That's right.

04-00:59:23
Eardley-Pryor: Well, tell me a little bit more about the zeolite work. You talked a good bit about the solution chemistry and the nucleation research that was the beginning portions of that. The work on zeolites—how has that evolved over time?

04-00:59:35
Bell: So most of what we did subsequently, and what we continue today, is involved in looking at exchanged metal cations. So we started out by looking at iron cations, because they would decompose nitrous oxide, N_2O, which is a pollutant, and we characterized those species early on by EXAFS. We did some theoretical work on N_2O decomposition contemporaneously with that. We then looked at copper—both single copper atoms and dimers of copper substituted into zeolites, because they would promote the coupling of CO and methanol to make useful products. This was under BP support.

04-01:00:36
Let's see, which other ones have we looked at? More recently we've been looking at gallium, introduced as a single cation, and looking at the ionization state of the gallium—does it form hydrides, which it does; identifying these with in situ infrared [IR] spectroscopy; identifying where the gallium sits in

the zeolite with EXAFS spectroscopy; combining that with theory, with the aim of understanding how these gallosilicates affect the dehydrogenation of light alkanes—principally ethane and propane to make ethene and propene, which are then useful precursors or monomers for polymers, or they can be converted subsequently into aromatics. And so here is, again, an example where we've used all possible techniques, including gallium NMR, which is very hard to do. And we've done it on a 600-megahertz machine over in Stanley Hall.

04-01:01:47
Eardley-Pryor: What was different about having to learn to use that particular element versus the others?

04-01:01:51
Bell: Well, it turns out, while we did it and we got nice line shapes, it wasn't that informative. Because it has a very broad frequency range over which Ga species can occur, and all we could tell was that it was tetrahedrally coordinated, but we knew that from other techniques, so we didn't learn anything else—except that we have one more fingerprint that we can nail down.

04-01:02:16
Eardley-Pryor: Before you begin doing the research, when you're at the formative stage of something, I'm thinking about this massive toolkit that you have in your pocket of all these possible instrumentation options. How do you choose which ones to move forward with?

04-01:02:32
Bell: Well, we know already in advance what information you're going to get from each tool and what it's good for, so the question is which ones to choose and which ones can you practice most easily first. Students, if they're graduate students, they have to acquire the skill of using the tool, and that's a constant headache, because as one generation of students leaves, you don't always have an overlap with the next to bring them on board. And so I have to start almost from scratch doing that.

04-01:03:06
Eardley-Pryor: And so that's part of your role, of teaching them—not the students to teach themselves?

04-01:03:09
Bell: That's right. That's my role, right. So I never have had a permanent assistant—I don't think I'll ever have one. But I have very good graduate students, and they're mostly willing to learn new things.

04-01:03:26
Eardley-Pryor: You have mentioned a few times now BP funding. Can you tell me about how BP funding began and when it began? How did this all come to be?

04-01:03:36
Bell: So it began in 2000—or just before 2000—when BP announced that they wanted to do some fundamental work in catalysis, both heterogeneous and homogeneous, and they put out a call for proposals. We answered the call—we being people both in homogeneous and heterogeneous catalysis within the College of Chemistry.

04-01:04:02
Eardley-Pryor: And your specialty is heterogenous?

04-01:04:03
Bell: Right. And I think Don Tilley might have been one of the—yes, I think he was one of the people from homogeneous catalysis who answered. BP down-selected five groups. A team from BP came around and visited everybody. There was one group at Imperial College in London, and the other four were in the US. So in the end, they liked what they saw in homogeneous catalysis at Caltech and what they saw in heterogenous catalysis at Berkeley, and so instead of funding one group for $2 million, which was their plan, they split the $2 million into $1 million here and $1 million there.

04-01:04:47
Eardley-Pryor: So Caltech got half, and here at Berkeley you got half.

04-01:04:48
Bell: Yes, we had half, right. So that's how things got started. In the first phase, it was called the Methane Conversion Cooperative, or MC squared. The objective was to use all this methane that they and other companies had, which either was being burned or flared, but nobody knew how to make something from it directly—you could convert it into synthesis gas and start from there, but that's a fairly expensive proposition. So I looked at direction for conversion of methane to formaldehyde, and Enrique, I think, looked at converting methane to aromatics in the very first phase. Neither of these ideas panned out in the end, because you could make small amounts of the material, but then the catalyst deactivated. So try as we might, we weren't able to make this work. But then we built on that. I started looking at reactions of methanol with CO to make something called dimethyl carbonate, which is a good additive for gasoline. It's also a methylating agent for all sorts of organic chemistry.

04-01:06:15
Eardley-Pryor: And so the BP funding for MC squared, the Methane Conversion Cooperative, that funding came right around the time you moved into Tan Hall or shortly thereafter?

04-01:06:24
Bell: That's right, yes.

04-01:06:25
Eardley-Pryor: So was the BP funding, I imagine, instrumental in helping shape the way that that lab was laid out?

04-01:06:32
Bell: Oh, well, it helped get a new burst of money for the work that we were doing. We had money already—baseline money, so to speak. So that was very useful. And they were good partners. Especially in the first, I'd say, six years, you were completely free to choose what you worked on. After the oil spill in 2010, things got much tighter as the years went by because now they wanted the results to be more applicable to their own interests, and that, for me, got more and more uncomfortable. But I hung in there, and I think we parted ways in about 2014. So it was a good run.

04-01:07:20
Eardley-Pryor: Yeah, the BP funding was instrumental. And while that BP funding is happening, you're still maintaining a relationship with the National Labs up on the hill, correct?

04-01:07:27
Bell: Oh, yes. Sure. Yes, yeah. Yes. That's been maintained continuously since 1975.

04-01:07:34
Eardley-Pryor: Great. The Methane Conversion Cooperative work: is this where the dispersed vanadia research was conducted?

04-01:07:44
Bell: The which?

04-01:07:45
Eardley-Pryor: The dispersed vanadia—the ODH [oxidative dehydrogenation] methods?

04-01:07:47
Bell: [corrects pronunciation, with emphasis on second syllable] Vanadia, yes.

04-01:07:47
Eardley-Pryor: Vanadia, I'm sorry.

04-01:07:48
Bell: Yes, that's right. We worked on that because you could take methanol to formaldehyde, which is a useful intermediate, and that taught us about how these vanadia entities operate. We also looked at some oxidative dehydrogenation work under that program to make alkenes. We did theory work. I brought Martin [P.] Head-Gordon into that program. It actually—the program started out with Arup [K.] Chakraborty, until he went to MIT [Massachusetts Institute of Technology], and then Martin came in a little bit later.

04-01:08:28
Eardley-Pryor: How did you and Arup first connect?

04-01:08:30
Bell: I hired him. So he came in as an assistant professor, had an interest in quantum chemistry for CO_2 scavenging agents—hindered amines, they're

called. And prior to that, in the early nineties, I had started working with Doros Theodorou, a colleague whom I hired from MIT, whose expertise was in statistical mechanics and molecular dynamics. He and I worked on adsorption and transport in zeolites for years—until he went back to Greece.

04-01:09:23
Eardley-Pryor: So the first theory work was with Doros on zeolite research?

04-01:09:27
Bell: Right. That was my first theoretical work.

04-01:09:30
Eardley-Pryor: Oh, okay. Great. And we will talk about the theory entries in our next session.

04-01:09:35
Bell: Okay, yes.

04-01:09:36
Eardley-Pryor: So we can revisit the zeolite work through the realm of theory.

04-01:09:40
Bell: Right, mm-hmm.

04-01:09:41
Eardley-Pryor: I want to ask a couple of questions about your writing process. Something came up with the wonderful article that some of your students wrote called "A Career in Catalysis" that was published in 2017 [Fuat E. Celik, et al, "A Career in Catalysis: Alexis T. Bell," *ACS Catalysis* 7 (2017): 8628-8640]. And in discussing your work around vanadates, they said that there was a series of papers from the mid-2000s to the 2010s that were trying to link the structure and activity of the vanadates on surfaces with various metal oxide supports. And this is what they said:

"The resulting collection of papers reads a little like a multi-perspective novel, with the reader's attention shifting back and forth between the point of view of two narrators, an experimental one and a computational one. And, as with the fiction, the two narrators tell the same story in an overlapping and complementary way."

I'm wondering if you can talk a little bit about that, as a writer and as an uncle who was a famous novelist, if you can talk a little bit about your process in writing collections of papers and thinking about it as a story.

04-01:10:43
Bell: Right. Yes, that's an appropriate thing to talk about. So what I like to do, if I can find the support for it in a sustained fashion, is to work on a class of catalysts for long enough that I can see it from various perspectives. And that way you get to know this material very intimately—you know its properties; you know what it can and can't do; you are able to relate its performance properties to its structure and composition. So it's not unlike getting to know a

person or a group of people, in terms of who they are, their personalities, and then what they can do professionally. That's the analogy. So on the one hand, you have to have empirical evidence for who people are or what the properties of catalysts are; that you gather from all sorts of experimental evidence. What the theory does is—the theory is developed not to answer any specific problem, but it's what I call context-free theory. So it's general and broadly applicable—and not designed to answer the problem, therefore it doesn't have any adjustable parameters. And if you've gotten the representation of what you want to describe correctly, then the theory should produce results that look like the experiments, but completely independently—they're not talking to each other. Therefore, we use the theoretical representation of what we believe to be reality, inferred from experiments, and check to see whether the two are consistent.

04-01:12:42
Eardley-Pryor: And so you're thinking about this as you're mapping out the whole series of papers, a whole series of research programs?

04-01:12:48
Bell: Yes. We're constantly going back and forth from these two perspectives, usually with different individuals, postdocs or students.

04-01:12:57
Eardley-Pryor: I see. And that work, the introduction of theory, was through your work with Doros?

04-01:13:04
Bell: Right.

04-01:13:05
Eardley-Pryor: And was he the one who kind of helped you to see these multiple perspectives?

04-01:13:09
Bell: No, he helped me with the specifics of transport properties and adsorption properties. We knew they were important. When Arup came, he added to this the perspective of quantum theory, so it's a complementary theoretical perspective. And it's taken a long time to build up these tools to the point where they're reliable enough, you trust them, you're familiar with them, you know which ones work and which ones don't, and apply them across the full spectrum of problems.

04-01:13:49
Eardley-Pryor: The continuation of that article—later in the article, one of your former students wrote, "Common threads found throughout Alex's work and exemplified in these series of papers are his ability to anticipate questions and criticisms and provide responses in the same papers, and his ability to predict correctly the findings of future papers in the same series."

04-01:14:12
Bell: Right.

04-01:14:12
Eardley-Pryor: So I'm wondering, as a writer, and thinking about your audience, who do you have in your head when you're writing your papers? What voices are you trying to speak to?

04-01:14:23
Bell: So first of all, I want to tell my story as I see it. Secondly, I'm thinking about the reader—the critical reader—and what is he or she going to be saying about what I've written. Are they going to be questioning me? Are they going to be challenging me? So I'm at the same time serving as my most severe reviewer.

04-01:14:48
Eardley-Pryor: When I am writing and I have a voice in my head, I can picture certain voices, certain people. Do you have certain people that you have talking to you?

04-01:14:57
Bell: No, I don't have certain people talking to me in that sense. What I'm trying to achieve is best described with a good German word, gestalt—you know, a whole picture—to the best of my ability. And this is always challenging, because you're pushing what you know of the experimental results and what you can interpret, but you also have to know how far—not to go beyond—you know, pushing where it's appropriate, so that you're credible. And the same thing is true of the theory. And while you'd love the theory always to be precisely in line with the experiments, that's not always the case. And so you have to understand the theory well enough to know its limitations, just as you have to know the limitations of your experimental techniques. And then you have to be softer when you're coming to the middle in terms of saying, well, you know, we have 80 percent, 90 percent agreement, here's why we might not have perfect agreement, and speculate a little bit about where the flaws are.

04-01:16:12
Eardley-Pryor: On the topic of speculation—as you brought it up—I have a curiosity about the role of intuition in science, especially with chemistry.

04-01:16:20
Bell: Ah! Yes, sure.

04-01:16:22
Eardley-Pryor: Can you talk about the way that intuition shapes some of your pursuits?

04-01:16:25
Bell: Right. So intuition is built up from experience, so that you have a sense of what you might reasonably expect from the next time you try certain types of chemistry. And it's not catholic in the sense that it applies to everything, but if you work in an area long enough, you kind of have a sense—a sixth sense—of what to expect. And that's your chemical intuition. So what I like to tell my

students is that what we do is build up our chemical intuition to a higher and higher level, so it's more precise.

04-01:17:10
Eardley-Pryor: Can you think of a time when you had intuition but not necessarily the empirical or even theoretical explicit information, but you pursued that intuition?

04-01:17:22
Bell: Well, it's hard to think of a specific time, but I'll give you kind of a sense of how this happens. So you start on a subject that you know relatively little about. You have all your past experience of dealing with science, so you can put together some hypotheses that are not absolutely crazy, but you have no idea whether they're right or wrong. So what I like to do is have a working hypothesis of how things work. Now, I'm willing to be shown that it's wrong. And that's the way science should work—is that you have a kind of a working model of how reality ought to be, or is, and then you gather experimental data, you gather information from theory, you check it out against the reality, and you realign. And so your perspective, your vision, your understanding becomes more and more subtle and nuanced.

04-01:18:28
Eardley-Pryor: With your research on zeolites, I'm thinking about some of the people you have worked with. You had mentioned, eventually, your work with Enrique Iglesia. I have a couple of other names that I'm interested in hearing how you came to work together, and one of them is Clarence Chang, starting to work [together] in the early 1990s. Tell me about the work that you and Clarence did and how you came to work together.

04-01:18:51
Bell: So Clarence was introduced to me by Heinz. Clarence was one of the key people at Mobil in the zeolite area. Clarence had a chance to come out here on an industrial sabbatical—which is really rare—for a number of months, and so we worked together in that context. Now, we weren't able to continue this after he went back, but he had a lot of intuition about zeolite synthesis. He had some specific problems on structure-directing agents that he wanted to look at, so we pursued that while he was here.

04-01:19:33
Eardley-Pryor: Great. Another name I pulled from some of the papers—your publications—is C.S. Gittleman.

04-01:19:40
Bell: Who?

04-01:19:40
Eardley-Pryor: C.S. Gittleman? [changes pronunciation] Gittleman, maybe?

04-01:19:43
Bell: Gittleman—Craig Gittleman?

04-01:19:44
Eardley-Pryor: Craig.

04-01:19:44
Bell: Yes, so Craig was a graduate student, and he worked in this area. He then went to work for General Motors, I believe—no, no, he went to work for British Oxygen Company, BOC, in the area of zeolites, on air separation. That's right. And he worked there for a while, so that was an extension of his knowledge on zeolites. And then he left—he had an opportunity to go and start working on fuel cells for GM [General Motors]. And at that time, GM had its laboratories somewhere upstate in New York State. So he worked there until GM decided to close down that laboratory. And then he moved to outside of Detroit, and so he's there. I've seen him recently. And he's one of the main participants in running their fuel cell activities.

04-01:20:47
Eardley-Pryor: You've had so many students, so many postdocs, so many collaborations. How is that you keep track of each other?

04-01:20:56
Bell: So unfortunately, I don't have a regularized way of doing it. I see these people at technical meetings. Craig, I ran into several times when I was working on a National Academies study to look at the US Drive Partnership. [knock on door] But it's—

04-01:21:31
Eardley-Pryor: Should we pause?

04-01:21:32
Bell: Yes, yes.

04-01:21:32
Eardley-Pryor: We'll just take a moment here.

[Break in recording]

04-01:21:35
Eardley-Pryor: Okay, Alex. You were saying—meeting people and crossing paths at conferences and working on [reports].

04-01:21:39
Bell: Right. So I had been working on this report—this group—for the National Academy, I was writing this report on the kinds of fuels, the kinds of engines that were going to come in the future, and DOE support of these programs with industry. And he appeared as one of the people representing GM. We hadn't seen each other in probably a couple decades, and so we reconnected that way.

04-01:22:10
Eardley-Pryor: That's wonderful. These kinds of reports, especially when they're National Academies-oriented, often have this futurist element to them.

04-01:22:18
Bell: That's right.

04-01:22:19
Eardley-Pryor: And I'm wondering what relationship between predicting the future of science and our discussion we just had about intuition there might be.

04-01:22:27
Bell: Right. So it's very hard to predict where science is going to go. There are many drivers for the evolution. Often it's a new tool or a new idea that sort of matures to the point where it can be used by lots of people, and all of a sudden the area explodes and lots of people get into it. Sometimes it takes decades for that to happen. Another driver would be the need to know, because some societal crisis is occurring—you know, climate change is an example of that—and so people get into studying, you know, what are the drivers there. So, different situations, different drivers.

04-01:23:16
Eardley-Pryor: Do you think it's useful to have these futurist-oriented scientific reports?

04-01:23:21
Bell: Yes, I do.

04-01:23:22
Eardley-Pryor: Why?

04-01:23:23
Bell: I've engaged myself in a number of these. I think they're useful because it provides some clarity for what is, what are the capabilities today, what would you like them to be, and why. What would it enable you to do in the future if you had them? And it provides guidance for the funding agencies. And so the funding agencies often request these reports from the National Academies. Sometimes they don't, and they have to be prodded to produce one.

04-01:23:57
Eardley-Pryor: Have you had experience with that?

04-01:23:58
Bell: Yes, I have. This was in the 1990s, where I prodded the Academy—it took me something like two and a half years to prod them to do the *Catalysis Looks to the Future* report, which came out, I think, in '91 or '92. And the first time around, I knew some people there; I suggested this, and they said, "Well, nobody's asking for this, and besides which, we think there's less and less funding in this area." And I said, "This is precisely why I'm asking to do it—because it's true, but it's undeserved." And after I got some people to lobby on

behalf of my idea, they said okay, and they raised money from the DOE and the NSF to pay for the workshop.

04-01:24:44
Eardley-Pryor: What do you think comes out of these workshops and these reports that you've been a part of? What's the end game for them?

04-01:24:53
Bell: So there are several end games. One is for the immediate participants—they learn a lot about their field that they wouldn't have known otherwise. But more broadly, it puts out a report that says, here's the current state of the art in our field; here's why it's important; here's what it could deliver if we pursue this farther; and these are the directions which we think are most fruitful. And so then the question is, so who reads these? Well, I know that young scholars read them, because you can see the report being quoted in their proposals—which is nice—it meant that at least they read the report. The funding agencies refer to them as a basis for creating new programs and moving forward. And sometimes they're used before Congress to defend existing programs that they have. But you can never predict exactly how it's going to come out.

04-01:25:58
Eardley-Pryor: Do you think that the '92 future report that you put together had an impact on funding in the US?

04-01:26:09
Bell: No, it didn't, unfortunately—not directly, that we could see. The group of us—a subgroup of us who worked on the report—went around and spoke to the staffers in the House and Senate funding agencies and made little presentations, and we were very cordially received, but we didn't see any net effect. As I think I may have told you, one of the biggest effects is that it helped launch the European efforts in catalysis—pan-European efforts in catalysis—and it sparked also the efforts in China.

04-01:26:54
Eardley-Pryor: So the United States didn't pick up the mantle that you laid before them in '92, but the EU and China did?

04-01:26:59
Bell: Yes. In fact, the report is translated into Chinese. And somewhere in my bookcase I have a copy of the report in Chinese. And I know for a fact that it helped stimulate them.

04-01:27:15
Eardley-Pryor: Today—just in 2017, for example—the federal government is calling for catalysis reports.

04-01:27:22
Bell: Right.

04-01:27:21
Eardley-Pryor: And you were involved, certainly, in one a decade earlier, in 2007, that had great influence.

04-01:27:25
Bell: Right. And I was in the workshop that came out with the report just last year, 2018.

04-01:27:32
Eardley-Pryor: When do you think that transition happened in the United States? When did they realize the message you were saying in 1992 was valid and needed to be revisited?

04-01:27:43
Bell: So, you know, things change over the decades. I think the recognition that we will depend on non-fossil fuel resources—the broadest way to call it—more and more in the future is becoming more evident—if not for everybody, certainly the scientific community is recognizing it. And as I've made clear in these reports, biomass conversion, solar energy conversion, CO_2 reutilization—all of these are going to depend on catalysis; you're not going to do it without it. So why not think about it today and develop the framework of thinking that will enable these technologies to come to the fore in the future?

04-01:28:33
Eardley-Pryor: Before we make a transition to talk about biomass conversion, I have a couple more people on the list that I wanted to know if you want to mention how you came to work on them in terms of zeolites.

04-01:28:42
Bell: Sure.

04-01:28:43
Eardley-Pryor: The first one is very early—Clay [Clayton J.] Radke—and then the other one is Kaidong Chen with Chevron. Could you talk about—those are different periods, clearly, in your research, but could you talk about them?

04-01:28:54
Bell: Right. So Clay is my colleague here in chemical engineering. And when I was starting to work on zeolites, I was also involved with administrative work, and so I wanted a partner to share some of the load. Since Clay is very knowledgeable in the area of colloid chemistry and related things, I thought that that he would be an appropriate partners, so I offered him to join forces with me—which he did, and we had a very enjoyable time working together for that period on zeolite synthesis, but it didn't continue beyond that.

04-01:29:34
Eardley-Pryor: And that was, in part, you were looking at partners because of your work as chairing the department at this time?

04-01:29:40
Bell: Yes, yes. Mm-hmm.

04-01:29:41
Eardley-Pryor: That makes sense. And with Kaidong Chen? How did you come together?

04-01:29:44
Bell: So Kaidong was a postdoc, and he worked with Iglesia and me. And he was very effective. And then he went to Chevron, and he's had a wonderful career there.

04-01:29:56
Eardley-Pryor: Oh, I see. I didn't know he went to Chevron from working with you as a postdoc.

04-01:30:00
Bell: Well, he worked as a postdoc, and he was immediately hired to Chevron. Yes.

04-01:30:04
Eardley-Pryor: That's great. Well, let's take a break here, and then we'll transition to talking about your work in biomass conversion.

04-01:30:10
Bell: Okay, good.

[Break in recording]

04-01:30:12
Eardley-Pryor: All right, Alex, let's continue to talk about your research in biomass conversion. Just to get us started, can you explain what biomass conversion is?

04-01:30:20
Bell: Yes, sure. So biomass conversion—the concept is that you would use biological material—grasses, woods, what we do currently is cornstarch—and convert this into a fuel for transportation. The basic concept is that nature takes carbon dioxide out of the atmosphere and together with water and sun light converts it into a carbohydrate—so these are the sugars from which most biomass consists. And then you harvest that material and process it in one way or another to produce things that look like motor fuel—either gasoline or diesel, or aviation fuel. And in the early 2000s, again, because of the trade imbalance in fuels—this is just before the discovery of shale gas and then shale oil and the US becoming a net exporter, eventually, of petroleum—that the country was feeling the sense that there should be a—and the world, for that matter—there should be a sourcing of fuels from biomass. And one of the leaders in this area was Lord [John] Browne, who was the CEO of BP. And he proposed to BP that there should be a major program, both in-house and out-of-house, devoted to this area.

04-01:31:57
Eardley-Pryor: And this was around the time that BP is shifting its identity from being explicitly known as British Petroleum.

04-01:32:03
Bell: British Petroleum to BP, informally known as Beyond Petroleum.

04-01:32:07
Eardley-Pryor: And their emblem changed to the green sundial, the sunflower

04-01:32:10
Bell: Right.

04-01:32:10
Eardley-Pryor: So this was something that wasn't just part of a marketing ploy, this was also a readjustment within the company.

04-01:32:17
Bell: That's right, that's right. So there was a call for concepts and proposals put out internationally.

04-01:32:25
Eardley-Pryor: You had mentioned, too, your previous funding with BP on methane conversion.

04-01:32:29
Bell: That's right.

04-01:32:30
Eardley-Pryor: And there was a call around a similar time period?

04-01:32:33
Bell: That call was earlier. This call came out in around 2005, so its five years into the other program.

04-01:32:42
Eardley-Pryor: I understand. Okay.

04-01:32:44
Bell: So the call came out, and BP was very much focused on biological processing—so not unlike what was already being done with cornstarch to ethanol. They thought that other enzymes could be used to break down lignocellulosics. So this is grasses and wood, where there are three components: there's the lignin, an aromatic component, and the carbohydrates are divided between hemicellulose and cellulose. Hemicellulose is largely five-carbon sugars, and cellulose is six-carbon sugars. So, biological processing—enzymes for hydrolyzing the carbohydrates into sugars and then fermenting the sugars to useful fuels. And so they put out a call—and I've forgotten how many universities both in the UK and the US responded. Eventually, there was a site visit here to the Chancellor's office, and I was

asked to participate in that, since I had already created a program with BP and knew about the ins and outs of their patent requirements.

04-01:34:09
Eardley-Pryor: Who else was a part of this meeting—the meeting from this second call with BP, around biomass conversion?

04-01:34:16
Bell: So this would have been here [at Berkeley], Graham [R.] Fleming, who was our vice president for research; Jay D. Keasling, who was one of the leaders in synthetic biology; Harvey [W.] Blanch, another colleague, who was doing biomass conversion from corn to ethanol—he had worked on that since the eighties. And there were people from other departments here—the molecular and chemical biology groups here. So it was a large group in the Chancellor's office. And since I knew the VP for research, Steve [Steven E.] Koonin, from my other BP program, during a break, I asked them if they were interested in any catalytic conversion. And I remember his response was, "Yes, I know where you're coming from, and no, we're not interested." So I took that in stride.

And eventually, the Berkeley team won the contract. So the idea was that we would be funded for ten years at $50 million a year—not quite all going to Berkeley. There would be $15 million out of that going to support BP employees working here at Berkeley, embedded into the center, into the institute. Another roughly $10 million went to the University of Illinois, which had been partnering with us, and so they were going to do the agricultural part, because they have a field station there where they were going to grow the biomass and monitor it and play with it. And we would do the processing. So that's how things got started.

04-01:36:08
Eardley-Pryor: That's a significant investment from BP.

04-01:36:10
Bell: That's a big investment, yes—$50 million a year for ten years. So, a big commitment.

04-01:36:14
Eardley-Pryor: Yeah, huge. And to even have some of their own hires here, embedded at Berkeley.

04-01:36:19
Bell: That's right. Right. Including, eventually, Paul Willems, who was the [BP] vice president for biomass conversion—and he came a few years later, but he lived here until he retired from the company. So the EBI, Energy Biosciences Institute, got started.

04-01:36:39
Eardley-Pryor: Here at Berkeley, that's what the BP funding enabled?

04-01:36:41
Bell: Here at Berkeley, right. And the way they got started is, they put out a call—now, internal to Berkeley—for proposals. And first of all, they hired a director, Chris [R.] Somerville, who was a professor of microbiology at Stanford, and he came over to Berkeley. He got a faculty position, and he became the director of the institute. And during this period where there was a call, I managed to see him—and I've forgotten what context—and asked again whether I might turn in a proposal along the lines of using ionic liquids and then chemical catalysts, and this would be jointly done with Harvey Blanch. And he said "Certainly. Why not?" He wasn't fully convinced that biology would be the winner at the end of the day. And so Harvey and I turned in a proposal and got it funded.

04-01:37:44
Eardley-Pryor: Well, tell me, where did the idea come from to use these ionic liquids?

04-01:37:47
Bell: Well, looking at the literature, it was known that ionic liquids would dissolve plant matter very effectively—so they're sort of super solvents. And this would allow you to disentangle the lignin—the aromatic part—from the carbohydrate part, which is the first step.

04-01:38:07
Eardley-Pryor: And you want to isolate those carbohydrates?

04-01:38:09
Bell: Right. And then we thought we might even be able to do some of the subsequent processing in the ionic liquid—or at least I did. Harvey was still wedded towards more biological processing, so he wanted to recover the carbohydrate and then use more traditional biological methods.

04-01:38:29
Eardley-Pryor: Well, tell me how that worked. So it sounds like you and Harvey had different methodologies for how you'd use these [carbohydrates].

04-01:38:33
Bell: We did, yes. So we had a common set of funding, which we divided more or less in half. And I did my thing, he did his thing. We wrote the quarterly and annual reports together, but we didn't really co-supervise students.

04-01:38:53
Eardley-Pryor: And your interest in biomass, it came out of—because you saw that there was a meeting and you thought—?

04-01:38:59
Bell: Yes, I saw that there was an opportunity to do some interesting chemistry. The starting materials are not awfully complicated—these sugars. And I had read an interesting review by Avelino Corma—who's a leading catalyst researcher in Spain, in Valencia—and George [W.] Huber, who was a postdoc of his at the time. George is now on the faculty in chemical engineering at University

of Wisconsin. And this looked intriguing. So that's what I knew about biomass, and I decided I could teach myself about the rest as we went along.

So we got the funding and we got off to a start. We had actually laboratories for this work in the Calvin Lab. It was originally thought it would be a building built at LBNL, but that didn't work out. So we had temporary space in the Calvin Lab, it was a circular building, until the Energy Biosciences Building was built a few years later.

04-01:40:15
Eardley-Pryor: And where did they put that?

04-01:40:16
Bell: They put that on the corner of Hearst and Parker. And so my labs moved down there. It's a fifteen-minute walk from here, but very nice labs.

So we got started. We bought equipment for that work. And our first thrust was to see how much biomass you could dissolve in various ionic liquids and then see if we could depolymerize the hemicellulose and the cellulose. And yes, sure, you could do that; the problem is that the solvent is so good, you can't get the stuff out—the products out. And this is a big problem, because if you can't get the products out, you can't recycle the solvent. An even worse problem is that biomass has water in it, so you contaminate the solvent with water, the water is hard to get out of this super solvent. And the super solvent is fairly expensive. So for the first, I'd say, three years, we did what we could with it—demonstrated that we could get products, but we couldn't convince BP that this was a way to go forward.

04-01:41:38
Eardley-Pryor: Because you couldn't continue using the same reagents?

04-01:41:39
Bell: Economic analysis showed that you couldn't afford to process the material. So at that point, I said, "Fine"—you don't want to give up good funding—and I said, "I'll assume the sugars are coming from somewhere, you know? You guys will do it biologically, up front, and I will convert the sugars into fuels," which is a lot easier to do.

So we started working on the fundamental problem, which is taking the oxygen out. So biomass has one oxygen per carbon. Motor fuels have almost zero oxygen per carbon, so you have to remove the oxygen. One of the easiest ways to do this is to dehydrate the sugar and make what is called a furan, which is a five-membered ring with a carbonyl group on the side and one in the ring. And this material has about half the oxygen than the starting material does, and you throw out water as the other part.

04-01:42:47
Eardley-Pryor: Do you simply heat it off?

04-01:42:51
Bell: You can distill it off, yes. That's not a problem. In fact, that's how furans are made commercially. So we were able to do that. Then we wanted to open the ring, do chemistry with these intermediates. So it's furfural and 5-hydroxymethylfurfural are the two products you make. And so we figured out a catalyst that would open the ring, make linear products, couple these in different ways, and eventually make very good diesel fuel. And if we could make longer chain starting materials, we even made lubricants this way. So the chemistry was not super fundamental that we did, but we did work with model compounds and intermediates—and could follow all the chemistry all the way and tell what kind of properties we needed in the catalysts.

04-01:43:52
Eardley-Pryor: What kind of catalysts did you choose to open up this ring?

04-01:43:55
Bell: We tried zeolites, but zeolites poisoned very quickly, because the sugars build up and then they make carbonaceous junk inside. So we largely worked with supported metals and supported metal oxides. Niobia on titania or silica turned out to be particularly good. And then we had some metal oxides promoted with a little bit of metal, like silver or gold, which worked very well.

04-01:44:27
Eardley-Pryor: How do you make those kinds of choices?

04-01:44:33
Bell: About which material to use?

04-01:44:33
Eardley-Pryor: Particularly the catalysts, yeah. Which do you experiment with first, and why?

04-01:44:37
Bell: Yes. So a lot of it is, again, trading on your understanding of the basic organic chemistry—for example, you want to have Lewis acids in the catalyst that will interact with the oxygen. Niobia is a very strong Lewis acid, so it's not an unintelligent choice.

So we got started. And eventually, we worked up to the point where we could show how you could make a group of what are called synthons by organic chemists—these are building-block molecules. And these are all either aldehydes or ketones. So an aldehyde has a carbonyl group and a hydrogen on one end and an alkyl group on the other; a ketone has two alkyl groups and a carbonyl group in the middle. And there are various ways in which you can get to these ketones. The nice thing about the ketones, now, is that you can do what's called aldol condensation with them. So you condense them; you throw out water and CO_2—not a problem throwing these things out, because they're coming from the biomass. But now you get a longer product, to which you can add hydrogen and make either alcohols—branched alcohols—or branched alkanes, which are just perfect fuels.

04-01:46:11

So we did that. We found we could also make condensed ring products which are called enones—so it's a cyclohexenone core—it's a six-membered ring with a double-bond here and a ketone—a carbonyl group that's within the ring, and then it has four alkyl branches—these are purely hydrocarbon branches—on it. You can then hydrogenate the double-bond and convert—get rid of the CO over here, convert it into an alcohol, and then clip that off as water. Now you have a cyclohexyl derivative with four branches on it. And the boiling point of these materials simulates very closely that of diesel and jet fuel. So we made simulated boiling curves and showed that this would work. And so we have some joint patents with BP in this area.

04-01:47:14

Eardley-Pryor: Well, I was going to ask you about the process in making these choices on the more successful routes that led to these lubricants and these simulated diesels. With the first effort that didn't prove economically feasible, was there a real strong effort on your part, or perhaps from BP, saying, start making choices that are different, to find ways that are more economical?

04-01:47:40

Bell: So the economical part was really the responsibility of BP. We wanted to at least start from a place that BP didn't think was mission impossible, so we did that. And again, my interests and those of the postdocs and students who worked on this effort were to focus on laying out the basic organic chemistry and some catalysts that would make the whole thing work. So we have a road map of how you would do this, and we published a paper in *Accounts of Chemical Research* summarizing this a couple of years ago.

And so it's doable—not only doable, but we showed in a life cycle analysis study that we did together with Corinne Scown from LBNL that it is going to save something like—it would result in an 82 percent reduction in CO_2 emissions from the processing of the materials to make the final product, relative to petroleum. So that's a big step forward.

04-01:48:55

Eardley-Pryor: Is it essentially because you're starting already with a bioproduct?

04-01:48:58

Bell: We're starting with green carbon, which came out of the ground, rather than with black carbon, which came out from below the ground, so we have a good green footprint. We didn't do an economic analysis—that's far too complicated and beyond our skill set. And then we were encouraged by BP to think not so much about fuels, which have a low markup relative to the starting material, but to think of more valuable products. And so we were steered towards lubricants.

So today, synthetic lubricants are made from polyalphaolefins—these are materials that come out of petroleum or are made from petroleum. And they have wonderful properties—low viscosity, at even 40 degrees C and 10 degrees C. And a viscosity index, which tells you how fast the viscosity changes with temperature. So with essentially the same number of carbon atoms—about thirty-three carbon atoms—we were able to make branched ethers, which had even superior properties than the polyalphaolefin base oils. And so we put in for a patent—a US patent—and we just had that granted this past year.

04-01:50:29

Now, all of that looked good. And now we're past 2010 when you had the BP spill in the Gulf of Mexico, and BP is contending with the costs of that accident, that tragedy, and things are getting tighter and tighter. We're being asked to be more and more relevant to BP, okay? So we try to be relevant and responsive.

04-01:50:59
Eardley-Pryor: Well, I want to ask you about that process. I mean, you have this long-standing work with the DOE up on the hill [at LNBL], but that's a different kind of funding institution relationship than with a private entity.

04-01:51:12
Bell: That's right, completely different.

04-01:51:13
Eardley-Pryor: So when you say that BP is encouraging you to pursue different avenues of methodology, how does that happen? How do they do that?

04-01:51:20
Bell: So the management is the one that communicates to this to you, in your reviews, okay?

04-01:51:30
Eardley-Pryor: So this is after you and Harvey are writing your reviews together?

04-01:51:32
Bell: Okay, so Harvey and I had, by that time, split and were no longer working together.

04-01:51:38
Eardley-Pryor: So this sugar work is something you did independently?

04-01:51:39
Bell: Yes, the sugar work is something I'm doing on my own, and Harvey's doing something else. And eventually, Harvey got out of BP funding and took all his money from JBEI—Joint Biosciences Energy Institute—which was funded at the same time, but by the DOE.

04-01:51:57
Eardley-Pryor: Oh, I see. Did you ever have any work that you did at JBEI?

04-01:52:00
Bell: No, no. I never even applied to them. Because it would have been a conflict of interest for me to do both, and I had more funding from EBI.

04-01:52:08
Eardley-Pryor: But these were two different massive funding sources around biomass conversion on campus?

04-01:52:10
Bell: That's right, yes. Yes. But JBEI was really 100 percent devoted to biological processing, whereas here there were, I think, four or five people out of the thirty-five PIs who were doing chemical processing.

04-01:52:29
Eardley-Pryor: And that's what you were able to do up at the EBI?

04-01:52:32
Bell: Right.

04-01:52:32
Eardley-Pryor: Or, I guess, down at the EBI. So when BP comes to you and says, "We're interested in doing a different methodology," it's the management here on site?

04-01:52:41
Bell: Well, they weren't saying change the methodology, because they didn't know what method would work. But they're saying, change the focus. So we would change the focus more towards lubricants. And we were successful. But when I kept asking, if you want further change, exactly what are you looking for? Well, they couldn't tell me—or they wouldn't tell me. Because here I'm starting to get into proprietary territory, you know. Instead, they would ask "But, what else can you do?" "Well," I said, "I can do lots of things," but I don't want to waste my time doing something and then being told, "No, thank you, that's not what we need." I want some guidance. And I could never get it.

So eventually, in 2014, I think it was, they came and said, "We're exercising our rights under the contract to phase out the program," which they did within another year. And everybody who was in there got cut off, including our dean, Doug [Douglas S.] Clark, and others. So that was an unfortunate transition. It was done very suddenly. So instead of having a ten-year run, we had a seven-year run of good funding with them.

04-01:54:02
Eardley-Pryor: And this, of course, happens in this context you've brought up of the Deepwater Horizon oil spill in the Gulf in 2010.

04-01:54:09
Bell: Right, yes.

04-01:54:10
Eardley-Pryor: Do you think there were other aspects that led to BP withdrawing its funding?

04-01:54:15
Bell: Yes. They didn't see how they were going to make money in the short term from biomass processing. They had a laboratory in San Diego, which they had been starting to beef up and do in-house work; they had bought a pilot plant in Florida from somebody else, and they sold that. So they collapsed all their internal work, and many good people left at the time—left the company and went elsewhere. It was unfortunate, because it was actually a very well-run operation when it was at its peak.

04-01:54:58
Eardley-Pryor: Do you think that there is a longer-term vision for biomass conversion?

04-01:55:04
Bell: In general? It's hard to see right now, for the following reason. First of all, the price of oil sank. US has more than enough oil to keep itself going and is exporting oil now for the first time in decades. Biomass is still at the cusp of a J-shaped curve. So if you plot the cost-per-barrel equivalent of petroleum versus various resources, starting with Saudi Arabian crude and march out on a scale that ends up at about 100,000 barrels—let's see, no, let me get the units right—I think it must be 100 million barrels a day, something like that—and the cost is rising from $10 per barrel up to $100. So this curve is fairly flat, and then it jacks up right about the crossing point of the cost and the demand. And that's where biomass from sugarcane sits. It's the first biomass raw material that you would use.

04-01:56:25
Eardley-Pryor: Not corn?

04-01:56:27
Bell: Not corn. Corn is only economical because it's subsidized. It has a marginal net production of energy relative to all the petroleum products used for driving the trucks around and processing—driving the water out of the ethanol—and it's only a modest saver on CO_2. So if your objective is to minimize CO_2 emissions, don't do starch to ethanol—cornstarch to ethanol.

04-01:57:00
Eardley-Pryor: Start with the sugar from cane?

04-01:57:01
Bell: Yes, right. So sugarcane is probably the best—that's using the sucrose from sugarcane. The next one would be to use some of the hemicellulose from sugarcane. Beyond that, you'd go to Miscanthus giganteus—it's a wild grass that grows in the Midwest, sort of related to bamboo. And switchgrass is another one. So these are wild grasses that grow very heavily on land that's not very good for agriculture—for producing food—and have lower water demand and almost no fertilizer demand.

04-01:57:47
Eardley-Pryor: Well, that sounds like that would be a promising avenue to pursue then.

04-01:57:49
Bell: Yes, but the problem is gathering the stuff and taking it to the processing plant. So unlike petroleum that you can pull out of the ground and put it in a pipe and send it to the refiner, here you don't have the equivalent.

04-01:58:03
Eardley-Pryor: Because those plants aren't built on those, or near those, locations?

04-01:58:06
Bell: Well, you have plants, but you can't afford to take the plant matter more than about 100 miles away, 120 miles away. So that's one of the problems. So there are multiple reasons why biomass isn't being as actively pursued as it was.

04-01:58:25
Eardley-Pryor: Part of them is, you mentioned, cost and the affordability of oil and the natural gas/oil boom.

04-01:58:30
Bell: That's right, yes, right. Yes, I've read a lot on this subject. The place where you're not going to get away with electrifying transportation is for aviation and ships—and eighteen-wheelers that go across the country—the batteries are just too heavy for the eighteen-wheeler to justify what you need. So that's about 30 percent of all transportation fuel in these three areas. And so I'm convinced that at some point, you'll have to use the carbon from either biomass or CO_2 recapture from the atmosphere and rebuild.

04-01:59:14
Eardley-Pryor: Not for economic reasons, but more for environmental reasons?

04-01:59:17
Bell: That's right, yes.

04-01:59:17
Eardley-Pryor: The tipping point will not be because of cost?

04-01:59:20
Bell: That's right. The turning point will be environmental reasons. But one doesn't see that happening any time in the near future.

04-01:59:29
Eardley-Pryor: Are you still pursuing biomass conversion as an avenue of your research?

04-01:59:33
Bell: So once the EBI support collapsed, I let go of the two postdocs I had.

04-01:59:41
Eardley-Pryor: Who were those people that you were working with?

04-01:59:43
Bell: So one was Shylesh, who's named here—Sankaranarayanapillai. And the other one is not on our list— Deepak Jadhav. So I let them go. Julie Rorrer was the graduate student who was left, and I easily moved her into the DOE program, because she was doing more fundamental work. And that's worked out very well. Moreover, she had an NSF fellowship, which made it even easier for me.

04-02:00:26
Eardley-Pryor: And she comes from a long line of chemical engineers, I understand.

04-02:00:29
Bell: Yes, her father is a chemical engineer at Oregon State.

04-02:00:33
Eardley-Pryor: Do you have other thoughts in thinking about biomass conversion—what you've done or where it might go?

04-02:00:40
Bell: So I think ultimately it probably will go towards chemical processing, because the time required for chemical processing is a lot shorter. So to process the same amount of material, you require a smaller vessel. And the capital cost is very much tied up with the vessel size. So if you want so many thousands of barrels a day productivity and your vessels have to be million-gallon drums which you have to keep clean, that's almost a non-starter.

04-02:01:18
Eardley-Pryor: But it's not a part of your research now, because the funding is not there for it.

04-02:01:20
Bell: No. No, I don't have specific research to work on biomass.

04-02:01:27
Eardley-Pryor: Well, do you have any other thoughts you want to share with regard to the topics we've covered today, before we end our session—from zeolite to the structure work and biomass conversion?

04-02:01:35
Bell: No, I think we've done a good job in covering these broad areas. And ending with biomass is appropriate.

04-02:01:43
Eardley-Pryor: That's great. Well, next time you and I meet, we'll continue your research discussions around electrocatalysis and also your work in theory that helped inform all of this work.

04-02:01:53
Bell: Right.

04-02:01:53
Eardley-Pryor: Great.

04-02:01:53
Bell: Okay, good.

04-02:01:54
Eardley-Pryor: Well, thank you, Alex.

04-02:01:54
Bell: Thank you.

Interview 5: March 25, 2019

05-00:00:00
Eardley-Pryor: I am Roger Eardley-Pryor from the Oral History Center at UC [University of California] Berkeley's Bancroft Library. We are here for interview session number five with Alexis T. Bell, for your oral history. Alex, it's great to see you again.

05-00:00:13
Bell: Likewise. Pleasure.

05-00:00:14
Eardley-Pryor: The last time that you and I met, we discussed zeolite synthesis and biomass conversion. And today we are reserving our continued discussion of research around electrocatalysis and also your work in theory. Today is March 25, 2019. We are in Alex's office here on Berkeley's campus in Gilman Hall.

Today I was hoping we could start the discussion of electrocatalysis with your discussion of the basic research report, *Catalysis for Energy*, that you helped make possible in 2007. And I'm especially interested in you talking about the cover design, and how that cover design relates to what you included in this research report. Could you talk me through some of that?

05-00:00:59
Bell: Sure. So the background for this Basic Research Needs report—or BRN as the DOE [Department of Energy] calls it—*Catalysis for Energy* was that the DOE periodically carries out studies of basic research needs that then serve as a road map for their future programs. The approach for developing a BRN is to collect people to do a workshop, the workshop is then written up, and the basic ideas in the workshop are put into the report. So Bruce [C.] Gates at UC [University of California] Davis, Doug Ray at Pacific Northwest National Labs [PNNL], and I were invited to be the co-organizers of the workshop, which we did. And then Bruce and I ended up being the principal writers of the report. So we held a two-day workshop in Washington, DC with probably sixty attendees, who then were broken out into five parallel sessions to discuss various aspects of catalysis and to draft recommendations and observations.

05-00:02:10
The interesting thing is that when you work with this many people, and even if you have five coordinators, what you get at the end is a collection of very differently written documents. So we were tasked with blending these together so that it was written with one voice and one frame of mind. And to make a long story short, Bruce and I discovered that it was not possible to simply edit the five documents. We had to take the essence and the content of these documents and rewrite the 200-page report ourselves.

05-00:02:47
Eardley-Pryor: A more substantial effort than I imagine you thought at the front end.

05-00:02:49
Bell: It was much more substantial than we had imagined. So we did that. The report was issued in early 2008. A part of the effort was also to design a cover. And I, on a piece of paper, just scratched out with a pen what I thought would be an interesting idea—starting with sunlight, going to plants, converting plant matter via various catalysts into fuels. A graphic artists at PNNL was then hired to turn this into a professional graphic. So what you see on the cover—and I'll show it to you here—is what resulted from our efforts.

05-00:03:40
Eardley-Pryor: And the backside, too. Because it begins on the back.

05-00:03:42
Bell: Yes, and the back. It's all one piece of artwork.

05-00:03:45
Eardley-Pryor: Could you talk about that piece—what you are actually seeing from that top left on the back cover, all the way around to the front?

05-00:03:51
Bell: Yes, sure. So since the workshop and the report talked a lot about using solar energy directly and solar energy to grow biomass—

05-00:04:03
Eardley-Pryor: Which was a big part of your research at the time, especially, and continues to be.

05-00:04:05
Bell: —which had been a big part of the research—and then convert the biomass into fuels. We decided to integrate all of this into one thread, and to show on the backside an enzyme catalyst for breaking down the biomass, various inorganic catalysts on the front side for taking the smaller fragments and converting them into things that looked more like fuel. So this was my brainchild, and I'm very happy with the way the graphic artist put it together. I should note that we did not consult with the people at the DOE about this. In fact, they were supposed to give us their blessing, and they forgot to do this. But when it was all said and done, the head of the Chemical Sciences Division was very happy with the artwork.

05-00:04:56
Eardley-Pryor: And since then, haven't you even seen the same model repeated in other reports?

05-00:05:00
Bell: Yes, I have. Yes.

05-00:05:01
Eardley-Pryor: For example, I believe you told me the Chinese have, in some of their reports, taken that same sort of artistic representation.

05-00:05:07
Bell: They've taken the same strategy, basically. Yes.

05-00:05:10
Eardley-Pryor: And you even were able to include zeolites on the front cover.

05-00:05:12
Bell: I included zeolites on the front cover, that's right—and a small metal particle, and a graphic of a molecule on the cover. So this integrates all the forms of catalysis, the fact that theory is included as well as experiments in biomass and solar energy. So it's a unifying thematic.

05-00:05:35
Eardley-Pryor: It, in some ways, encapsulates a big part of your research trajectory in catalysis, as well.

05-00:05:40
Bell: That's right. Yes, it does. Yes. And it predates my work on electrocatalysis, which was highlighted in the report and noted as something that would be important in the future—both water splitting to produce hydrogen as an energy carrier for solar energy, and to reduce CO_2—taken either from fixed industrial sources or, ultimately, from the atmosphere, and convert that into fuel, as well.

05-00:06:12
Eardley-Pryor: Can you tell me a little bit about how this basic research report eventually helped lead to the creation of the Department of Energy's call for what became known as Energy Hubs, or these Energy Research Frontier Centers?

05-00:06:23
Bell: Right. Mm-hmm. So it took a couple of years, but after the report was issued, the Department of Energy, particularly the Chemical Sciences Division, formulated the notion of the Energy Frontier Research Centers. And subsequently, when Steve Chu became the director of the Department of Energy—

05-00:06:45
Eardley-Pryor: Steve Chu, the Berkeley[-trained] PhD.

05-00:06:48
Bell: Yes. And he had been the director of the [Lawrence Berkeley] National Lab [LBNL] here, as well as a member of our physics department.

05-00:06:59
Eardley-Pryor: And Nobel laureate, at that.

05-00:07:00
Bell: And a Nobel laureate, very much so. When he moved to the DOE, he decided that there should be, in addition to the Energy Frontier Research Centers, hubs, which would be a central part coordinating work at other laboratories on some big theme. So the Joint Center for Artificial Photosynthesis [JCAP] was

created as one of these hubs. There was another one on nuclear energy and eventually one on batteries—JCESR [Joint Center for Energy Storage Research], it's called. And these are large programs.

05-00:07:41
Eardley-Pryor: And one of them eventually became very influential here at Berkeley, with your involvement.

05-00:07:46
Bell: That's right.

05-00:07:48
Eardley-Pryor: But let's step back, before we get into that, to talk a little bit about how you mentioned electrocatalysis in this report, but it hadn't been yet a part of your research, actual work [yet].

05-00:07:58
Bell: That's right. That's right.

05-00:07:59
Eardley-Pryor: When and how did that develop, where it became part of your work?

05-00:08:02
Bell: Well, that happened in a natural way not long after the report was issued, when Paul Alivisatos, who was then division director at LBNL, launched an effort to create the Helios Center, and under that the Solar Energy Research Center [SERC]. And this eventually was funded at $15 million a year for about three years.

05-00:08:30
Eardley-Pryor: Was that also from DOE, the SERC?

05-00:08:32
Bell: It's also DOE, yes. The idea was to use solar energy directly to produce fuels. And of course it was always obvious that electrocatalysis would be a part of this. So I wanted to join the effort, and I was involved in helping write the proposal for that center. And I volunteered to adapt and apply the techniques that I had used for studying gas-solid catalysts for liquid-solid catalysts in an environment where electrocatalysis is happening.

05-00:09:10
Eardley-Pryor: What were the thoughts that you had about how to translate this previous work you had done into this work that involved liquids?

05-00:09:18
Bell: I quickly discovered out that it was going to be hard to do infrared spectroscopy, because the water absorbs a lot of infrared energy. So we decided to work first on Raman spectroscopy, in which you use a visible laser—a visible frequency laser—which will pass through the water to interact with the surface and take the scattered light out. And we developed one of the

first in situ methods for looking at the surface of an electrocatalyst while it's working, and looking at how it changed its oxidation state as you applied a higher and higher potential.

05-00:10:00
Eardley-Pryor: How did you go about developing that, and with whom?

05-00:10:02
Bell: Well, I hired a very bright young man, Boon Siang Yeo, from Singapore. He had done his PhD in Switzerland, and he came here. And he had done some Raman spectroscopy as a part of his PhD studies, so it was natural. We acquired a Raman spectrometer and set it up, and together we designed a cell for doing this. And it was a very clever idea, that you had to put the optics very close to where the catalysis is occurring, less than a millimeter away. So he developed a way to put a little Teflon-like layer, a coating, on the lens so we could dip it into the electrolyte, which was at pH 13—it's very alkaline—and it would have destroyed the lens otherwise. It would have corroded the lens. And so we took this $650 lens and bathed it in alkaline solution and protected it and were able to get very good-quality spectra this way. So this, again, was an example of innovating as the need required.

05-00:11:22

So we started the work with him. We observed these transformations of metallic catalysts into their oxide and oxyhydroxide forms. And that was the beginning of our work.

05-00:11:35
Eardley-Pryor: And that was through SERC again?

05-00:11:36
Bell: This was through SERC, right. And that lasted three years, just about the time Boon Siang left and went back to Singapore to become a professor at the National University of Singapore. And then it was followed by Shannon Klaus, a graduate student, and others who worked on this project and related things.

Ultimately this work led to a study of iron-promoted nickel hydroxide. It's a material that had been known for a long time to be a very good water-splitting catalyst, because it works with nonprecious metals, it works under alkaline conditions, but there were some misconceptions about why it worked and how it worked. And so we used a combination of Raman spectroscopy, done here at Berkeley, with synchrotron radiation studies, which were done at SSRL, the Stanford Synchrotron Radiation Laboratory down at Stanford University.

05-00:12:42

And I put together a team of people at Stanford and at Berkeley who did this work, and a theorist, Michal Bajdich, who did the theory on why this iron-nickel oxyhydroxide worked. And we published a very influential paper in the *Journal of the American Chemical Society*, which showed, through the

Raman, the phase changes that occur in the catalyst. The synchrotron radiation studies were used to identify at what potential nickel underwent an oxidation from +2 to +3; that iron doesn't undergo such a thing; that the iron is located in places where it's substituting for nickel and finds itself in a very unusual environment, and as a consequence, those iron cations are super-active. We were able to verify this by doing the theory. So each part contributed to telling the whole story.

05-00:13:49
Eardley-Pryor: That's a great story to tell. Take me a little bit bigger-picture into the details of what's happening in this particular catalytic reaction that you're analyzing. What were your broader goals, when you began work in electrocatalysis, that you hoped to accomplish?

05-00:14:04
Bell: Well, the broader goals were first of all to develop and use spectroscopic tools for interrogating catalysts in their working state, which continues a theme that I had been doing all along with gas-solid catalysts—and, at that time, had not been heavily exploited for looking at electrocatalysts, even though electrocatalysis was a well-established field already at the moment. And as a result, there were some, what I would call hand-waving explanations for why things happen—chemical explanations which turned out not to be fully correct.

05-00:14:44
Eardley-Pryor: So there was some basic research that you knew you could contribute?

05-00:14:46
Bell: That's right. Yes.

05-00:14:49
Eardley-Pryor: What do you think the goals are long-term—the big-picture goals—in terms of this research in electrocatalysis?

05-00:14:55
Bell: Well, today, there are two broad themes. One is to look at the physical chemistry of what happens near the electrode surface. And we know from classical electrochemistry that there's something called a double layer. This is the layer where you get charge separation between the cations and anions, and that creates a field. The field influences what happens at the metal surface. The water molecules that are there are affected by the cations and they become polarized, and they can lend their hydrogen atoms to the surface more effectively than if they were not polarized; the surface polarizes things further by the charge you impose on it. All of this happens in a layer that is a few tenths of a nanometer, which means a few atomic layers thick—a very thin layer, and very hard to probe. So what we started doing already back then was using all available techniques to probe as much as we could and then infer what was happening and use theory to try and validate what was going on. So

we started back around 2007 on this, and twelve years later, we're doing this on a grander scale.

05-00:16:18
Eardley-Pryor: Tell me, what do you mean by that, on a grander scale?

05-00:16:20
Bell: Today we're asking more precise questions about, not so much water oxidation, which is what we started with, but CO_2 reduction, which is a far more complex problem. And we're asking, where does the hydrogen come from that results in forming hydrocarbons from CO_2? So you have to add hydrogen to the carbon, take away oxygen as water, and it's happening in a quite alkaline environment. It turns out that the water molecules that are riding along with the cations are the donors of the hydrogen. And they become sufficiently polarized near the surface that they hop off one carrier and onto the intermediates leading to hydrocarbons produced from CO_2.

So we know this in part from theory, in part from experiments. We know that the choice of cations affects the outcome—you can get faster reactions in cesium cation electrolyte than you do in lithium, for example. We proposed not so many years ago—about four years ago—why this happens, theoretically, showed that it could happen, and subsequent experiments done by other have shown that we were correct in our physical thinking. So it's one of the rare examples where theory leads experiments.

05-00:17:56
Eardley-Pryor: It sounds to me like the early work—the SERC and then what eventually became the Joint Center for Artificial Photosynthesis, the JCAP—was thinking about trying to mimic photosynthesis—I mean, the name JCAP itself.

05-00:18:09
Bell: In the name, it is, right.

05-00:18:11
Eardley-Pryor: But it's evolved since then to stealing carbon dioxide out of the atmosphere to create a fuel.

05-00:18:15
Bell: Right. So photosynthesis takes water and CO_2 out of the atmosphere and transforms it into carbohydrates, sugars. It's a very complex process which is fairly well known—most of its parts are well known—and it involves homogeneous catalysts. So the early thinking was, well, let's borrow from nature and make homogeneous catalysts. And this works to a limited degree—very limited degree—and the only products you can make this way are carbon monoxide—from carbon dioxide—and formic acid. But you don't form any of the things that are truly fuels.

05-00:18:59
Eardley-Pryor: Why is that?

05-00:19:00
Bell: Well, the catalysts that people have used are very different from the ones that nature uses, and nature doesn't make carbon-carbon bonds; it makes carbon-oxygen bonds—mostly. It makes some carbon-carbon bonds, but mostly carbon-oxygen bonds. And this is not what you want in a fuel, because a partially oxidized fuel has low energy density. So we've looked for ways to make carbon-carbon bonds and found that nature has already optimized that problem by picking copper. And copper still, to this day, after forty, fifty years of research on the subject, is the one metal that makes carbon-carbon bonds with high efficiency. So understanding that has been a part of our efforts, both experimentally and theoretically. Asking how could we make the next carbon-carbon bond, beyond making one, is the subject of current research. Because in fact, everybody finds that after you've made ethylene and ethanol, which only have two carbon atoms, there's very little that has three and even hardly anything with four carbon atoms in it. So this is a puzzle that nobody really understands and we're trying to probe.

05-00:20:24
Eardley-Pryor: What are the ways that you've attacked this new challenge—trying to probe to the larger carbons?

05-00:20:30
Bell: We're doing that largely with theory, because there's not a good experiment to tell you how to do this, so we're trying out various scenarios with theory to see if our thinking is correct. We're also trying to develop some model catalysts that don't look like a bulk metal, but have metal-like properties, like a cluster of copper atoms sitting—tethered to a board of carbon—graphene, to be precise—and seeing if it isn't enough to have just two atoms close to each other. It's almost a homogeneous catalyst, but most homogeneous catalysts just have one active center; this has two, or we could put in three or four, but not an extended metal. And so this is a concept—it may not work out—but at least we have a hypothesis for what might be important.

05-00:21:35
Eardley-Pryor: Tell me a little bit, too, about how you select the catalyst that you'll dive in on research for. You mentioned copper, and earlier you mentioned this iron-nickel catalyst. Why go for those particular metals?

05-00:21:49
Bell: In the case of the water splitting, it was already known for several decades that the iron-nickel-oxygen system was very good, but not how to optimize it or how it worked, so we put our attention on those subjects. And since then, there have been literally hundreds of papers on the iron-nickel oxyhydroxide material, but mostly on how to prepare it. It's produced in very thin layers that look like rags, and they align and make what is called double layers—so it's a layered compound, and you can get thicker or thinner sheets. But it's really only the outer sheets that are catalytically active, so making a lot of very thin,

rag-like sheets on a surface is important, and that's what the synthetic work has demonstrated.

05-00:22:45
Eardley-Pryor: Could you talk to me a little bit about the development of these research proposals? So you're up doing work at Berkeley Labs, at LBNL, and just on the wind you hear that there's going to be this solar energy emphasis? Tell me about how these sorts of things develop.

05-00:23:02
Bell: These things have developed with somebody taking the lead role in gathering people who might be interested and saying there's an opportunity—you know, we foresee an opportunity or we know that the DOE or some other agency is interested in this area. What do you have to propose? That's the way it starts. And there's a lot of chaotic talking around the table. Everybody sees the problem from their own perspective. Things get thrown out. Eventually, somebody has to pick up all the bits and pieces and synthesize out of it a coherent proposal. So I've done this for the electrocatalysis, both with SERC and twice now with JCAP—the first phase and the second phase of JCAP. And it requires reading the literature in a selective fashion to identify themes, looking at the work of very good people that you can trust, and then kind of building a picture of what you think are the interesting issues to look at.

05-00:24:13
Eardley-Pryor: And when you were considering contributing to the SERC effort, the first [major solar fuels] effort on campus here, you had already written the 2007-2008 report that mentioned the possibilities of electrocatalysis.

05-00:24:26
Bell: That's right.

05-00:24:27
Eardley-Pryor: How influential was your work in creating this report on catalysis to what eventually became your research?

05-00:24:34
Bell: Well, it helped. I drew on the literature that was in this report and referenced it, but then I had to read a lot more things about electrocatalysis, since I was a novice in this area, and put the pieces together. And I think the emphasis on spectroscopy was something that I could bring from the outside. That was new. The emphasis on doing in situ characterization, which I had done my whole career, was new. But now, for me, the challenge was to do this literally under water.

05-00:25:10
Eardley-Pryor: Talk to me a little, if you can, about the transition between what became SERC and what eventually became JCAP on campus. How did these things combine or shift?

05-00:25:19
Bell: So SERC was purely a Lawrence Berkeley National Lab [Lawrence Berkeley National Laboratory] project, funded by DOE. When Steve Chu announced the possibility of having a solar hub, then Nate [Nathan S.] Lewis, who had been working on similar things down at Caltech [California Institute of Technology], said, "This has to be a multi-institution effort, so let's partner with people at Lawrence Berkeley Lab and the campus, some people at Stanford, some at UC [University of California] Riverside, and San Diego." And so we had a number of, sort of brainstorming meetings held here, also at Caltech, to sort of listen to him and to also put our own thoughts down and articulate what we wanted. And as you might imagine, when you get twenty or so very bright, articulate people into a room, all hell breaks out. It's really chaotic.

05-00:26:27
Eardley-Pryor: What were your memories from that experience? I'd love to hear more.

05-00:26:29
Bell: Well, one of the memories was my telling the guy who brought us together to stop talking and let others speak, because he wanted to dominate the conversation.

05-00:26:39
Eardley-Pryor: This was Nate?

05-00:26:39
Bell: Nate, yes—who thought he knew everything, and about everything. And he knew a lot—he's a very bright individual. But, you know, he needed to listen to other people, as well. So getting others to listen is part of the challenge.

05-00:26:56
Eardley-Pryor: Was he receptive to your encouragement?

05-00:26:58
Bell: Sometimes. Yes. I had to speak up loudly, because I'm not a recognized expert in this area, so challenging one of the experts to tone it down and listen to others doesn't go over well.

05-00:27:14
Eardley-Pryor: But it is a theme throughout your career, [challenging entrenched ideas].

05-00:27:16
Bell: Yes, but I do this when necessary.

05-00:27:19
Eardley-Pryor: Well, tell me a little bit about how JCAP evolved from your first proposal to eventually what was your second. What was different between what you proposed through SERC from what your first proposal was with JCAP?

05-00:27:30
Bell: So there was some overlap, but we expanded the horizons, because we were going after $25 million a year for the various parts together.

05-00:27:40
Eardley-Pryor: Of JCAP?

05-00:27:41
Bell: Of JCAP. And we did talk about CO_2 reduction from the very start—electrochemical, photoelectrochemical. What was supposed to differentiate the JCAP effort is that it would be direct photons in, chemical products out, no wires in between the photoreceptor and the fuel producer. And this is something that JCAP struggled with from day one and is still struggling to maintain what I'll call the myth, that you can do this effectively. Because it's very hard. I mean, today there are some demonstrated examples where you can do direct photons to fuels, but the amount of fuel you make or chemicals you make is very, very small compared to what you can do by decoupling the electrochemistry and the generation of electricity by photovoltaics. And also, by decoupling, you eliminate all sorts of materials compatibility issues. But it's a source of tension, because the DOE wanted something brand new, and bringing it together would be brand new if you could succeed. But lots of years of work before us and subsequently continues to show that the best way to do it is to decouple these things, and bring them together as effectively as possible.

05-00:29:13
Eardley-Pryor: When you were mentioning the one example with the minute efficiencies, I'm thinking—I've heard of something called the artificial leaf that was developed [by Daniel Nocera]. Is that what you are talking about and had in mind?

05-00:29:24
Bell: No. This was developed by someone else. However, the concept of an artificial leaf has been used as a cartoon to represent what we're doing.

05-00:29:35
Eardley-Pryor: And that cartoon representation—what purpose do you think it served?

05-00:29:40
Bell: I think it captures the imagination. I think people are very amenable to having pictures drawn of what reality might look like, or trying to represent reality as we best know it, and this stimulates their imagination. Therefore, as I say, eye candy is always useful, and we work on that all the time—to put it into reports, into manuscripts, and so forth, but particularly when you're going out to the public in general.

05-00:30:15
Eardley-Pryor: And it's important for sparking the imagination to capture funding, and to encourage the work to be done?

05-00:30:18
Bell: That's right, that's right. Yes.

05-00:30:21
Eardley-Pryor: But from what I'm hearing, it sounds like it's not helpful in terms of what happens in the lab.

05-00:30:26
Bell: It tends to be overly simplistic. And the problem is that if you start believing it as you start doing your work, you're trying to verify the cartoon, rather than learn what really is there. And that's not helpful.

05-00:30:43
Eardley-Pryor: Had that been challenged in JCAP?

05-00:30:45
Bell: Oh, yeah. It's been challenged. Yes. Yes, it's been challenged. But nevertheless, we use cartoon chemistry to sell to the outside world.

05-00:30:57
Eardley-Pryor: To allow the work to happen. Tell me a little bit about how JCAP has evolved over its funding in 2010 until its continued funding all the way through the present—but it had been renewed. How has your work within JCAP changed?

05-00:31:10
Bell: So the first five years, even though we had the stated goal of converting CO_2, we found that regardless of how you do that, you're going to have to split water, generate reducing equivalents, and throw away the oxygen as just oxygen. And electrochemically that's a more demanding process, and one that needs a very efficient catalyst so that you don't waste a good part of your potential, which is your driving force, resulting in large ohmic losses in the cell. Electrical potential in electrocatalysis plays essentially the same role as temperature in thermocatalysis: if you want the reaction to go faster, you jack up the temperature; here, you jack up the voltage. Just as you don't want to have the reactions running at excessively high temperature, because the catalyst may not survive, here you don't want to have it going at excessively high potential, because you pay for that electricity, and it's wasted if it isn't doing chemical work. So this is the analogy and this is how it works.

05-00:32:43
Eardley-Pryor: To make it the most efficient reaction?

05-00:32:45
Bell: Yes, make it the most efficient. So we worked the first five years—my group worked on the electrochemical splitting of water. And then, as we were approaching the end of the five years, in year four, I realized that that's not going to be the future and started working on CO_2 reduction, even before we ended the first phase. It was the right decision, because the DOE at the end of the five years said, "Well, you've been reasonably successful in your first five years working on water splitting. Now you have to work almost exclusively

on CO_2 reduction in the next five years." So we had already a year of work done before we got the new proposal.

05-00:33:30
Eardley-Pryor: And how did that help you in the crafting of the new proposal?

05-00:33:33
Bell: Well, it gave us a running start. We got into it by reading the literature on CO_2 reduction, which is quite different from water splitting and oxygen generation. And we got to build some cells, make mistakes, discover how you build a good cell. We eventually wrote a whole paper on best practices for measuring CO_2 reduction. And this was motivated by the fact that if you looked at various papers, many researchers did one thing, but the next research group did something different, and you couldn't put the results together one on top of another—they weren't reproducible. So we evolved the best protocols to be used and published a paper together with our colleagues from Stanford on this subject.

05-00:34:34
Eardley-Pryor: I understand that you were also on the reverse site visit to Washington, DC for the renewal.

05-00:34:38
Bell: Yes, right.

05-00:34:40
Eardley-Pryor: What are some of your memories of that experience?

05-00:34:41
Bell: Well, it was an intense day and a half. We had a small team of, I don't know, six or eight people. The director, Harry [A.] Atwater[, Jr.], gave an overview of the accomplishments of the first five years at JCAP and an overview of where we'd like to go next. Then each one of the participating individuals talked about his or her part. Mine was to talk about CO_2 reduction.

05-00:35:13
Eardley-Pryor: What the future would be?

05-00:35:14
Bell: Yes, what it looked like. And it was well received. We got good questions from the DOE participants and went from there.

05-00:35:30
Eardley-Pryor: You had mentioned that Nate Lewis, who, at the very front end, was considering this very much his baby, the JCAP process.

05-00:35:38
Bell: Right.

05-00:35:39
Eardley-Pryor: But eventually he was no longer the administrator of it—Carl [A.] Koval came in.

05-00:35:43
Bell: Yes. Nate was the director for the first year and a half, almost two years. And it became evident to many of us here that he was taking this much too personally and took criticism personally and was not an effective director in the sense of listening to everybody and also responding appropriately to the comments from the DOE. eventually, enough people got agitated—and some even left JCAP because of this—that he was told by the president of Caltech that he was no longer the director. He took this decision very, very hard and was bitter about it, which is understandable. But then Carl Koval from the University of Colorado was brought in to be his replacement. Carl was a completely different personality—he didn't see himself as a superstar, didn't need to have his ego pampered all the time, and did, I'd say, quite a good job of saving our bacon in the first five years and then getting us ready to do the next five years. And then he retired just as we were completing the five-year period.

05-00:37:15
Eardley-Pryor: And is that when Dr. Atwater came in?

05-00:37:17
Bell: That's when Harry Atwater—Harry had been a part of the JCAP all along, and he was asked to become the director. In my opinion, he's been a very effective director.

05-00:37:26
Eardley-Pryor: Once this transition between Nate Lewis and Carl happened early in JCAP, did the research focus shift, as well?

05-00:37:36
Bell: Not really. We got more and more calls to do direct photoelectric chemistry, but some of us just kept doing what we thought was right, and others chose to follow. But you have so many people there that it—you know, nobody's going to tell you exactly what to do.

05-00:38:01
Eardley-Pryor: Yeah. There's plenty of opportunity.

05-00:38:03
Bell: Yes.

05-00:38:04
Eardley-Pryor: Can you share some of your visions for what you think the long-term products, technologies, will be from some of this research? What do you hope will come out of it?

05-00:38:15
Bell: So what I'd like to see is first of all a much more efficient way to produce hydrogen directly from water. Because you can store hydrogen in large quantities in caverns and run it back through a fuel cell and produce electricity. So if nothing else, it's a way to store electrical energy. The next thing would be to take out oxygen from CO_2. The question is, where are you going take your CO_2 from? Well, initially you could consider taking it from aluminum smelters, cement makers, iron makers, manufacturers, a few other sources where you have large amounts of CO_2 produced which otherwise are going into the atmosphere. So to do this, the price of electricity has to be low enough that the cost of producing a kilogram of the final product, chemical or fuel, is tolerable in the marketplace. And that means you have to make your photocatalytic process better and better—or you have to make your wind generator better and better.

05-00:39:38
Eardley-Pryor: So the first part of what you were talking about is storing the hydrogen. That needs to be more and more efficient to drive the costs down so that you can use electricity to capture the carbon that's coming out—or that would be coming out otherwise, of CO_2.

05-00:39:51
Bell: Right, right.

05-00:39:52
Eardley-Pryor: I see. How do you envision these things actually existing in terms of structure and the actual technologies? Size-wise, what are you seeing these things look like?

05-00:40:02
Bell: Well, they'd be huge enterprises. Because if you look at the tonnage of hydrogen made today, it's—well, it's small compared to the fuel industry, but it's still sizable. Most of it is used for making ammonia. You add hydrogen to nitrogen in order to make ammonia. So probably its first use would not be to make fuels but to make hydrogen as needed for chemical industry. And in fact, the Netherlands is thinking of converting all of its chemical industry to hydrogen derived from water, using photovoltaic things, and they have already signed contracts with a French firm to develop the electrolyzers. And this is a reasonable goal, and it's long-term, so it can be pursued. It's one of the first examples I know of.

05-00:41:10
Eardley-Pryor: What do you think about these ideas of a hydrogen economy? These ideas have been bandied around for decades.

05-00:41:16
Bell: So the hydrogen economy was something that [Arnold] Schwarzenegger popularized here in California—and the "hydrogen highway" was the term he used. If it's for driving automobiles, I'm not a big fan of it, because of the

huge—the multi-trillion-dollar infrastructure you'd have to build up. Right now there are something like twenty stations around LA, maybe another dozen or so up here in the North Bay, but they're far and few between. And you'd have to bring down the cost of making a hydrogen station—refueling station—cheaper and cheaper. They're about $2 million a pop right now. And you'd have to have many more of them in order to fuel the cars. So I think it's more likely that we'll see battery-driven cars—all-electric battery-driven cars.

05-00:42:18
Eardley-Pryor: Some of the visions I've heard, even around the ideas of the myth of this artificial leaf with JCAP, is to have individually distributed sources of energy, so you don't have to have these massive centralized forms of energy production.

05-00:42:34
Bell: Right.

05-00:42:35
Eardley-Pryor: But from what I'm hearing from you, it sounds like that centralized, massive form is the way that this technology tends to be moving?

05-00:42:44
Bell: I think so. I think that's the most efficient way. Things tend to get cheaper per unit of mass that you're producing with increasing scale. The cost of large processes does not scale up linearly; it goes sublinearly. Therefore, you get more and more value for the dollar expended with increasing scale.

05-00:43:05
Eardley-Pryor: In terms of thinking about the future, where do you see your research in electrocatalysis going?

05-00:43:12
Bell: I will continue to work on CO_2 reduction, with the idea of looking for materials that will produce more and more carbon-to-carbon bonds efficiently. And I will continue the basic work we're doing, both experimental and theoretical, on understanding what goes on in the double layer and being able to predict from first principles what happens on the catalyst surface.

05-00:43:38
Eardley-Pryor: That's great. Well, maybe that is an opportunity for us to transition into talking a little bit about theory, if you're thinking about the role that theory plays.

05-00:43:42
Bell: Sure, yes.

05-00:43:45
Eardley-Pryor: Great. Well, I think it might be nice to just even talk from the beginning. Eventually, we'll link your work on electrocatalysis in theory, we'll get to that. But to start at the beginning of some of your theory work, maybe even to step back and ask you, why do you think doing theory is important?

05-00:44:03
Bell: Sure. I think theory is important because it provides a way to explain observations that are made experimentally. I like to say—you know, give a short explanation to say that what you get from experiments are deductions. You make an observation and then you make a deduction. If the observations from many points of triangulation view give you a picture that is a set of deductions that are self-consistent, well, then you can draw a sketch of what you think is happening, or a computer graphic—but you don't really know that this picture is completely correct. What theory allows you to do is to develop a sense of how things may be happening in what I call a context-free manner. By this I mean theory that was not developed to answer a specific problem. For example, Newton's laws of motion is a context-free theory. It can be used to talk about the motion of, meteorites, planets, baseballs—anything—and it's still correct. So being able to use a theory like this to describe the behavior of atoms and how they assemble and how molecules are transferred is highly desirable. Therefore, a good theoretical framework allow one to develop an independent picture and then see if it's consistent with the one developed from the interpretation of experiments.

05-00:45:45

Beyond that, theory is useful for making predictions. So here's where the engineer comes in. The engineer says, I think I know how things work. Let me predict that it will be different if I change the components—either more active, more selective, or less selective, more active, or the reverse. So I think these are the things that theory can deliver.

And when I started working in this area, there was little reliable theory that you could call upon to address technical questions. It was pretty crude.

05-00:46:28
Eardley-Pryor: In catalysis?

05-00:46:29
Bell: Mm-hmm.

05-00:46:30
Eardley-Pryor: Why do you think that was?

05-00:46:32
Bell: Simply the level of development of quantum mechanics hadn't risen to where it is today. Not that the principles weren't known, but the computer architectures, the efficiency of code to solve the questions posed weren't where they are today. And so there's been a lot more improvement on computer codes—just raw improvement on the efficiency of computers that enable you to make quite significant calculations today.

05-00:47:11
Eardley-Pryor: Talk to me, if you can, about the role that you see theory playing in helping reduce time for analysis. That seems to be a theme that I saw in some of your theoretical interventions.

05-00:47:22
Bell: Mm-hmm.

05-00:47:23
Eardley-Pryor: How do you use theory as a way to reduce time-intensive empiricism, especially for catalyst development or design?

05-00:47:32
Bell: Right. So the first thing you want to reduce is time-intensive computation, which can be sometimes overwhelming. And so we use strategies that are not unlike what you do in engineering: you start somewhat sloppier than you'd like to be, in terms of convergence criteria; you get a result; and then you can always refine that to whatever point you feel necessary. And also, the level of theory development at a given point may limit how far you can get with accuracy and speed. So my ideal is that my coworkers submit a job during the day, get the results the next morning, and have the rest of the day to think about the meaning of what they computed and prepare themselves to submit the next job in the evening.

05-00:48:32
Eardley-Pryor: A human time-scale, to allow theory development to happen.

05-00:48:36
Bell: Right. Because if you are inundated with computer output and you don't have time to think and reason, then you won't see what is the purpose and meaning of the computations; you'll just be inundated with data.

05-00:48:49
Eardley-Pryor: Getting lost in the weeds of all the theory.

05-00:48:52
Bell: And data is not the issue; you want extract information from the data.

05-00:48:56
Eardley-Pryor: How is your work in theory different from empirical, experimental work in the lab? Is it funded differently?

05-00:49:05
Bell: Well, it's usually funded from the same sources as the experimental work. And the thinking is often guided by what we have learned from experiments, in terms of how do you model the catalyst, what do you think about, what kind of reactions may be occurring. So these would be the first things that we would try theoretically. If it doesn't work out for whatever reason—we find the energetics are too high or that physically you can't get one thing into that

space—then you have to relax those constraints and think out of the box—which we do, periodically.

05-00:49:43
Eardley-Pryor: What about writing or publishing theory? Is that different than writing or publishing your experimental work?

05-00:49:48
Bell: Not really. Most theorists want to make sure they're right by comparing to some experiments—so there's enough mistrust in their theory that they want some validation. And the question is, you know, is the validation always there?

05-00:50:08
Eardley-Pryor: Yeah. I've heard some debate within the simulation—computer simulation, especially molecular simulation—community about whether discoveries can be made with theoretical work alone through simulation work. What do you think about that?

05-00:50:23
Bell: I think discoveries can be made—if you inquire about parts of the landscape for which you have no other evidence. However, its best if some part of the landscape has been validated against direct observation because the predictions for conditions removed from those previously observed will be more likely to be correct. But otherwise, it's going to be difficult.

05-00:51:00
Eardley-Pryor: Do you need to have the experiment confirm discovery in theory or through simulation in order to make it a discovery? Or can simulation create a discovery outright?

05-00:51:13
Bell: It can create discovery.

05-00:51:17
Eardley-Pryor: Even without experimental backing?

05-00:51:19
Bell: Without experimental backing. But the framework in which you would apply the theory has to have some grounding in experiment. Otherwise, you can do a lot of churning and calculating things that are unreal. And so knowing to what extent your theoretical results are real is an important thing—to keep yourself honest all the time.

05-00:51:45
Eardley-Pryor: So there needs to be some applicability to the [theoretical discovery].

05-00:51:47
Bell: That's right, yes. There needs to be a reality check, at the end of the day.

05-00:51:53
Eardley-Pryor: In terms of how theory is looked upon by others—either here at Berkeley within the department, the chemical engineering community broadly, or by industry—how is theory perceived, in your experience?

05-00:52:07
Bell: So over the time that I've been doing it, which goes back to the early nineties, it's changed immensely. When I started, the old-timers, both here at Berkeley and elsewhere in the field, thought it was a total waste of time—that the theory was not good enough to give you anything realistic and that you were just trying to fool people by doing theory calculations—or wasting your time when you could have been doing better experiments. I think the issue is always, what question are you trying to answer, and do you have an experimental protocol that you can articulate and carry out which will answer the question unambiguously? If you can't, then you're stuck. You don't have the right tool to take the nut off the bolt. And so then the question is, will theory give you any more insights as to what the problem is? And sometimes, the answer is yes.

05-00:53:14

So that's where we started—and a lot of skepticism. I've persisted in applying theory to problem in catalysis, because I believe in playing what I call the long-range game and doing research for the long haul, not the short haul. And eventually you discover that yes, you have to climb a lot of hills, you have to improve your tools; just as you do with experiments, you have to ask more and more refined questions; you have to see if your theory holds up as you do this. But then you look around and, Hey, everybody else is starting to do the same thing. And today there is almost no experimental paper in the literature that isn't accompanied by some level theory.

05-00:54:02
Eardley-Pryor: That seems like a big change in the field itself.

05-00:54:04
Bell: Yes, it is. However, today one of the problems is that because theoretical results can be displayed nicely with molecular structures that are visually appealing, there's an increasing amount of what I call "decorative" density functional theory [DFT] – calculation that are done to decorate the article but do not really address these central issues or even may not be valid.

05-00:54:34
Eardley-Pryor: Oh, like, DDFT?

05-00:54:35
Bell: Yes, right. And I've started to use this term—and I use it sparingly, because I don't want to disparage people or improperly criticize them. But it is true, that a lot of articles have a little decoration—two or three plots at the end to show that the authors' sophistication.

05-00:54:57
Eardley-Pryor: But they're not necessarily meaningful.

05-00:54:58
Bell: Correct. And, in fact, such calculations do not contribute anything.

05-00:55:01
Eardley-Pryor: Maybe if you could talk a little bit about the different kinds of theory that you've done over time?

05-00:55:07
Bell: Sure.

05-00:55:07
Eardley-Pryor: And I have in my mind thinking, like, computational theory versus statistical mechanical theory, and then eventually the quantum mechanical theory. Can you talk about what these things are?

05-00:55:14
Bell: Right, right. So I've done various kinds of theory. The earliest work we did was what's called continuum representations and simulations. So you treat matter as if it's continuous—you don't worry about molecules and atoms. For example, a fluid has a continuous density, a viscosity, a thermal conductivity. Solids, gases—the same thing. And you could look at representing what happens in a plasma as saying it has a conductivity—you don't have to look at the electrons and cations and talk about individual particles. At this level, one write down differential equations for mass and heat transfer as functions of concentrations and temperature, respectively. You can also introduce chemical kinetics into these differential equations. You then solve this set of very highly coupled differential equations together with an appropriate set of boundary conditions in order to obtain concentration and temperature profiles as a function of space. So that's the first kind of thing I've done.

05-00:56:27

Then you have what I'll call molecular and atomic scale calculations—these are called by chemists electronic structure calculations—which involve quantum mechanics. Now you're talking about the principles of quantum mechanics being used to solve for the distribution of electrons that create the bonding between the atoms. And there are various ways to do that with increasing accuracy or less accuracy. So that's the—actually, the third kind of theory I got involved in with Arup [K.] Chakraborty when he first came here to Berkeley.

Another one would be statistical mechanics, which is asking, what's the probability of my finding myself here versus there versus here, and how does that relate to the strength of interaction in the various locations? So this is the kind of theory that I did with Doros Theodorou when I hired him here.

05-00:57:35
Eardley-Pryor: And this was more around the lines of the Monte Carlo methods and pushing those forward?

05-00:57:40
Bell: About what?

05-00:57:41
Eardley-Pryor: The statistical mechanics, the statistical theory—is that more along Monte Carlo methods and advancing those?

05-00:57:46
Bell: Yes, it involves Monte Carlo methods for the statistics. This is how you move—you choose your moves and whether you accept them or not. There's molecular dynamics, which involves solving Newton's laws of motion in time. And you can explore space, and if you explore enough space with one method you get the same answer as with statistical mechanics. So there's a concept of ergodicity—you have to explore the space thoroughly either by statistical mechanics or molecular dynamics to have a true representation of the properties.

So we did both of those—statistical mechanics, molecular dynamics—and then the third one was quantum mechanics, which I started with Chakraborty, and then when he left in the mid-2000s moved over to work with Martin [P.] Head-Gordon.

05-00:58:44
Eardley-Pryor: That's great. I think that's a great summary of the different pieces of your theory work. Let's dive into chronologically moving through who you were working with, and what you were working on, perhaps.

05-00:58:54
Bell: Sure, sure.

05-00:58:57
Eardley-Pryor: Before we do, it strikes me—hearing you talk about the types of theory that you've done and how that work has evolved, it almost is reflective of the changes in chemical engineering as a discipline, from the transport [phenomena], to the molecular approach, to this much more even refined molecular approach that the quantum might represent. Does that sound like a fair [analogy]?

05-00:59:16
Bell: Yes, that's very much true. That's very perceptive. Chemical engineering in its early days started looking at units—processing units—each of which was represented theoretically by a box with inputs and outputs of molecules or materials and energy. And you did a heat and mass balance on that. And then you did this for a continuous string of boxes, and that told you how the plant was going to work.

Then people got involved in transport phenomena and theory, which is a more detailed look at how mass and energy are transported in mesoscopic arrays of things—you know, how do you describe the flow of mass to a spherical particle that's in a stream of gas or liquid? That really became big-time stuff in the sixties, with the appearance of [Robert Byron] Bird, [Warren E.] Stewart, and [Edwin N.] Lightfoot's textbook on this subject. And that eventually started to play out in terms of all the novel things you could do. Most of it was done with polymers.

05-01:00:40

And then people started to look at a more and more molecular perspective. How could you predict the properties of the continuum from the molecule properties? Could you build that up from first principles? And the answer is yes. Even going back to the thirties, there were ideas of how to do this, but with better and better computers you got faster and faster at doing this. So John [M.] Prausnitz, one of the most distinguished members of our department, has used this idea to predict the thermodynamic properties of gases and liquids and gas-liquid thermodynamics and phase stability.

Then you go beyond this, even, to ask, what keeps the atoms in a molecule together? Why do compounds form? This is now at the scale of electrons and bonding of molecules through their orbitals and the exchange of charge or the sharing of charge to make new orbitals. So this gets you into the forming of individual compounds. If you look at their jiggling and wiggling, you can predict their vibrational (infrared) spectrum and rotational (microwave) spectrum.

05-01:02:03

Then there's interaction of molecules with surfaces. So this is where I come in, because catalysis is all about making and breaking bonds on surfaces. And what's intrigued me is, how does that happen? You know, which atom comes off first? What happens next? And so forth. You first do experiments to give you some guesses as to how things work, and then you try to validate this with theory.

So then you say, All right, well, how did the molecules get there? Well, they have to transport from the gas phase. There are many circumstances where the transport from the gas phase is slow. You can't process more because it's not coming down—there's no feed because it's limited. So then you'd couple the mass transport with the surface chemistry and understand how to get that going more rapidly.

05-01:03:04

So for most of the period in the nineties and 2000s, this was what chemical engineers in catalysis were doing—gas-solid interactions. More recently, there's been a growing interest in, say, how do batteries perform. These are electrochemical systems. How do supercapacitors store charge? How do electrochemical systems work? Now you're getting into, again, electron flows, but coming out of an anode or cathode and doing chemistry at its surface. And these systems are influenced by the electrolyte above the surface.

The next thing beyond that, which what we are just starting to get into, is, what happens when you replace an aqueous electrolyte with a polymeric electrolyte that has a catalyst on either side. Now we need to understand how one treats the ionic transport through this polymer, which is not anything like water? The polymer has little pockets of water, but it has also cation and anion exchange sites on the side groups of the polymer. So now we need to formulate how to describe the transport of water and cation or anion through a solid. Finally, one needs to describe the interactions of water and charged species coming to or from the solic electrolyte with the surface of the catalyst.

05-01:04:35

The question of how to describe the interaction of an aqueous electrolyte with a solid catalyst is something that we started working on about five years ago with Martin Head-Gordon, taking the simplest possible representation of what is called an implicit solvent. In this case, we treat the solvent as a continuum, but we treat everything on the surface atomisticly—and we say, well, this is just like changing the dielectric coefficient—so that's the continuum property. And yes, this has an effect. Qualitatively, it's correct, but quantitatively, it's not sufficiently accurate. So now you put in some explicit waters into this thing. And yes, that's better, but it's not completely accurate, because you haven't put in the cations and the anions. You put those in, now things get very messy to do it right. And that brings us up to where we are today—is trying to figure out how to do this most effectively.

Just last week, we had a meeting of Martin Head-Gordon, his wife Teresa [Lyn] Head-Gordon, who's over in bioengineering and has a zero-FTE appointment in chemical engineering, and myself, and our respective postdocs, discussing, how do you bring the best theoretical methods together to do this in a compute-efficient manner, but also in a physically accurate manner? So that's the cutting edge.

05-01:06:03

The next problem of what do you do with a polymer is at the level of treating things empirically, and that's what Adam [Z.] Weber and I are doing right now. And we have a graduate student who's done that very effectively, but she's using continuum representations. And we'll get to molecular representation when we know how to do it better.

05-01:06:25

Eardley-Pryor: So the theory, in some senses, follows the process that the discipline has moved.

05-01:06:29

Bell: Right.

05-01:06:30
Eardley-Pryor: But it's always just a little step behind, as you go forward?

05-01:06:33
Bell: Well, the discipline is using the latest advances, either within the discipline or in neighboring disciplines. Chemical engineering is very good at importing things from other disciplines. Therefore, it causes the discipline of chemical engineering to evolve. So actually, the drivers are coming from outside. And this is what makes this field a lot of fun. You never run out of things to do.

05-01:07:03
Eardley-Pryor: Always more fun things to learn and explore.

05-01:07:04
Bell: Yes, yes.

05-01:07:07
Eardley-Pryor: Take me back, if you would, to the late 1980s when you first entered into doing theory work. And this was with a man named Evgeny Shustorovich?

05-01:07:18
Bell: Evgeny Shustorovich, right.

05-01:07:21
Eardley-Pryor: Shustorovich worked at Eastman Kodak, in New York.

05-01:07:24
Bell: Right.

05-01:07:24
Eardley-Pryor: How did you two first come together to begin working on theory?

05-01:07:29
Bell: So we came together because I was asked to be a consultant for Kodak in Rochester, NY, and I went out there regularly. He was in a group working on catalysis. In those times, Kodak had a pretty free-wheeling and very high-quality corporate research effort. So they had people working on surface science, looking at how molecules hopped across the surface; they had people working on how do atoms of silver form little nuclei that directly relevant to photography; they had people working on photoreduction of silver cations. But they also had people like Shustorovich who were doing fairly fundamental theoretical calculations that had nothing to do with photographic film. Since he was a native Russian-speaker, we spoke Russian and this gave me an opportunity to practice my technical Russian. Evegny was a very animated gentleman, so we hit it off. In the context of our interactions he shared his papers with me. I read them and concluded that, yes, this looks interesting.

05-01:08:45
At that time, in the eighties, quantum chemistry was not accurate enough to make good predictions, and so we used these semi-empirical rules that he had

developed on bond energy and bond order (BEBO) to predict how things ought to change. Now, the BEBO relationships are qualitatively very good, and semi-quantitative; however, they're not perfect—and they never will be, because they have a lot of assumptions built into them. They also have parameters that have to be gotten from experiment, but they let us go a long way towards explaining phenomena. So we used his approach to explain how certain reactions occur on surfaces, and we got things that are actually observable. So it was useful in that way. It got criticized, by the early nineties, for not being first principles enough for the taste of some people.

05-01:09:55
Eardley-Pryor: Meaning it didn't have enough of the quantum chemistry in it?

05-01:09:57
Bell: Yes, it didn't have any quantum chemistry in it. And, you know, "Why don't you do things more fundamentally?" And the initial rejoinder was, "Well, the quantum chemistry just isn't good enough." And oh, that affronted a lot of people theoretical chemists because you were telling them what they were doing wasn't good enough. But eventually, in the early nineties, I started to see that the quantum methods were getting better and better, so I decided why not try that, too? And this is when I began working with Chakraborty.

05-01:10:31
Eardley-Pryor: Okay. Well, before we move into that, I think there's a neat story to be told here with some of the work you did in the late eighties, with the publication that you did with one of your students, Steve [Stephen J.] Lombardo.

05-01:10:43
Bell: Right, mm-hmm.

05-01:10:45
Eardley-Pryor: This publication you put out in 1991 on the reaction of gases on metal surfaces—can you talk a little bit about that article? Because it became so definitive in citations in the field.

05-01:10:57
Bell: Yes. this was a *Surface Science Reports* article which we did, which ended up being the first chapter of his thesis—this is Steve Lombardo. And the idea was, he was the one and only student who did all his work with this theory that we developed with Shustorovich. We wanted to see how far we could push it. And so we studied reactions, we studied something called temperature programmed desorption—you adsorb something on a surface, you raise the temperature, and you do a Monte Carlo calculation to see what and when things come off. It's a good calculation to do, because there are lots of experiments to compare against.

05-01:11:41
Eardley-Pryor: Can you maybe talk about what a Monte Carlo experiment involves?

05-01:11:45
Bell: Okay, so a Monte Carlo experiment is the following—or [a Monte Carlo] calculation is the following. You put a number of things on the surface to start. You then have the precise locations adsorbed species. You throw the die and that tells you whether to choose this spot or that to look at, so it's random. Then, once you've chosen the location, you have three or four options of what could happen next. You throw the die again to identify which option you're going to take. Then, when you've completed a cycle, now you have a new scenario, and you do this over. And you do it millions of times. So this enables you to evolve the surface as a function of time. And now if temperature is changing, well, that changes over some scale with time, so you can change the temperature, as well.

05-01:12:48
Eardley-Pryor: As you're going through all of these probabilistic scenarios, [they're] the Monte Carlos?

05-01:12:51
Bell: Right, right. So you write a computer code to do this for you. And it's using this bond energy, bond order conservation method—BEBO, we called it—B-E-B-O—method. It was fairly rapid to converge, because you didn't have to do quantum calculations. And so we could learn some other things about how things happened on a surface.

One of the things we showed towards the end was how to interpret an experiment had been done in Japan where the surface was fully covered with carbon monoxide and then ^{13}C-labeled carbon monoxide was brought in and found experimentally to exchange rapidly with the preadsorbed ^{12}CO. Now the person who did this study was Kenzi Tamaru, one of the leading people in Japan. He couldn't understand why the exchange of ^{12}CO for ^{13}CO happened, because CO is very tightly bound, and if the preadsorbed CO doesn't come off, then there shouldn't be any place to put in the new ones. What we showed is that while CO is tightly bound, but as you stuff more and more molecules on the surface, the binding energy falls off because of repulsive interaction between the neighbors—you know, they don't like being jostled together. Therefore, by the time you have full coverage, the binding is so weak that you get periodic pop-offs of CO, and then the new one can come in. Then we showed that we could represent his experiments very nicely with our Monte Carlo simulation.

05-01:14:26
Eardley-Pryor: So you could explain this unexplainable phenomenon through the theory that you had done?

05-01:14:28
Bell: Right, right. Yes, yes. Which is a nice thing to use theory for.

05-01:14:33
Eardley-Pryor: Yeah, that's exactly right. Well, before we move forward into the next stages of research, tell me a little bit more about Evgeny Shustorovich. How did this Russian scientist end up working in New York, for you to begin collaborating in the late eighties while the Soviet Union still existed?

05-01:14:52
Bell: Well, yes, okay. So he had emigrated with his wife from the Soviet Union well before this. I think it was in the period where it was possible for Jews to emigrate—both he and his wife are Jewish—so they left at that time. Robert Woodward helped to move to Cornell for a short while and then helped him find permanent position at Kodak.

05-01:15:19
Eardley-Pryor: But that was his experience—is fleeing, essentially, as a Russian Jew, away from the Soviet Union?

05-01:15:21
Bell: Yes, right, yes. Evegeny got to Kodak and was very happy there until Kodak decided to close their lab in the nineties.

05-01:15:33
Eardley-Pryor: Which was a trend across many industrial labs.

05-01:15:35
Bell: Which was the trend across the whole US, yes. And then he retired and—yes, we've sort of lost track of each other. I think he's still retired, and I don't know what he's doing now.

05-01:15:48
Eardley-Pryor: Well, the review that you just discussed with Steve Lombardo was published in 1991, and that same year, I have a note that Shustorovich put out an edited book collection on metal surface reactions.

05-01:16:00
Bell: That's right. Right.

05-01:16:01
Eardley-Pryor: And in that, you published a chapter with Doros Theodorou.

05-01:16:05
Bell: Yes, so I don't recall that it was with Doros, but I do remember writing a chapter for that book.

05-01:16:11
Eardley-Pryor: So tell me a little bit about how you're—because Doros' collaboration with you seems to be the next phase of your theoretical work.

05-01:16:18
Bell: Right, yes. That was separate. Evgeny was invited to edit a book, and so he collected a group of people, and I said, "Yes, I'll agree to contribute a

chapter." I summarized, really, our work—joint work—together. And that went over well. Yes.

05-01:16:40
Eardley-Pryor: And how, then, did you lead this next phase of your theoretical work with Doros Theodorou?

05-01:16:45
Bell: So Doros—I was department chair from '81 to '91. And about—somewhere—more than halfway through this, he appeared on our radar screen as a very bright young person at MIT [Massachusetts Institute of Technology] finishing his doctoral work with Jimmy [James] Wei, who was department chair. Doros was doing statistical mechanics and problems in diffusion. So we interviewed him and eventually hired him as an assistant professor. And after he'd been here a while, I thought it might be interesting to join forces with him to look at adsorption and diffusion in zeolites. And in fact, he had done some initial work with Wei on this subject. That worked out beautifully. We did quite a few papers together on adsorption—predicting the isotherms, how the occupancy of the zeolite changes with the pressure as a function of temperature.

05-01:17:53
Eardley-Pryor: And was this also using the Monte Carlo methods and statistical physics?

05-01:17:55
Bell: This used Monte Carlo and statistical mechanics methods. Doros also used these methods very effectively to look at polymers, but that was work he was doing on his own.

05-01:18:05
Eardley-Pryor: Your work was focused more around the nanoscale pores in zeolites.

05-01:18:08
Bell: Yes, the zeolites. Right. And then we did molecular dynamics also.

05-01:18:13
Eardley-Pryor: You and Doros did?

05-01:18:14
Bell: Yes. And we did also transition state hopping.

05-01:18:21
Eardley-Pryor: What is transition state theory?

05-01:18:22
Bell: So transition state theory goes back to [Henry] Eyring, and says, I have an adsorbate sitting in this pocket over here and it wants to go over there and there's a barrier between the movement between the two locations, how do I describe the rate of hopping. One approach would be to explore he migration from one site to another by doing molecular dynamics. This says that I'm

going to start with some adsorbate velocity here, associated with a temperature, and let the adsorbae wander around and till it eventually crosses over the barrier to its new location. However, when molecules are very tightly bound, this happens so infrequently that you have to calculate for a very, very long time, and that's not very efficient. So Eyring, in the thirties, said—and this was for chemical reactions, the same thing—Let's imagine that there's an equilibrium, a dynamic equilibrium, between the initial state and the transition state, the saddle point over here. Once I get to the transition state, there's a probability that I'm going to roll over to the other side. And so there's an equilibrium constant times a rate coefficient that describes the rate of crossing the barrier. Eyring's transition state theory has turned out to be a remarkably powerful way of describing the dynamics of infrequent events.

05-01:19:30
Eardley-Pryor: Even within? The movement within a zeolite?

05-01:19:34
Bell: Yes. So we applied this to benzene hopping in a zeolite, and it worked extremely well. Yes, so that was a different kind of theory applied there.

05-01:19:54
Eardley-Pryor: How was the actual working-process different between the work that you did with Evgeny Shustorovich and with Doros Theodorou?

05-01:20:03
Bell: Well, with Evgeny it was—you know, we saw each other face-to-face only when I was in Rochester. I think he came here only once or twice. It was very infrequent. And then when we were writing papers together, I would do most of the writing, because my English skills were better than his, and then send him the copy, and then would get on the phone—and this was before you had, you know, Skype and Zoom and all these telecommunications—we'd get on the phone, and I'm holding the phone with my arm or putting it on speakerphone, and each of us had a written copy, and we'd mark up the copy. And then I'd retype this thing and send it off to him.

05-01:20:51
Eardley-Pryor: How much of your discussions together were in Russian versus English?

05-01:20:53
Bell: Oh, this was all done in English. Yes. It was more efficient. So that's how we worked on these manuscripts. With Doros and also later with Chakraborty it was much easier, because they were physically down the hall. So we would get together with the student or postdoc and sit—it was a threesome. And that's how all my other collaborations have been.

05-01:21:19
Eardley-Pryor: I see with Doros, there's a few names that have come up in looking through your publications of students who worked together—people like [R.] Larry June, Randy [Randall Q.] Snurr, Edward [J.]—

05-01:21:29
Bell: Maginn.

05-01:21:30
Eardley-Pryor: Maginn?

05-01:21:30
Bell: Yes.

05-01:21:32
Eardley-Pryor: What role did the students play in your collaborations?

05-01:21:35
Bell: Well, they did all the work. Yes. They did all the work. So we'd start off, as we do in every collaboration, telling them about the interesting problems, what approaches we thought might be useful to implement, and then they would go learn about it and write the computer code and get it going. Doros would help them with one code or another and Arup with the quantum mechanics. And then they'd come back with the results. We'd look at them and try to make physical sense of them. That's how it worked.

05-01:22:11
Eardley-Pryor: Today, I know that a number of the students you do theory work with also have a component that includes the experimental work in the lab.

05-01:22:18
Bell: Some of them do, yes.

05-01:22:19
Eardley-Pryor: Were these students pure theory?

05-01:22:22
Bell: Yes, they were pure theory.

05-01:22:23
Eardley-Pryor: What's the difference in managing a student that's doing theory work as an advisor versus being an advisor to an experimentalist?

05-01:22:30
Bell: Well, it's really no different. I mean, the kinds of problems people run into are different—you know, your coworker runs into with theory versus experiment. But a lot of it in the end is sitting here and de-bottlenecking what's the issue so the workflow can continue.

05-01:22:47
Eardley-Pryor: So it's not a substantial difference in the theory work?

05-01:22:50
Bell: Well, it's a very different kind of issues that you're dealing with.

05-01:22:54
Eardley-Pryor: But as far as a mentor goes?

05-01:22:55
Bell: In terms of the mental game that you're playing, it's more or less the same. Yes.

05-01:23:03
Eardley-Pryor: Maybe you can tell me about how you began work with Chakraborty. There was a time where both your work with Doros and Arup Chakraborty overlapped.

05-01:23:12
Bell: That's right.

05-01:23:13
Eardley-Pryor: Did all three of you work together, or separately?

05-01:23:17
Bell: No, we worked largely separately. Yes—although sometimes on related problems. So with Chakraborty, I started working on quantum theory.

05-01:23:27
Eardley-Pryor: And what's his story about how you two first collaborated?

05-01:23:29
Bell: Well, let's see. He had done quantum theory at Minnesota—he taught himself how to do it. And he was working there on CO_2 interacting with what are called hindered amines. These are amines that have a certain structure that makes it bulky at the end, where the CO_2 reacts to form what's called a carbamate, and it means that the CO_2 doesn't bind too strongly, and so it can be taken off. And so you put these amines in water, you put it in what's called a scrubbing tower, pour the water in one end, the CO_2 and air goes through this way, and the CO_2 gets onto the amine and come out in the water stream. And then you heat that water stream up and the CO_2 released. And now you have a more concentrated CO_2. So this is the way to take CO_2 out of flue gas. And he wanted to understand the details of how CO_2 interacts with a hindered amine, so he did this quantum mechanically.

I was fascinated by Chakraborty's calculations. While I had studied quantum mechanics as an undergraduate at MIT, it was not at the level that he was capable of doing. So after I hired him—I was department chair at that time—I suggested that we collaborate.

05-01:24:48
Eardley-Pryor: This seems to be a convenient theme in your theory work.

05-01:24:50
Bell: It was convenient, right. Yes. I hired him—much to the consternation of some of my most senior colleagues.

05-01:24:57
Eardley-Pryor: Oh, is that right? Why?

05-01:24:58
Bell: Well, they thought Chakraborty's work was a bit too far out—and not real chemical engineering. Yes. And if you took their perspective—you know, these were—I'm in my early forties at the time; they're in their sixties, seventies—took their perspective, you could see why they'd be critical. But I thought that the future looked different from the past, and certainly that had been my trajectory, and I thought this was the right thing to do. Anyway, I hired Arup, and he did a lot of work on his own and eventually went into problems in statistical mechanics related to immunology, which had nothing to do with me, and then we worked for a good while on things related to zeolites. So Bernhardt [L.] Trout was our first student.

05-01:25:55
Eardley-Pryor: Well, before we talk about Bernhardt, what eventually happened to Doros in your collaboration? How did that end?

05-01:25:59
Bell: What ended our collaboration was the request from his mother that he return home. Doros is an only child from a Greek family. As he relayed it to me, his mother contacted him and said two things: "Doros, you need to get married," and "Doros, your father's getting older and you need to come home and help take care of the family." And as a good European—young man—he felt that call very seriously, and he went back. His mother introduced him to a young woman, whom he eventually married. She arranged to have an apartment just on the other side of their apartment, in the same complex. And he took care of his dad until he passed away. When he first returned, he got a position at the University of Patras, which is not in Athens, so he had to commute back and forth to Athens to see his wife and mother and father. Eventually, though, he got a position at the University of Athens, and so everyone was able to live in one city.

Doros' leaving was really unfortunate. We were both quite upset, because we enjoyed working with each other, we got to know each other very well. We both felt that we were breaking a human bond as well as a professional bond when he left.

05-01:27:17
Eardley-Pryor: Yeah. So I was going to ask you, how much did you share in that discussion about family obligations, especially as the only child of two Russian immigrants?

05-01:27:26
Bell: We talked about it quite candidly with each other. And yes, I supported him in—even though it was hard for me, both as department chair as a professional colleague working with him, to lose him, I fully understood what motivated him. So I didn't want him to feel guilty about leaving.

05-01:27:50
Eardley-Pryor: That's nice. Well, back to the work with Arup Chakraborty. You had mentioned that Bernhardt Trout became one of your first students together.

05-01:27:58
Bell: Yes, right.

05-01:27:59
Eardley-Pryor: Tell me about how that development happened.

05-01:28:02
Bell: So Bernhardt came here as a first-year student. We recruited him together. And he worked out beautifully. He was interested in learning what density functional theory could do. As I may have mentioned, he wrote his own code for doing this, with Arup's help, because the commercial codes were not yet available for licensing. Something called Jaguar, which came out of Bill [William] Goddard's group at Caltech—became just available at the time that Bernhardt was finishing.

05-01:28:40
Eardley-Pryor: So he basically developed his own company, then another company swooped in?

05-01:28:44
Bell: Right. So when the next coworker came along, a postdoc, we started licensing software.

05-01:28:52
Eardley-Pryor: I'm sure it was a huge experience to learn how to create the code from scratch that Bernhardt did.

05-01:28:57
Bell: Yes, yes.

05-01:28:59
Eardley-Pryor: I'm sure that's served him well.

05-01:29:00
Bell: Right. But other people were rapidly then making advances on what are called the functional part, which is, there are some rules for how you put that functional together, but it's largely empirical. And there are adjustable parameters and you have to tune the parameters against experiment. So it's not completely ab initio. But—

05-01:29:21
Eardley-Pryor: Maybe you can talk a little bit about what exactly density functional theory is?

05-01:29:24
Bell: Sure. Schrödinger's equation is at the heart of quantum mechanics. This equation represents atoms and molecules using a wave function. Schrödinger developed a differential equation that you solve to get the wave function. An

alternative way to solving the problem was developed by Walter Kohn and is called density functional theory. It says what one needs to know is the density of electrons yielding the minimum energy. This configuration then defines the structure and energy of a molecular state. So now you represent the density as a sum of wave functions. So it's an expansion, in mathematical terms. You then use the Kohn-Sham relationships to find a way to minimize the energy by adjusting the parameters that weight these wave functions so that you get the right density representation.

05-01:30:46

It turns out for large systems this is more efficient than solving the Schrödinger equation, but it's all dependent on how accurately you describe the Hamiltonian, which is the representation of energy. And most of it is not a problem, but the last 1 percent or less, which dictates the accuracy, is all tied up in the functional. And the functional represents the energy changes when you replace electrons this way—and the fact that when electrons dance around, they're not independent of each other—and if I pull this one, this one feels the fact that it's been pulled. And that's the correlation part of the functional. And there's a whole cottage industry that's developed on writing better and better functionals for various applications.

05-01:31:43
Eardley-Pryor: So writing those functionals was really the challenge in making density functional theory more applicable and useful?

05-01:31:48
Bell: Right. And then some functionals make it very hard to obtain a converged solution to the problem; others are better. Some have as many as thirty-four adjustable parameters or more; some have fewer—the fewer, the better, for speed. Therefore, there are tradeoffs. And there must be something like fifty functionals in the literature now, and I've lost track on them all. But as an engineer, what I want to know is, which functional gives me the most accurate results and is not excessively compute-intensive?

05-01:32:26
Eardley-Pryor: Yeah, the efficiency and accuracy.

05-01:32:28
Bell: Yes. And that's the one I'll use, because I'm going to use it as a tool, not make a research project out of studying the functional. So Arup was not an expert in this area, but he was very good at using density functional theory. When I stopped working with him and started working with Martin Head-Gordon, I discovered that he is much more of an expert on the functional development.

05-01:32:58
Eardley-Pryor: Well, before we dive into the next phase of this work with Martin Head-Gordon, I did note that Bernhardt Trout—after working with you and Arup in the early nineties—that in 1998, after getting his PhD with you, went back to MIT and took a faculty position there.

05-01:33:14
Bell: Yes, yes.

05-01:33:15
Eardley-Pryor: And now he holds the Raymond [F.] Baddour chair.

05-01:33:18
Bell: Yes, right.

05-01:33:19
Eardley-Pryor: I thought, "Wow, what a great circle."

05-01:33:20
Bell: That is a connection, right. Because Raymond Baddour was my research director [at MIT].

05-01:33:24
Eardley-Pryor: Right. And so now the student that you have mentored in theory has gone to MIT and holds the chair that your advisor had named.

05-01:33:30
Bell: Right, uh-huh. Yes.

05-01:33:31
Eardley-Pryor: What a great link.

05-01:33:32
Bell: Uh-huh.

05-01:33:33
Eardley-Pryor: Well, what happened with the end of your work with Arup that allowed you to then begin new work with Martin Head-Gordon? How did your work with Arup sunset?

05-01:33:44
Bell: So Arup told us that he was planning to leave to go to MIT.

05-01:33:50
Eardley-Pryor: He also went to MIT?

05-01:33:51
Bell: Yes. And in part, that was unfortunate, because we didn't want him to leave, but the dean at the time, Clayton [H.] Heathcock, didn't do enough to retain him and didn't take him seriously enough that he would actually leave.

05-01:34:11
Eardley-Pryor: He thought it was just a threat?

05-01:34:12
Bell: Yes, he thought it was a threat, and he wanted to be shown the offer letter and kept playing Arup along—which was a very bad strategy. And we didn't appreciate that. But Arup eventually left. Also, there was an opportunity for

his wife to go to the Sloan School. She was very good in the business area, had a PhD in business, and our school here, the Haas School, couldn't find a place for her, and so also contributed to Arup's leaving.

05-01:34:56
Eardley-Pryor: And this was around the mid-2000s?

05-01:34:57
Bell: Yes, the mid-2000s. I think he left in 2005—'04 or '05, somewhere in there. So at about that time—that's right—yes, about that time, I had an offer from a young man in Moscow, Rustam [Z.] Khaliullin, to come here and do his master's thesis with me—which would be granted by the Higher College of Chemistry in Moscow. So I agreed to have him here, and he came over. And we worked on theoretical calculations to represent the interactions of weakly-bound methane with the sodium cations in zeolites. These interactions distort the symmetry of methane, which could be observed by infrared spectroscopy.

05-01:35:57
Eardley-Pryor: But this was a theoretical approach that you were exploring?

05-01:35:59
Bell: Mm-hmm, right.

05-01:36:00
Eardley-Pryor: And in this work that you're doing with this Russian student who's come over, are you doing your discussions together in Russian?

05-01:36:08
Bell: At that point—let me think—yes, some of it was in Russian, some of it was in English. Because I had started that transition back in the mid-seventies with my postdocs from Novosibirsk. Yes. So we did both. Rustam spent a year here, went back, defended his thesis, and then he said he wanted to do graduate work in chemistry—he's a chemist—in the US. So he applied to six schools—Caltech, Berkeley, Princeton—golly, I don't remember the other three—MIT and two more—and he got in everywhere. In the end he said, "Well, I really want to come to Berkeley because I liked it here." So he came back, and I saw him in his first year here. He told me, "I enjoyed working with you, but I want to do real theory." I knew what he meant.

05-01:37:06
Eardley-Pryor: What did he mean by that?

05-01:37:07
Bell: He meant he wanted to do theory development, as well as applied work. And that's correct—for somebody who's going to be a chemist and wants to have an academic life, that is an essential component. So I said fine and I encourage him to speak with Martin. Martin, of course, didn't know anything about this young man, but he had heard that he had worked with me, so he came down and started talking to me. And somehow it became—either I offered it or Martin offered it, I can't remember who initiated it—but we said, Why don't

we do it together and jointly sponsor him? Which we did. And it was a fifty-fifty deal—half his time was spent doing theory development, half was application. And it worked out very nicely. Martin and I felt comfortable together. After Rustam, we then took on another student—and another and another. You know, and what is it, something like eighteen years later, here we are.

05-01:38:05
Eardley-Pryor: Wow.

05-01:38:05
Bell: We're still doing it.

05-01:38:06
Eardley-Pryor: That's great. So that's a great story of how you two first came together—through this Russian student.

05-01:38:12
Bell: That's right.

05-01:38:13
Eardley-Pryor: But it set a model for how further students could happen through the department.

05-01:38:16
Bell: Yes, right.

05-01:38:17
Eardley-Pryor: That's great. One of the ways I thought maybe we could talk about some of the work you've done since this mid-2000s period to the present is to talk about the 2004 review that you wrote in *Molecular Physics* that was titled, "Challenges for the Application of Quantum Chemical Calculations to Problems in Catalysis." And in that, you outline a number of the challenges that theory would have towards catalysis. And then since then, over the past decade-plus—

05-01:38:44
Bell: Yes, we've been chipping away at them.

05-01:38:46
Eardley-Pryor: —you've been solving these problems you've laid out.

05-01:38:47
Bell: Right.

05-01:38:48
Eardley-Pryor: So I'm wondering if maybe you could talk a little bit about what were your thoughts in the early 2000s of the problems of using theory for catalysis, and how you've since helped solve them.

05-01:38:59
Bell: So I don't remember exactly what I wrote back in that period, 2004—

05-01:39:04
Eardley-Pryor: Well, I can give you a little bit of prompts of what I saw as some of the things.

05-01:39:07
Bell: Okay.

05-01:39:07
Eardley-Pryor: One was accurate rate expressions for elementary steps.

05-01:39:10
Bell: Yes. Right, right. That's what I would have guessed.

05-01:39:12
Eardley-Pryor: Another one would be accurate models of active sites and adsorbate interactions in zeolites.

05-01:39:18
Bell: Right, okay.

05-01:39:19
Eardley-Pryor: And then another piece is making more efficient and automated methods for discovering reaction pathways.

05-01:39:25
Bell: Right, okay. Okay, so that's more or less what I would have imagined I put there. So, yes, it follows that if you want to use a theoretical method, what are you going to ask for? The first thing would be rate coefficients for what are called elementary reactions. So this means, how do I describe the rate at which molecules actually transform?

05-01:39:53
Eardley-Pryor: And why was that a challenge for the theory for catalysis at this point?

05-01:39:58
Bell: Well, because you couldn't do it. You could get an answer, but it wasn't necessarily accurate or representing experiment. And so the issue was one of accuracy. So you had to capture the reactant state and the transition state properly; you shouldn't overbind the transition state or underbind it; you had to represent not only the energetics but the entropic portions. So these were the challenges for getting the energetics right. So—right for what environment—you have to represent the catalyst, too. That means you have to have a model for what you think the active center looks like. While, many people could draw something they thought, which they called a model, it was just based on chemical intuition.

So what we did was to blend experimental observations in order to better refine what could be drawn using only intuition. We could then build this model of an active center on the computer, minimize its energy, and see if it looks like what you think it looks like, and could calculate its vibrational spectrum, and calculate other properties, to see whether they concurred with what we measured experimentally. So that's how this evolved. It was basically defining our ignorance and the scope of our ignorance at that time. And it turned out to be a well-read paper and helped us focus on what's important.

05-01:41:42
Eardley-Pryor: Well, maybe talk, if you can, a little bit about how you and Martin Head-Gordon did move forward in helping solve some of these issues that you had outlined.

05-01:41:51
Bell: So one of the things we moved forward with is implementing functional representations and other representations that capture not only the strong interactions formed through bonds with the active center, but also what are called dispersion interactions—these are weaker interactions that don't involve an actual physical bond. So water molecules daisy-chain together through what are called hydrogen bonds, and these are not chemical bonds—they're much weaker—but they define the properties, the colligative properties, of water. You have the same thing with, say, oxygen and nitrogen: if you put it into a zeolite, the nitrogen interacts more strongly with the cations in the zeolite than the oxygen, and so you can separate oxygen from nitrogen this way. This is a practical process for making enriched air for people who suffer from emphysema. Okay—so understanding how these dispersion interactions fold in on top of the chemical interactions is important.

05-01:43:07

And then on top of that are what are called coulombic interactions, which are from charged fields that are created within the zeolite. So you have positive and negative centers—just—equal numbers of these, but they're scattered around. And this cloud of charge imposes a field locally, here, which can influence what happens. For example, if molecules are polarizable, meaning that their electrons can be moved around by applying a field, that changes their bonding. And that turned out to be an important part of getting the energies right. So once we put in these things correctly, we got to within experimental accuracy.

05-01:43:49
Eardley-Pryor: I'm hearing you talk about the energy fields within the zeolite. Was that something you were able to then build on in the wake of the JCAP theory work?

05-01:43:58
Bell: No, this had nothing to do with JCAP. This was outside of JCAP.

05-01:44:01
Eardley-Pryor: I'm just thinking about understanding electronic fields and the influence on the catalysis.

05-01:44:04
Bell: Oh, yes—well, yes—those are actually stronger fields that you're mentioning than the ones I'm talking about. These are relatively weak fields. So we did that. We then developed ways to calculate transition states, which are saddle points. So you have curvature this way and that way if you have two dimensions, but this is in multidimensional space, so you can't visualize these things, but you can define characteristics for them that tell you when you've hit one.

05-01:44:37
Eardley-Pryor: When you've crossed over an energy barrier?

05-01:44:39
Bell: When you're near the hilltop to cross the barrier. So a mountain pass is a 3D illustration. But these happen in many more dimensions—you know, it could be twenty dimensions—and there are mathematical definitions, but you can't visualize them. So anyway, we developed, building on stuff that we started with Baron Peters and Arup Chakraborty on the freezing string method, we built better and better methods which are less compute-intensive and converge more effectively.

05-01:45:18
Eardley-Pryor: This is the growing string method? Is that what you're talking about?

05-01:45:21
Bell: The growing string method was the first thing. Then the frozen string method was the next evolution. And then we used that to get an approximation for the transition state, and then we used the dimer method, which converges even faster. So it's this ability to concatenate methods. You get a rough approximation, then a refined one. But all the time you're trying to minimize the cost to get to the goal. So that's a constant theme.

Then we developed a quantum mechanical/molecular mechanics representation. So the challenge here is that when you have things like zeolite, atoms very far away from the active center have an influence. But if you wanted to compute all these—you know, five, six hundred atoms quantum mechanically, you'd be sitting there until the cows come in. So that's not very effective. And most of these atoms are wiggling around, so why minimize their energy?

05-01:46:18
Eardley-Pryor: Spending the time calculating it.

05-01:46:20
Bell: So we just fix them where they're going to be in crystallographic space and we represent all these far interactions classically. So that happens very quickly, and that classical force field influences what happens here and does influence the quantum mechanics, but you don't have to make iterative adjustments on what goes on over there.

05-01:46:41
Eardley-Pryor: You can spend your time calculating just the quantum mechanical piece.

05-01:46:43
Bell: That's right, yes. Yes. So we got 500-fold improvements in speed by playing this trick. And you get away from what other people do, which is to take small unit cells and just replicate them in three dimensions. And that technique works well, but now what goes on in this cell sees what's going on in this cell and you have artificial interactions that don't exist. Because these things are more dilute, actually, in reality.

05-01:47:11
Eardley-Pryor: Because in reality, those cells are not communicating with each other.

05-01:47:14
Bell: In our system, they're not communicating with each other. There's just one cell. So there are two paradigms for doing these calculations. We like ours; some people like theirs, even though we see some issues with it.

05-01:47:30
Eardley-Pryor: And those issues are about speed and efficiency?

05-01:47:32
Bell: They're more about accuracy—the self—seeing your image in the mirror, so to speak, and being influenced by that. So we get away from that problem.

05-01:47:45
Eardley-Pryor: All of this sort of work with the dimer method, the growing string to the frozen string—it all has to do around the realms of linear interpolation. Is that right?

05-01:47:55
Bell: Linear interpolation? No. No, not really.

05-01:47:58
Eardley-Pryor: Tell me, then—because I understood that that was also another part of the work you did with Martin Head-Gordon.

05-01:48:02
Bell: Oh, so—not linear interpretation. There's the linearized Poisson-Boltzmann representation of the field, but that's a completely different subject—for electrochemistry.

05-01:48:14
Eardley-Pryor: Oh, okay. Well then perhaps we can—if there's more to be said about the growing string method and frozen string method—are there other aspects of that research that you want to talk about?

05-01:48:24
Bell: No, I think that's probably enough. Yes.

05-01:48:27
Eardley-Pryor: Then maybe how did you make this transition with Martin from the theoretical work around zeolites to the theoretical work around electrochemistry and electrocatalysis?

05-01:48:36
Bell: Okay, so this started more or less at the time when I became interested in electrochemistry, particularly CO_2 reduction. It turns out that Martin has had an intrinsic interest also in moving ahead and looking at other classes of problems besides the ones we were looking at already, and thought it was an interesting and challenging business to tackle. So we recruited a postdoc, Jason [D.] Goodpaster, who ended up after two years, going to University of Minnesota and becoming a faculty member in chemistry there. So he was the first one to work on this. And then the next one was Alejandro [J.] Garza, a Mexican—what was he—he had done a postdoc already—one postdoc—and then his graduate education here in the US, so he came to us. He was particularly effective. And now we have a third postdoc working in this area, Zhou Lin, who's from China originally.

05-01:49:52
Eardley-Pryor: It's nice to have that international experience involved in all of that. So how does the electrocatalytic work differ?

05-01:50:01
Bell: It differs from our work on zeolites in a number of ways, for one you have a plane representing either the anode or the cathode—the cathode, in our case. And the plane is usually represented by a single crystal surface. And then we represent the electrolyte using this linearized Poisson-Boltzmann equation. And you do iterative calculations, where you start off with an assumption of what the field is, and do this on the first pass on the quantum mechanics. You then update the charge distribution, recalculate the field, and iterate until you reach convergence. And this works quite well.

The theoretical approach for handling the electrolyte, though, is—it's one of the simpler methods. It works, but it's not accurate. And now the question is, how do we make it more accurate? And this is work we're pursuing not in JCAP but through a SciDAC [Scientific Discovery through Advanced Computing] project.

05-01:51:11
Eardley-Pryor: We can fill it in later.

05-01:51:12
Bell: Martin put together a group of about to ten people for this large DOE contract. It runs five years. And we are all working on various aspects of very difficult, frontier elements of applied quantum mechanics. So there are some mathematicians there, and, you know, largely theoretical chemists, and then there's me, who's at the borderline. And I'm asking what I think are the challenging physical chemical questions, which then we're trying to address

with theory. So Martin and I are asking the questions, Okay, if you're going to do quantum mechanics, what's the best functional and best theoretical method for describing what is on the surface, never mind the electrolyte? And how do we know?

05-01:52:13

So we've decided to look at the heat of adsorption of CO, a small molecule, and its vibrational frequency on different metals. And we want to get the properties of the metal correctly, as well. It turns out that you can get bits and pieces of this problem right, but not with the same functional. And if you're going to do that, this is a bit of a nightmare, because one approach of theory should get all the properties right. And so we're struggling with how to bring this into focus. We've gotten a lot of insights over the six months that we've been working with a joint postdoc, Christianna Lininger.

And the next step now is to represent the electrolyte, beyond the linearized Poisson-Boltzmann. And how do we make it nonlinear? Well, it turns out you can do that, but now the computing costs mount up very rapidly. So we're working with some postdocs in Teresa Head-Gordon's group to see what's the optimal way to get that part of the physics right, at a reasonable price.

05-01:53:32
Eardley-Pryor: At a reasonable calculating price?

05-01:53:33
Bell: A reasonable calculating—

05-01:53:34
Eardley-Pryor: Time-calculation price.

05-01:53:36
Bell: Yes. Don't sacrifice accuracy, but keep the cost to a reasonable level. And this is an interesting challenge. We just had a meeting of three faculty members and four postdocs in last week to see how we're going to challenge this, how we're going to meet this challenge.

05-01:53:57
Eardley-Pryor: In terms of also reducing time and calculation as another thematic in your work, I'm wondering if you could talk a little bit about your work in 2012 and since then on the DEMS—D-E-M-S—differential electrochemical mass spectrometry. What is that?

05-01:54:15
Bell: So this is a different problem. This is an experimental problem. Let's say that you'd like to sample the products that are formed in an electrochemical cell right where they're formed, DEMS offers a means for doing so because you can sample the products very close to the cathode where they are made. Differential electrochemical mass spectrometry is not a new theme, but when I wanted to start doing this with my graduate student, Ezra [L.] Clark, we

surveyed the literature and a review of the literature and we found that none of the published methods did this exactly right. None of them were going to do the job. They either distorted the electrochemical field or they sampled in the wrong way or they had the reference electrode in an inappropriate way. And we said, "Nuts! We're not going to build something that's wrong." Oh, and we actually purchased a commercially made DEMS cells from Hiden, a British mass spectrometer company, and we tried it out, and it performed very poorly. So we said, "Okay, we spent $1,000 on this, it's not going to be useful, and we can't fix it."

05-01:55:29

So he and I sat down and said, "Well, let's be engineers and say what are—list all the properties we want in the product, in the final product—and how should it behave? And we scratched this out on paper. And then Ezra went off and did a CAD drawing of our sketch, which could be updated and played with. And eventually we had the machine shop build one for us. And we got it to work. We bought a mass spectrometer from Hiden, put it together, and it didn't work the way we expected. And we discovered that there are bubbles that form and hang up in places that are awkward and give you an electrical disconnect. So we went back to the drawing board and we modified the thing. And we went through, I don't know, four or five iterations of redrawing and rebuilding—and Ezra was very clever at doing these things—until we finally got it to work. The final design worked beautifully, and we published a paper on it in *Analytical Chemistry*.

05-01:56:31

Since our DEMS cell design was so different form previous cell designs, we applied for a patent through LBNL. Along the way, Hiden got wind of the fact that we had something that was far better than what they were selling, and they said, we want to license your patent. So they did eventually. They did a deal with LBNL. Our cell is now available commercially. So that's a nice output of the experimental research.

05-01:56:57

Eardley-Pryor: That's a great story. Okay, so that doesn't have anything to do with the theoretical piece in reducing time.

05-01:57:04

Bell: No, no.

05-01:57:04

Eardley-Pryor: I misunderstood what the point of that was. Getting back to the theoretical piece, maybe. The Vienna Ab initio Simulation Package—what is VASPsol?

05-01:57:16

Bell: So VASP is a commercial algorithm, which you can license, and it's great for solving problems involving surfaces. It's very efficient and readily available. It works well. And so that was the thing of choice. We would have used something coming from Q-Chem, Martin's company, but they haven't yet finalized and developed their periodic boundary code. Q-Chem works very well on molecules and now the firm wants to market a periodic boundary code and is developing one, but it is not yet ready for general use. This is why we are using VASP. VASPsol is the add-on to VASP that handles the linearized Poisson-Boltzmann. So we're using their algorithm for handling this, but with a twist that is developed by Jason Goodpaster, which was original to him.

05-01:58:28
Eardley-Pryor: Could you talk a little bit about what Q-Chem is? Because it hasn't come up yet in our recorded conversation.

05-01:58:31
Bell: Q-Chem is a company that develops commercial software. I can't remember the year that Martin founded this company—it's quite a while ago. And they used to be in Pittsburgh; then they've moved out here to the West Coast, so the code writers and developers are here—I think down in Burlingame or something like that.

And what is nice for us is that we can get to the source code, which is the guts of the program, and work with the source code and modify it for our specific needs. And then we work with the developers of Q-Chem and the company to take the better parts of what we have developed and embed them into the next iteration of the software. So some things that we've developed for finding transition states have been embedded there. We have found some errors in the code which have been fixed—you know, thanks to our sleuthing efforts. And so forth. Every four years, five years, Martin gets together all the people who have contributed to the last iteration and improvement, and there's a giant article written and published. And those are some of the better-cited papers I have.

05-01:59:59
Eardley-Pryor: So when you and Martin take on students to work on a theoretical piece, do you have them thinking about contributing something to Q-Chem specifically?

05-02:00:09
Bell: No, no.

05-02:00:09
Eardley-Pryor: It just happens to come out of their work?

05-02:00:11
Bell: If it comes out of it, it comes of it, and it's added on to Q-Chem. If it doesn't, that's okay, too.

05-02:00:16
Eardley-Pryor: Over your career, you've done a lot of consulting work, like you mentioned with Kodak. How does your work that is more in the experimental realms differ from your work with Q-Chem that's in the theoretical realm?

05-02:00:30
Bell: So I don't consult for Q-Chem, and I'd not be in a good position to do that, because I'm not a theoretical chemist. So my consulting work is all with companies, and it's all about experimental things—or it's more long-range policy. I've done a few things with ExxonMobil the last couple of years in that area.

05-02:00:53
Eardley-Pryor: About where they should invest their efforts?

05-02:00:56
Bell: Yes. Well, one was on reviewing their catalyst technology here in the US. And then last winter break I went over to Belgium, to Brussels, and was part of a small team that did a review of their chemical technology.

05-02:01:13
Eardley-Pryor: But going back to Q-Chem, some of your students do contribute and do consulting work with Q-Chem, it sounds like.

05-02:01:21
Bell: Not that I know of. I don't think I have any of my graduates doing consulting work for Q-Chem.

05-02:01:26
Eardley-Pryor: It just happens to be that some of their work contributes to the code?

05-02:01:29
Bell: Contributes to them—and we just pass it over and it get incorporated. We get acknowledged, but they're not paid for that.

05-02:01:37
Eardley-Pryor: I see. Okay. I'm understanding a little bit more the relationship that you have with Q-Chem. That clears it up. Are there other pieces in your theoretical work in your career that you want to talk about, that you think have been meaningful or that are just interesting stories that come up for you?

05-02:01:53
Bell: No, I think we've largely covered it. I've brought you up to date on this. And I'll mention that I like to blend the theoretical work and the experimental work. So I'm currently in the midst of trying to write a white paper to the Department of Energy. So a white paper is a proposal for a new direction of research. This is the way the DOE likes to get things started—you write a five-, six-page, very densely-written prospective and send it in, and then they'll say, Yes, this looks very interesting, give us a more detailed—what's called a field task proposal, FTP.

So at the last review of our catalysis program, two of the people in the program, Peidong Yang from chemistry, Miquel Salmeran from LBNL, and I put together a first cut at this white paper. And I gave an oral presentation to the people at DOE via Zoom—that's a teleconferencing software. And this was a fifteen-minute presentation. At the end, the folks from the DOE told me that they liked it, and we talked about broadening it so that other divisions at the DOE might be able to participate and fund it. And we got the word that what they'd like is a white paper. So, this is the signal that you're trying to induce in them to say when you go in and make the presentation.

05-02:03:33
Eardley-Pryor: So what's the white paper about?

05-02:03:35
Bell: Well, the white paper will be about how to use synchrotron radiation from the Advanced Light Source (ALS) to characterize liquid-solid interfaces. here—The synchrotron at the ALS is unlike the one at Stanford or at Brookhaven or Argonne in the sense it's lower-energy—lower-frequency X-ray radiation, all the way from maybe twenty electron volts to a thousand, or several thousand. So, you'd call it either tender or soft X-rays. This enables one to probe the electronic states of atoms and molecules on solid. You could also couple this with *in situ* infrared spectroscopy, which I've been doing all my career.

And the discussion was with one of their beam scientists and specialists in this area this morning, Musa Ahmed, and one of his colleagues, focused on how we could join forces to take advantage of some of his know-how in technology, my interests in electrochemistry specifically, also Miquel Salmeron's knowledge on how to build *in situ* cells for these applications, mate these things together, show what's new, and present this in this white paper that we're going to write together.

05-02:05:03
Now where does this fit into theory? Well, we're going to try and answer some of the questions that we're probing theoretically, which right now don't have experimental evidence to show whether the theory is right or wrong. So you have to move these two parts up and down together.

05-02:05:23
Eardley-Pryor: That's a perfect melding for your discussions here today.

05-02:05:27
Bell: Yes.

05-02:05:28
Eardley-Pryor: Just to wrap things up for the research portion—because our next set of interviews will shift to talk more about your administrative role. In thinking about your approaches to research, I'm interested in hearing what things influence you. I mean, there's just a blizzard of information, of possibilities, of directions you can go in. So how do you choose? How do you pick things to be active in?

05-02:05:54
Bell: So I have to say that one of the things that shapes my thinking is, I have a small group—relatively small by chemistry standards, you know, anywhere from sixteen to twenty people—I don't have a group of fifty people. So, I can't afford the luxury of trying out lots of different things and picking the winners. Therefore, I have to be a smart player. This means that I have to think strategically about, what do I want to do in an ideal world—you know, supposing that I can find funding for it—that will have the most impact for the money spent. And that means not following the crowd, in the sense of doing whatever is popular, trendy, whatever—the last thing that appeared in *Nature*, you know, or *Science*—but rather using my own head to figure out, if we could do it, this would have meaning.

05-02:06:56
Now, it's one thing to say, if we could do it. The next thing is to say, how might we do it, and how am I going to find a partner with whom to do it if it's not within my skill set? So that's been a constant process, and that's a constant challenge. And it's not easy. It requires constant rethinking. So that's, in a very few words, how I look towards moving forward. And as I say, I like to play for the long term. And I've been doing it for enough of a while that I figure, you know, I think I know how to do it.

05-02:07:34
Eardley-Pryor: In thinking about that long term, what are the things you hope to accomplish with the active years you have left in the laboratory? What are the things that you have insight that you think, "This is something I really want to get done before my career is over?"

05-02:07:49
Bell: Right. So I'd like to address these electrochemical problems more than we have been able to so far. And I think this is a nice, meaty challenge, because there are so many different elements here—different kinds of physics that have to be brought together. Throughout my career, I've liked to bring together what seem like disparate areas, either experimentally or theoretically, and see how we can show that if you do this right, you can get multiphysics, multiscale representations correctly. Because I think this is where the future of the game lies. For me, that's exciting.

05-02:08:35
Eardley-Pryor: What other things, looking forward, do you really have your hopes set on? The electrochemical work, certainly. Are there others?

05-02:08:43
Bell: Yes, the electrochemical work, right now. The zeolite work is coming to a point where I'm starting to see that we are more or less exhausting the things that I can think about that are really exciting. We can still do good work and we will do good work in this area, but if I had money that allows me to do basic science, I might do something else. That's the problem—finding money to do basic science is becoming harder and harder.

05-02:09:20
Eardley-Pryor: Well, if we're going to change directions from looking forward to then looking backwards over your career, what are some of the things you're most proud of, that you feel like might be your research legacy?

05-02:09:31h
Bell: My research legacy?

05-02:09:32
Eardley-Pryor: Mm-hmm.

05-02:09:33
Bell: Okay. I'm proudest of the fact that throughout my career, I've been able to show how, through good experimental and theoretical work, you can develop deep perspectives of complex systems, and by doing this discover what are the key operating forces that shape a catalytic system. I see that people refer to our work and build on it, so I'm planting seeds for the future. And periodically I hear that somebody in industry even has picked up on this and built on it, which is pleasing to see—that our work has practical output.

05-02:10:18
Eardley-Pryor: What have been some of the greatest challenges, as you think back on the many decades you've been doing this work, that you've been able to overcome?

05-02:10:28
Bell: Well, there are technical challenges that are involved in getting experiments to work the way you think they ought to work. Because when you start, you're never sure that it's going to work out. Yes. So it's like rock climbing—I'm not a rock climber, but I've watched people climb rocks, including one of my stepdaughters. You have to find the right toehold; then you have to look out for where you put your hands next and not lose the first toehold that you have; and gradually, you can go up the wall. This takes a lot of mental and physical effort. The same is true, in many respects, in theory, too. It's just a different kind of thinking and different set of questions. But now that I've been doing it so long, this ability to go back and forth seamlessly between theory and experiments is good, because sometimes the theory suggests a set of experiments that we want to do or which we have done, and vice versa.

05-02:11:36
Eardley-Pryor: This sounds to me like there's a good point for us to conclude today. And then we'll talk, next time, about your administrative work and how you've helped shape Berkeley to be the place that it is.

05-02:11:44
Bell: Right. Yes, yes.

05-02:11:45
Eardley-Pryor: All right.

05-02:11:46
Bell: Good.

05-02:11:46
Eardley-Pryor: Thanks a lot, Alex.

05-02:11:46
Bell: Great, thank you.

Interview 6: April 26, 2019

06-00:00:00
Eardley-Pryor: Today is Friday, April 26, 2019. I am Roger Eardley-Pryor from the Oral History Center at the Bancroft Library at the University of California Berkeley, and we are doing interview session number six with Alexis T. Bell.

06-00:00:14
Bell: Correct.

06-00:00:15
Eardley-Pryor: Alex, great to see you, as always.

06-00:00:16
Bell: Good to see you, Roger.

06-00:00:17
Eardley-Pryor: Today we have the joy of discussing your very deep and long and extensive administrative history at the university. And the first topic that I was hoping you could tell me about is your first work in administration with the Berkeley Faculty Club. This was from 1974 to 1976.

06-00:00:37
Bell: Right. Yes, yes.

06-00:00:37
Eardley-Pryor: What got you involved in the Faculty Club?

06-00:00:39
Bell: Well, I got involved because of a colleague of mine—in fact, the colleague who hired me into this department, Charles [W.] Tobias. He was a long-time member of the Faculty Club. He used to go there and have lunch regularly and then go to what is now the bar, which was called the card room at the time, and play hearts with George Maslach and other people from the campus administration—deans—and do that from maybe one o'clock until 3:00, and come back and visit with his group and finish up his day before he went home.

06-00:01:13
Eardley-Pryor: That sounds like a good afternoon.

06-00:01:15
Bell: It was a good afternoon, and a very leisurely, classical, European-style professorship day. So he convinced me to join the Faculty Club, and he said it would be a good place to meet faculty from other departments, as well as to see my own colleagues more regularly. And I did, I followed his lead. And then when the presidentship—no—first, membership on the board of directors opened up, he urged me to run for a position there and he supported me politically—because nobody on campus knew me at that time—and I was elected to the board.

06-00:01:53
Eardley-Pryor: What did you think about your joining the Faculty Club? Was it something that lived up to Charles's hopes for you?

06-00:01:57
Bell: Yes, it did live up. The camaraderie around the chemistry table was very good. The table was located under the moose's head—which is still there—and was occupied exclusively by members of the College of Chemistry. So, people from our department, senior members from Chemistry. That was good way to get to know them, as well.

06-00:02:21
Eardley-Pryor: Were there collaborations that came out of that?

06-00:02:24
Bell: Not scientific collaborations—well, probably some scientific collaborations, but not for me, personally. But it was mainly to hear what other people were doing and what their thoughts were about the campus. So it was a good move. And then it was interesting that Charles suggested that I join the board, which I did. And I found that very interesting, because I immediately started working with faculty members from other parts of the campus, who were actually much more senior than I was—I was in my thirties at the time. Much to surprise I was elected as the president of the board.

06-00:03:04
Eardley-Pryor: How did that role, for you, change with the presidency?

06-00:03:08
Bell: Well, I now had to take responsibility for the monthly meetings. We had also, it turned out at the time, received money from the [Evelyn & Walter] Haas Foundation to renovate the club—actually, renovate both clubs—the [Berkeley] Women's [Faculty] Club and the Men's Faculty Club, as it was called at the time.

06-00:03:29
Eardley-Pryor: And these were separate?

06-00:03:31
Bell: They were separate. And the idea that Walter Haas had—[Walter Haas, Senior] —was that the two clubs would amalgamate and form one club, because it didn't seem right to have two clubs separated by gender.

06-00:03:46
Eardley-Pryor: It seemed about the right time, in the mid-seventies.

06-00:03:47
Bell: It seemed about the right time, yes—the seventies. So Peg [Margaret D.] Uridge, who was from the School of Librarianship and myself worked on doing this, as well as planning for the renovations. And we succeeded very

well in doing the renovations, but try as we might to amalgamate the clubs, we were opposed by the individual memberships, for different reasons.

06-00:04:16
Eardley-Pryor: What were the men's reasons versus the women's?

06-00:04:18
Bell: So the reasons from the men's club were that the women's club had a debt to the [University of California] Regents for the land and the building—this is dating back to the 1920s—and they didn't want to assume any debt. On the women's side, it was a little more personal: They didn't like the director—the manager—of the men's club, who was a retired staff sergeant from the Army and a bit brusque. And they thought their ambience and the spirit of their club would be destroyed by having this gentleman be in charge of both clubs.

06-00:04:53
Eardley-Pryor: Wow.

06-00:04:53
Bell: They made the tacit assumption that that would happen. Of course, it might not have. And so the two constituencies voted down the proposed articles of incorporation, which we had drafted. We had worked with a law firm to draft articles of incorporation. And I had even gotten our club to vote to change its name from Men's Faculty Club to the Faculty Club, which we did. And we also got a liquor license along the way, and we started admitting women as well as men. So that was a good step forward, but we never amalgamated the two clubs—and they're still separate.

06-00:05:29
Eardley-Pryor: They still are today?

06-00:05:30
Bell: Yes. Today. Yes.

06-00:05:32
Eardley-Pryor: Wild.

06-00:05:32
Bell: Although they have cross-membership.

06-00:05:34
Eardley-Pryor: Oh, I see. Was the issue of the men saying they did not want to take on debt—was that sort of a false front?

06-00:05:43
Bell: It's a false front, yes. Yes. Yes. There were enough senior members who liked the fact that they were separate. And it goes all the way back to, I think, 1905, 1906, when the men's club was first formed, when there were only men—you know, in the tradition of gentlemen's clubs—first in England and then later on the East Coast and now the West Coast. It was a place where gentlemen could

retreat and talk about politics, smoke a cigar, have their liquor after lunch and, you know, enjoy.

06-00:06:17
Eardley-Pryor: But under your term as president of the board of the Faculty Club in '75 to 1976, that was when the club did open to women?

06-00:06:25
Bell: We opened up membership, which was a good thing. We did the renovations. We had a few million dollars, which was a large amount of money at the time. And we did a beautiful job. The serving area was changed; the main dining hall was stripped and re-stained; the Howard Room was redone; we redid a number of the guest rooms upstairs; and we built the bar—we designed and built the bar, which is now, today, a fixture in the club.

06-00:06:56
Eardley-Pryor: What role has the Faculty Club continued to play in your career since then?

06-00:07:01
Bell: So the club gave me an opportunity to see what management was all about. I had never done it before, never had that responsibility. And I learned that you have to listen, first of all, to alternative views—and they may not be consistent with what you think should be going on—and how to integrate that and present a more unified view. And that was a good learning experience, and later made it easier for me to become department chair.

06-00:07:35
Eardley-Pryor: So before you became department chair, the next stage I have in your administrative career is actually a pretty big step up, in 1979, as assistant dean for the entire College of Chemistry.

06-00:07:46
Bell: Right, yes.

06-00:07:47
Eardley-Pryor: So tell me about how that experience came to be.

06-00:07:50
Bell: So that came to me because the dean asked me to do that service. And I thought, "Well, that would be a next step, possibly, into administration."

06-00:08:01
Eardley-Pryor: Who was the dean at that time?

06-00:08:02
Bell: Norman Phillips—a physical chemist. It had a very smooth working relationship with him. I had responsibility for all of the laboratory renovations, for the infrastructure, the mechanics of running the College.

06-00:08:32
Eardley-Pryor: That's a pretty significant role to play in such a facility-dependent college.

06-00:08:36
Bell: Right, very heavily dependent on facilities. And so that was something I could easily do part-time fairly, and balance it with my professorial responsibilities.

06-00:08:51
Eardley-Pryor: Tell me a little bit about that balancing. Because the Faculty Club is the first time you took on an administrative, managerial role. Now, as assistant dean for two years of the College of Chemistry, how did you balance managing that part of administrative work with your ongoing and extensive research?

06-00:09:06
Bell: Right. So the Faculty Club was fairly easy, because we had only monthly meeting for the board. And there were periods where I had to go over to the club—it's just a five-minute walk away—and speak with the manager or deal with particular issues that would come up. But this was easy to do in the middle of the day. You'd just schedule the time. The deanship—the assistant deanship—was more of a partitioned part of the day. I had an office in Latimer Hall where I could go and meet people as I needed to, and the rest of the day I spent in my office—faculty office—here in Gilman Hall. So it was done by partitioning the day.

06-00:09:50
Eardley-Pryor: So the way that you helped manage it was separating spaces?

06-00:09:52
Bell: Separate spaces and separate times, yes—where I only did one thing or the other thing, but not both. Yes. Now, this changed later, when I became department chair. It was no longer feasible or practical to separate the day into halves or fractions, so I did everything out of one office.

06-00:10:17
Eardley-Pryor: So that step, into becoming chair of the Department of Chemical Engineering at Berkeley, you were in that role for a full decade: 1981 to 1991.

06-00:10:24
Bell: A full decade, yes. Correct.

06-00:10:27
Eardley-Pryor: And there are some significant changes that are happening within the department at that time.

06-00:10:29
Bell: Right, yes.

06-00:10:31
Eardley-Pryor: Among those, you had told me, is the wave of hiring that happens in the wake of the "founding fathers" of the department retiring.

06-00:10:39
Bell: Right. That's right.

06-00:10:41
Eardley-Pryor: Tell me a little bit about what your experience was within the department of that massive change, especially as chairman.

06-00:10:47
Bell: Yes. So the people who had founded the department in the late forties—'49—and fifties—I came in '67—had established in the department kind of a culture and a spirit and a sense of what is chemical engineering. Several of them had industrial experience, and that was reflected in their perspective. But by the early eighties, things were starting to change. There was more and more of a trend to look at fundamentals rather than just empirical observation and integrating it with some equations, which was the early days of chemical engineering. And there was also a sense that with time, things would change even further towards fundamentals. And this was particularly sharp here, because we were part of the College of Chemistry. So the chemists were always at the scientific end of the spectrum; and here is this smaller group of [chemical engineering] faculty who are dealing with applied issues. You know, I've coined it "intellectual arrogance." It's maybe a sharp term, but that's how I felt.

06-00:12:01
Eardley-Pryor: Unpack that for me. What do you mean?

06-00:12:03
Bell: I mean that there was a sense of superiority on the part of those who were doing more fundamental things. And there's kind of a pecking order, if you like, an informal pecking order: that mathematicians who are above the fray of doing anything practical are on top; physicists come next; chemists below that; engineers, certainly, a notch down; and biologists are, you know, somewhere to the side, at the time. Yes.

06-00:12:29
Eardley-Pryor: And this was apparent throughout the College of Chemistry?

06-00:12:32
Bell: This was apparent to many of us here that, "You're dealing with practical things; you don't quite know what's going on, because you don't"—well, we knew that we don't have the tools to be as precise as one would like to be as a scientist. But nevertheless, we were doing things which were transformative and enabling chemistry to be practiced on a very large scale, even if we didn't know exactly how the phenomena we studied occurred. It's not unlike, in the extreme, medicine does a good job, even if their scientific underpinnings are not always there. It's effective.

06-00:13:08
Eardley-Pryor: Yeah. The drugs are working.

06-00:13:10
Bell: The drugs are working, right. The patient gets better.

06-00:13:13
Eardley-Pryor: So with that tension—the "intellectual arrogance," as you say—was that something that was apparent also during your time as assistant dean for the College?

06-00:13:21
Bell: To some degree, although since I wasn't dealing with the intellectual aspects of the discipline or the College, that was not really apparent to me.

06-00:13:32
Eardley-Pryor: Why would that become more so to your perspective as chairman of the department?

06-00:13:37
Bell: Well, because now you're trying to shape what the department in terms of its academic program—more importantly the people who are here. The deans at the time were all chemists, so you have to sell your new candidates to somebody who has a very different perspective and set of values. And so that was, I always felt, an uphill climb. Jud [C. Judson] King, who preceded me, sensed it. Perhaps he didn't articulate it as much. Jud is a very smooth operator, and if he feels there's tension, he doesn't always articulate it. He's very good at that. Charles Tobias, who had been chair before Jud, certainly knew this and had sensed it.

06-00:14:35
Eardley-Pryor: How would you describe yourself as a leader—an administrative leader, as chairman—in relation to either Charles or Jud? How was your operating style different?

06-00:14:45
Bell: So I learned a lot from Jud, I have to say. I really admired his style of consultation and doing what I called administration by walking about. He would come into my office, come into the office of colleagues, and ask if he could spend a few minutes talking about an issue that related to the department. And after he had heard you out—and he listened very, very well—he would summarize all these things. And so when we had a faculty meeting, he pretty much knew what to expect from each individual, and he knew who was going to be very articulate and passionate about something and who, you know, more or less didn't care, at the other extreme. And I found that that was very effective, and I tried to adopt his style in that sense.

06-00:15:37
I probably was more opinionated than he was at his stage when he did this as to what we should and shouldn't be doing. Sometimes I found that created problems for me if I was pushing too hard for something I wanted to do and I didn't have the whole group behind me.

06-00:16:01
Eardley-Pryor: Can you think of an example?

06-00:16:02
Bell: Well, it's hard to think of an immediate example. But what I did do is to learn over time that you had to step back and recommunicate your ideas and get everybody on board before you move forward. And I see that the most successful administrators on campus at various levels do that effectively.

06-00:16:30
Eardley-Pryor: That's an important lesson in leadership.

06-00:16:31
Bell: Yes, it was an important lesson to learn.

06-00:16:33
Eardley-Pryor: Let's return to the issue of the founding fathers of the department retiring or passing on, and what kind of challenges and opportunities that created for you as chair.

06-00:16:41
Bell: So this created new openings. We were never going to grow net-net as a department—we were never more than twenty individuals here. And so when I became chair, there were opportunities almost every year, in quick succession, to hire new people. So being inclined towards applied physical chemistry, I had kind of a kindred feeling towards those candidates who shared this view. And it wasn't hard to find people like that, because this was the wave which was just beginning around the country. And so Jeff [Jeffrey A.] Reimer was the first person I hired, who is our current chair. He's also served, I think, eleven years now, so a comparable amount of time to that which I served.

06-00:17:36
Eardley-Pryor: And as I recall, you and Jeff began collaborations almost immediately in research.

06-00:17:40
Bell: We began a collaboration shortly after he got here. Jeff is an expert in the use of NMR spectroscopy, and I was interested in Fischer-Tropsch synthesis, which is the hydrogenation of CO to make hydrocarbons. I proposed to him that we use his capabilities to look at the intermediates that are formed on a catalyst. And so we undertook some really difficult experiments with C-13-labeled carbon monoxide. So you can enhance the NMR signal, and we were able to see what I call the "growing whiskers"—short hydrocarbon strands coming off the surface of the catalyst. And this was published sometime in the early eighties, this work—and I find it remarkable that nobody has picked it up. It's cited, but nobody has picked it up and done it again or done it better. Because they were challenging experiments to do. So we had to figure out a way to put the sample into a little ampoule that was spun at kilohertz rates and didn't fall apart and blow up. And it was a really nice couple of papers that we got out of this.

06-00:18:57
Eardley-Pryor: That's a nice welcome to the department for Jeff.

06-00:18:59
Bell: Yes, it was. Yes. And actually, it was something I did with a couple of other people who came here during the period when I was chair.

06-00:19:08
Eardley-Pryor: Give me a sense of scale. During this time, this ten years that you're in service as chair, how many of these retirements or passings-ons and new hires did you have to oversee?

06-00:19:18
Bell: So I did seven altogether.

06-00:19:21
Eardley-Pryor: That's a significant turnover.

06-00:19:22
Bell: Which is approaching somewhere between a third and maybe 40 percent of the faculty.

06-00:19:27
Eardley-Pryor: So that's a real shift.

06-00:19:29
Bell: That's a real shift, right.

06-00:19:30
Eardley-Pryor: How do you think the department changed in the wake of those hires?

06-00:19:34
Bell: Well, it changed from a more traditional process orientation to looking at fundamentals—how they apply to processes, but also progressively looking at materials. Because we could say that for materials—particularly the electronic materials, semiconductors—chemical engineering was starting to play more and more of a role there. Eventually, also, in drug delivery devices—patches of polymer that had a drug imbibed in it and was put on the skin and went through. You know, so there was the nicotine patch and—

06-00:20:11
Eardley-Pryor: All of these transdermal patches.

06-00:20:12
Bell: Yes, transdermal patches for other diseases. There was a patch for treating glaucoma. You put it under your eyelid here and it leached out the drug that treated the glaucoma.

06-00:20:29
Eardley-Pryor: Give me a sense, if you would, of how the department was changing, as you say it was, in terms of its shift towards fundamentals—and the way that

chemical engineering as a broader discipline outside of Berkeley was changing.

06-00:20:42
Bell: So that came a little bit later—that came after the first five years of my tenure, so around '86. There was a sense by the National Academy [of Sciences] [NAS] and its working arm, the National Research Council [NRC], that a study be done of the field of chemical engineering: What has it delivered? Where is it heading in the next decades? The ultimate product was this report, which is called the Amundsen Report, although its official name is "Frontiers in Chemical Engineering: Research Needs and Opportunities." And I was invited to lead one of the seven panels. So that was an eye-opener, because first of all, I got to meet a lot of my contemporaries from other parts of the country. We had several meetings in Washington in preparation for the writing of the report. And then we had workshops—one, two-day workshops held in Washington. And then the groups each wrote a chapter. I wrote one on materials development and the last chapter in the report. And this gave me a sense that the future is in this materials—very fundamental outlook on chemical engineering.

06-00:22:03
Eardley-Pryor: Had that sense of where the discipline was moving—had that also influenced your hirings?

06-00:22:10
Bell: It influenced my hiring.

06-00:22:12
Eardley-Pryor: In what way?

06-00:22:14
Bell: Well, I personally wanted people who were more forward-looking than retrospective. And even though we had great successes in past developments—Charles Tobias, actually, shared this idea with me early on—that you should look forward, never backwards. And so he was a big supporter of finding people in the semiconductor area, which we succeeded in doing this. And then polymers—fundamentals of polymer area and so forth. So he actually set the scene and helped me, because he was much more senior than I. And I picked up on that. My inherent interest in fundamentals played into this, as well. So that's how we pursued things.

06-00:23:11
Eardley-Pryor: Who were some of the folks—you mentioned Jeff Reimer—that you brought in to help fulfill some of this [vision]?

06-00:23:16
Bell: Let's see. I have to consult my cheat sheet here. Jim [James N.] Michaels was the next one. Doug [Douglas S.] Clark, who is our current dean—he was chair for a short while before he became dean. David Graves, who is with us now

and is about to retire, who is in the semiconductor area. When he first joined the faculty, he was interested in plasmas, much as I had been when I started my career, so he took over that area. More recently, he has moved into plasma treatment of wounds and plasma treatment of cancer, in fact. So that's an evolution. Doros [N.] Theodorou, who is Greek and had been at MIT [Massachusetts Institute of Technology], I hired. And then I collaborated with him on statistical mechanics and molecular dynamics.

06-00:24:08
Eardley-Pryor: Yeah, that took your theoretical work into a new dimension.

06-00:24:10
Bell: That's really the beginning of my theoretical work. Let's see. The next one was Arup [K.] Chakraborty, who was chair from 2001 to 2005, and then in 2005 left to go to MIT.

06-00:24:25
Eardley-Pryor: You also had intimate collaborations in research with Arup.

06-00:24:28
Bell: I started a collaboration with him in the area of quantum mechanics. And then Doros, Arup, and I as a threesome worked together. And then let's see, who was next? The last one was Susan [J.] Muller, who was the first woman to join the faculty.

06-00:24:45
Eardley-Pryor: And when did Susan join?

06-00:24:47
Bell: She came in 1991.

06-00:24:50
Eardley-Pryor: Okay, so '91 was the first female faculty member to join chemical engineering?

06-00:24:52
Bell: Yes, that's right. Yes. Right.

06-00:24:55
Eardley-Pryor: Tell me a little bit about the desire to have more gender equity. I know that was a big push among the sciences, particularly at Berkeley, and there was, even from the administrative level, some real push to make that happen.

06-00:25:08
Bell: Yes, there was.

06-00:25:08
Eardley-Pryor: Tell me about—with all of these hires, and the last one being a woman—what was your sense, as chair and overseeing a lot of these faculty searches, on the role of gender equity in the department here?

06-00:25:19
Bell: So I felt that yes, we should have a woman, but—as I feel today—we shouldn't hire a woman simply because it's a woman. The person who we hire should meet Berkeley standards, which are very high. And whoever was the first woman should feel proud to be part of the faculty and not feel that she's there because she's representing her gender.

06-00:25:47
Eardley-Pryor: So it must not be a token hire.

06-00:25:50
Bell: It must not be a token hire, and especially for the first person.

06-00:25:53
Eardley-Pryor: Why so?

06-00:25:54
Bell: Well, because I believe that if you're starting something new, it's really critical to get the right people at the outset. And if you don't, it's hard to fix afterwards. If you get the right people with the right spirit and the right frame of mind, things will work.

06-00:26:13
Eardley-Pryor: It's about setting a precedent.

06-00:26:14
Bell: Yes. You're setting a precedent. And actually, I shared this idea with Jud when he was Provost. When the [University of California] Merced campus was being discussed and it was agreed that it was going to be formed, I said "The success of Merced will depend on who you hire in that first round." And it was a mixed bag, and it hasn't worked out really well.

06-00:26:39
Eardley-Pryor: It set the wrong precedent.

06-00:26:40
Bell: Yes, yes. And I really believe that it's better to do nothing than to do second best.

06-02:11:46
Eardley-Pryor: Well, as you were going through this process of elite hires and a woman, Susan, was hired as the last of that round of hiring, what sort of challenges did you face in selecting these men over and over as chairman?

06-00:27:03
Bell: Well, there wasn't too much pressure until this latter part. Gender equity was just starting up at the time that we hired Susan, so I didn't feel a lot of pressure as department chair.

06-00:27:17
Eardley-Pryor: And tell me, how do you feel Susan has done in setting the precedent that you hoped would happen?

06-00:27:21
Bell: She's done well. I mean, each person sets their agenda on their own. She's done well. She's been a superb teacher here, very much respected. She has not evolved to have a very aggressive and large research program, but that's by her own choice. She's worked very effectively as the assistant dean of graduate education, so she's contributed in that respect. And then she spent one year recently at the NSF [National Science Foundation]—unfortunately, under the [Donald J.] Trump administration, and she hated the experience in Washington because of the political climate currently.

06-00:28:04
Eardley-Pryor: A learning experience—not always a good one.

06-00:28:05
Bell: Yes.

06-00:28:06
Eardley-Pryor: All right, well, tell me a little bit—as a woman joined the faculty for the first time, how did the department change? Or did it?

06-00:28:14
Bell: Well, the department accepted her quite readily. There were no dramatic changes that occurred. Subsequently we hired more women. The next one was Roya Maboudian, and then Rachel [A.] Segalman, both of whom have done extremely well. Unfortunately, Rachel left us to go to [University of California] Santa Barbara. But eventually this is what you expect—that while you want to have a certain character or profile of person, you can't always necessarily keep them. There are competitive forces out there.

06-00:28:47
Eardley-Pryor: Yeah. Berkeley is an elite institution, in competition with other elite institutions.

06-00:28:50
Bell: That's right. That's right. Yes.

06-00:28:52
Eardley-Pryor: Take me back to the Amundson Report—this "Frontiers in Chemical Engineering" report. Was that your first experience in doing a report in collaboration with the National Academies [of Science, Engineering, and Medicine]?

06-00:29:05
Bell: Yes, yes. That was my very first experience.

06-00:29:07
Eardley-Pryor: Because you have had several since that have also had influence in shaping fields, and shaping your research projects at Berkeley.

06-00:29:13
Bell: Right. Yes. And it gave me a sense of the importance of these reports. And of course you can't guarantee their outcome, but if nothing else, lots of people read them. And a lot of young faculty at the time read the report and used it to help shape the directions for their research. I found it very useful for myself, too, as a broad education in what is our field, where is it going—to use that to help shape the profile of our faculty.

06-00:29:50
And then the next thing was the shape of our undergraduate program, which had been more or less the same from '49 until the eighties. You know, things don't change very rapidly at universities. We're very good at self-sustaining our traditions, much like the Church. But we spent a good part of the late eighties—three years—discussing the undergraduate program, with a lot of dissension on the part of people who were bound to teaching the way they wanted to teach their courses and didn't want to listen to their colleagues saying maybe there's a different way. So we had to break that down and chew on it and digest it.

06-00:30:35
But after three years, we succeeded in putting together an undergraduate program that had a core and four areas in which students could specialize as they ended the core part, in the four years. And everybody bought into that and we accepted it. Today it's more or less the same program. We've expanded to include biology—a required course in biology. We had a required course in technical communications, which survived everything but the last round of budget cuts. And unfortunately we had to give that up a couple of years ago, and Jeff Reimer reluctantly terminated that program. And we've added some additional electives for students: there's one in business administration now, and I've forgotten what the additional one is. But the students love it.

06-00:31:36
Eardley-Pryor: What else is part of the core that has, maybe, evolved from the founding teaching methods into the new curriculum that you helped carve out?

06-00:31:44
Bell: So the core consists of courses on thermodynamics—so, you know, what determines whether a reaction is going proceed all the way or not; what is determined vapor-liquid equilibria; kinetics, which discusses the factors determining the rates of chemical reactions; and transport phenomena, which deals with the transport of momentum, heat, and mass. This more or less forms the core of the curriculum.

06-00:32:20
Eardley-Pryor: And that's what all undergraduates will take as they come in?

06-00:32:21
Bell: Yes, all undergraduates will take that. They'll take a course on heat and mass balances, because those are conserved quantities—and how you quantify that and put this into the description of a process. So that was retained, but the application areas started to be more modern than simply petroleum processing.

06-00:32:40
Eardley-Pryor: Was that where the "chewing" that needed to happen within the department—was that where most of the chewing was involved?

06-00:32:45
Bell: That's some of it. Some of it also—new textbooks were coming out on the market that faculty could use that represented some of these more modern perspectives.

06-00:32:56
Eardley-Pryor: In the wake of the Amundson Report—your experience of learning and shaping where the field was going to be moving, the discipline itself—what was your role during those three years as chair of the department in getting the curriculum to be agreed upon?

06-00:33:14
Bell: Mostly talking with individuals, some of whom were quite set in their ways—or had written a book on the subject and didn't want to teach from another book—or change the way of looking at things. One individual who was particularly obstreperous left—went to another university—and that was ultimately fine. But eventually everybody accepted this perspective. And then we went on, with much greater rapidity, to do the graduate program.

06-00:33:48
Eardley-Pryor: Once the hurdles were accomplished with the undergraduate curriculum?

06-00:33:50
Bell: Yes. Right. We had gotten the pieces working together. And what was also remarkable about that period is, never had the faculty worked on a common problem where everybody had to get involved. It was usually, come to faculty meeting, discuss maybe a faculty hiring, but that was largely in the hands of the chair—the mechanics—or come and discuss some one-off issue and vote on it and then you go back to your office and do your thing. So most people were part of a federation of scholars but not working towards some common set of goals. And I found it very difficult, but rewarding, to induce people to work toward a common set of goals—and figure out what those goals are, define them and work towards them. And it's one of the harder things we do as colleagues, and it's one of the hardest things that anybody in the administration has to do.

06-00:34:52
Eardley-Pryor: In doing some of my background research in preparation for our talk today, one of the things that came up often in describing your administrative work

was your ability to form consensus among diverse ideas and get people to move together.

06-00:35:04
Bell: Right. Yes.

06-00:35:05
Eardley-Pryor: So what is it that you were able to do to help make that possible? You mentioned learning from Jud—administrating by walking around. You mentioned being a good listener. What was it that you were able to do to help get through that first major hurdle in the curriculum development changes?

06-00:35:20
Bell: So what I've developed in myself is an ability to listen to a complex set of voices, see where there's commonality, see where the fundamental issues are, and articulate them. And I find that people who can do this well—and I've met other people in the administration here and in the outside world—are effective. And as I say, it begins with listening, because you have to hear the sounds and the chaos and then shape that chaos into something that is half formed but not fully, put it out on the table, and say, you know, "Here's what I'm hearing. Here's what I'm seeing. What do you think?" And then get people to buy into that, and then we work with that to shape it into something whole that feels good to everybody.

06-00:36:14
Eardley-Pryor: So collecting general ideas and then presenting them to them—that gets their investment into them?

06-00:36:20
Bell: Right. Yes.

06-00:36:21
Eardley-Pryor: That's wonderful.

06-00:36:23
Bell: That's been a lifelong process of learning how to do that. It's not a skill that you're trained to do by anybody.

06-00:36:32
Eardley-Pryor: Was being chair of the department where you really honed this skill, or did it come from earlier experiences?

06-00:36:36
Bell: It was where I started to hone it. I then did this later as dean and as chair of various committees for the NRC and elsewhere, [like Berkeley's] Academic Senate. And today I practice it more in the research domain, where I have collaboration with people who are very different from myself and my skill levels. But I'm able to listen carefully and after a while say, you know, "Men and women, this is what I'm hearing, and this is what I think are the issues." I was just doing that this morning in the room next door on an area of theory.

06-00:37:19
Eardley-Pryor: So the skills and experience you had as an administrator, actually, has shaped the way that you do research?

06-00:37:26
Bell: Yes, it helps. Yes. Everything is seamless. So I have found that the most effective way to work, even when I've had heavy administrative responsibilities, is to be able to switch from one thing to another seamlessly, just as time allows. So I can switch from working on an administrative, to working on a research paper, to dealing with a tricky interpersonal problem. You know, it's just whatever is on the table at that moment or in front of me at that moment.

06-00:37:58
Eardley-Pryor: How are you able to block the times for all of these things?

06-00:38:01
Bell: I don't. I just let it flow. I've evolved the skills for handling each aspect, so I just put those skills to work at the moment. And many of the things are transferrable. That's something you have to learn.

06-00:38:23
Eardley-Pryor: In relation to your administrative work flowing into your research career, I'm wondering if your experience on the Amundson Report—which was sort of like a chemical engineering version of the Pimentel Report—

06-00:38:36
Bell: Yes, that's exactly was it was.

06-00:38:37
Eardley-Pryor: I'm wondering if your experience working on that led to changes in your research. Did it create opportunities for collaboration with other chemical engineers? Did it elevate your status nationally as a renowned expert in your field by serving on this committee? What kind of things came from that?

06-00:38:53
Bell: I think on that latter point it was very helpful. I was department chair at the time, I was serving on this committee; it gave me national visibility. While I was serving on the committee in '87 I was elected to the National Academy of Engineering, which was a major step forward for me in my career, and at a relatively young age. So I felt that being visible on the national scene certainly didn't hurt.

06-00:39:22
Eardley-Pryor: How does it help?

06-00:39:26
Bell: It helped as all recognition helps: It elevates you in the eyes of your peers. Whether that's justified or not is debatable—you know, whether that should—but it certainly did here. And I'd say the chemists are much more status-

conscious than the engineers are, although we're not immune to this—it's human. And so it gives you a little more credibility, so to speak. You have the US stamp of approval on your backside.

06-00:40:04
Eardley-Pryor: Does that then translate also into your ability to be a more effective administrator, by having that sort of national recognition?

06-00:40:10
Bell: Yes, it does. People are more inclined to listen to you and not argue with you. But I've never used professional standing to get my way or to make it easier for me to have my way.

06-00:40:27
Eardley-Pryor: You mentioned that part of the changes you brought from the Amundson Report to Berkeley, here in the department, was also changing the graduate curriculum. Could you talk about the changes you made from what was to what become?

06-00:40:39
Bell: At the time we started our discussions, the department didn't have as set of core courses that was required of all graduate students. And this very much emulated what Chemistry did. Chemistry didn't believe in having many courses required for graduate students, if any; the most important thing was to do your research and to acquire some coursework or skills to do that effectively. But the notion of educating a graduate student for a broader set of problems was not a part of the Berkeley tradition.

06-00:41:14
I felt differently. I believed that chemical engineers in particular were likely in the span of their forty, fifty-year career to do many different things, and even in their first job might not be doing anything like their graduate research. Instead, I believed that they should be highly educated generalists and have an ability to tackle hard problems involving chemical and physical transformations in the broadest sense. To do that effectively, graduate students would need more than an undergraduate education, and you had to have some graduate courses in the core areas. This idea was opposed by some of our colleagues, especially those who had started very young in their career here at Berkeley and had adopted the Chemistry point of view. But I still felt that our students didn't have to emulate chemists; they had to be faithful to their profession. I still think that way.

06-00:42:20
Eardley-Pryor: Did you see other graduate programs as examples for what you'd like to create here?

06-00:42:23
Bell: This has been asked frequently—you know, "What's MIT doing? What's Princeton doing?" I said, "In a certain sense, I don't care. Because we're at the

top of the heap. We should be defining what Princeton and MIT should be doing, not vice versa." Which I still believe. Why should we follow?

06-00:42:47
Eardley-Pryor: Do you think that's the case?

06-00:42:49
Bell: I think that's the case, and I think we're very much respected for setting a tone on our own. Of course we look and see what others are doing, and it would be unintelligent to do otherwise, but I think it's very important that a leading institution should lead. And administrators should not just administrate the process, but lead—and figure out what's their vision and exercise it.

06-00:43:21
Eardley-Pryor: And you said it was much easier to get that vision enacted for the graduate program than the undergraduate?

06-00:43:26
Bell: Well, it was, because we had been through the process of doing the undergraduate program, and the process was more or less the same, except a different set of courses.

06-00:43:36
Eardley-Pryor: So are there core courses that all graduate students will take here at Berkeley in chemical engineering?

06-00:43:42
Bell: There are four courses that students are required to take. However, it's changed a little bit with time. We used to have a course in mathematics and transport phenomena, and now those two have been merged to make room for a required graduate course in biological phenomena.

06-00:44:01
Eardley-Pryor: Oh, so that was part of the introduction of biology to the department?

06-00:44:03
Bell: Yes. That's right, yes. It's a continuation of the introduction of biology.

06-00:44:07
Eardley-Pryor: Did that happen while Harvey [W.] Blanch was chair?

06-00:44:09
Bell: No, that happened actually much more recently, while Jeff has been chair. And it's appropriate, because a lot of the research opportunities are in the biological sphere. I'd say maybe a third of our graduate students out of 150 are doing biomolecular engineering-type research, so they should know something. Actually, it's required of everybody, so it's appropriate—just as those who do biomolecular engineering should know something about transport phenomena and kinetics, even though they resist and they say, "Why do I have to know this?"

06-00:44:47
Eardley-Pryor: But that speaks to your desire to make sure that you're creating these generalists who are able to move in a dynamic field.

06-00:44:52
Bell: Yes. I tell people, "When you leave here, you should be overeducated, not just adequately educated, for your first job." Because you're putting in your acquiring tools that you don't know when you're going to use them, but you undoubtedly will use them, and maybe even in your first job these tools will prove unexpectedly useful.

06-00:45:13
Eardley-Pryor: And their performance, of course, also reflects then back on the department itself that produced them.

06-00:45:17
Bell: Yes. Right. Exactly. Yes. People want our graduates. They come here and they give us money and they seek our people.

06-00:45:25
Eardley-Pryor: What are some of the things, when you think back of your ten years as chair of the Department of Chemical Engineering, that you are most proud of and think helped really change the tenure or the tone, the direction of the department?

06-00:45:37
Bell: There are really three things—or maybe just two. One is the people that we hired. I keep saying, we are who we are, and I really believe that. If we didn't have first-rate people, we wouldn't be first rate. The second is changing the curricula, first the undergraduate and then the graduate. And that's served us in good stead and is more or less the same right now. It hasn't changed in the decades intervening. So these are the things I'd like to think that I've left behind on behalf of the department.

06-00:46:17
Also, maybe a third or fourth would be maintaining the spirit of the place. It's particularly easy today for young faculty to do their thing, be focused highly on their research, getting money to support their research, making sure their students are productive, and not interacting with their colleagues. And as a result, you then are not a family of scholars; you're a federation of scholars who happen to share the same building—you know, you're apartment-dwellers. And I think this works against what we should be, which is a community of scholars—and not monks, each in his or her own cell. And so I participate in the daily luncheons next door in 109 Gilman, and there's a core cadre of maybe three or four of us who meet there, and we encourage the younger people to come. Sometimes they do; some don't come at all, which is unfortunate, but you can't force them. But they miss out on something very important.

06-00:47:32
Eardley-Pryor: What are some of the other mechanisms that you would like to see happen to help create that spirit and help elevate that spirit?

06-00:47:39
Bell: Well, I'd like to see more of my colleagues encourage their colleagues, in turn, to participate. Actually, Jeff is the one who's used the phrase, "We're all part of the family." And he's very much a family person, and it's a good phrasing to use—that we're part of a community. We should have shared values, because if we don't have shared values, what are we? Just people coming to teach the courses and run the research groups.

06-00:48:14
Eardley-Pryor: On that note—that's a really interesting point, to think about values for the department—what are your values for the Department of Chemical Engineering? What do you think the values are?

06-00:48:23
Bell: So I think the values are extremely high scholarship, a very high level of intellectual curiosity about what is, what ought to be—and the directions are changing all the time. You can start by saying: What does humanity need that we are capable of delivering, and how do we achieve that delivery in an effective, cost-effective, environmentally responsible manner?

06-00:48:57
Eardley-Pryor: That sounds like a value of service.

06-00:48:58
Bell: Yes. A value of service to humanity. And ultimately, that's what we're doing. We're educating young people to go out and work in the public and private sector, each in his or in her own way. But I'd like to see them, not just thinking that I'm going into a job where I'm highly paid and that's all that mattered—that yes, you should be rewarded for your service, you should work in an environment that is conducive to your being effective; but also, you should think about how and what you do serves humankind. And how else can you do that besides work?

06-00:49:45
Eardley-Pryor: And those values that you're enunciating, how do those translate into the hires, all of these hires that you made over this ten-year period?

06-00:49:53
Bell: So the most effective part of hiring for me—there are two parts. One is to hear, early in the morning, the research presentation of the faculty candidate, because that tells me how well can the individual communicate, especially if he or she is talking about something I know absolutely nothing about. If they can communicate to me in a half hour or 45 minutes what they've done and why it's important, I'm already feeling pretty warm towards them. Then the next part is when they come to visit me in the office. Now I only have half an hour with each individual, unless I go to lunch or dinner with him or her. I

want them to engage with me in a technical conversation, which may start for a few minutes talking about what they've been doing as a graduate student and postdoc, but then veers off into: So what would you like to do with yourself? Where do you see yourself in five years? What do you want to be known for?

06-00:50:48
Eardley-Pryor: You're testing their imagination.

06-00:50:50
Bell: Yes, I'm testing their imagination. I'm also trying to gently move them out of their comfort zone—where they can talk endlessly about what they've done—and I want to know what motivates them. How do they think? What turns them on intellectually? And if they can keep me engaged for half an hour to an hour, well, this is looking very good. And they have to be personable, too. Somebody who keeps staring at the floor rather than looking at me in the face and doesn't interact with me until I ask a question isn't going to fare very well.

06-00:51:29
Eardley-Pryor: That speaks to the spirit of the department you've talked about.

06-00:51:31
Bell: Yes, yes. And the people we've hired, especially recently, all meet this mold. And then it's self-fulfilling, because those people want to have people like themselves, and so then you don't have to worry about getting the right people in.

06-00:51:48
Eardley-Pryor: It's keeping the ship not just afloat but actually moving in the right direction.

06-00:51:51
Bell: Yes, right. Right.

06-00:51:55
Eardley-Pryor: The next phase I would love to talk about with your administrative career is, after stepping down as chairman in '91, [you spend] just a few years outside of administrative work. [Then], in 1994 all the way through 1999, you serve as dean of the entire College of Chemistry. Tell me a little bit about that experience—even why you chose to take on that role.

06-00:52:16
Bell: So I thought after serving as chair that I might want to do more in the area of administration. I felt I had a knack for it. The next obvious place would be as dean.

06-00:52:31
Eardley-Pryor: Maybe I could pause for a moment. Why did you step down as chairman?

06-00:52:36
Bell: Well, after ten years, I felt that I had served the department, and it was really time to let go and let somebody else take that responsibility on. I didn't want

to wear out my welcome, so to speak. I also had found it particularly time-consuming and stressful with regard to my family, and I needed a break. So ten years is a good time. Jud had served ten years before me, and I had matched that, and so—"Great. Yes. Let's see what's next."

06-00:53:10
Eardley-Pryor: So in the intervening three years from stepping down, you decided, I'm going to go back into this and take the next step up?

06-00:53:17
Bell: Well, yes. After this was over, the dean's position opened up, and so I applied for it. Yes. And I was successful and taken on, and I succeeded Brad [C. Bradley] Moore, who was my predecessor.

06-00:53:41
Eardley-Pryor: Tell me about Brad.

06-00:53:42
Bell: So he's a physical chemist—a, very prominent physical chemist and a member of NAS. He had followed Jud as dean. And I served my last years as chair under him. Then he retired from his position and eventually went on to be Vice President for Research, at Ohio State University—and then moved on in his career through administration. So the position opened up and I applied for it and was able to get it. So now I was faced with an even bigger challenge. Because, as I mentioned before, in '83 we started fundraising for a new building: Tan Hall. It didn't break ground until '93, so a good ten years later.

06-00:54:51
Eardley-Pryor: A decade after starting?

06-00:54:53
Bell: Yes. And it wasn't completed until '97. So it was already started under Brad Moore's tenure. The hole had been dug and the basement level was starting to be filled in, and so I saw it from that level to the point where we opened it.

06-00:55:09
Eardley-Pryor: So essentially, as you became dean, you inherited a hole in the ground.

06-00:55:12
Bell: I literally inherited a hole in the ground, right—and raising the rest of the capital for the building.

06-00:55:19
Eardley-Pryor: Oh, the capital had not been completed, the capital campaign?

06-00:55:20
Bell: Not fully. Yes. There were promises, and then we still needed to raise some more capital. So it was a 40 percent state, 60 percent private funding, although it had started originally just the opposite way around. And this was in that intervening period where you could still get some state funding for buildings,

which then rapidly evaporated altogether and is now nonexistent. So that was also an interesting experience, because I had to do fundraising; I had to oversee the construction from the point of interest of the College and make sure the building was built on budget. And there was always the worry that that would not happen. In fact, most buildings around campus at that time and subsequently went well over budget, and the campus had to step in and, with a lot of teeth-gnashing and bitterness, pay the bill. Because what are you going to do? You're not going to stop the construction.

06-00:56:25

So here we found with the contractor that they wanted to charge us for change orders. Sometimes the change orders were engendered by them not reading the blueprints properly—like the height below the ceiling at which pipes were hung. And this is critical, because you're going to put in equipment, and you have to have all the space you can have between the floor and the pipes. And so at one point, a gentleman named Harry [Charalambos] Chiladakis, who was our college engineer, and I walked through the building and we discovered that the pipes were hanging a few inches lower than was called for. And we found out it was just easier to do this for the constructors—the workmen—and it was not according to plan. So we had them rip it out. There was a lot of gnashing of teeth and bellyaching and wanting to have the university pay for that, but I dug in my heels. I said, "No. We're not going to do it. Try and sue us." But they didn't. And it all worked out in the end. Interestingly, near the end of construction, the contractor again threatened to sue the university for extra costs, so I went to the Chancellor's office and I said, "I don't think it's appropriate to pay them another nickel.

06-00:57:49
Eardley-Pryor: Who was the Chancellor at the time? [Robert J.] Birgeneau?

06-00:57:52
Bell: Let's see. It was [Chang-Lin] Tien—no— it was [Robert M.] Berdahl. Yes. I said to the chancellor, "It's not ethical." And we stood our ground and we won with the contractor. They were paid a little money, but certainly not everything they were asking. So we ended up 10 percent under budget, which was unheard of.

06-00:58:18
Eardley-Pryor: Tan Hall was under budget?

06-00:58:19
Bell: Under budget.

06-00:58:19
Eardley-Pryor: Under your administration?

06-00:58:21
Bell: Yes. And it turned out that when the building was built, you couldn't really move in the thirteen groups that were scheduled to go in there, because the

electrical outlets and the plumbing weren't exactly where people needed them. So what we did is, we had every group that was moving in, including my own, specify what they needed in order to be able to move in. So each group went through and specced their space. We gathered that up, and then we used the remaining 10 percent to fund the retrofit, something that had never been done before. So the administration was saying, "No, no. You have to give the money back to the donors." I said, "Nuts. We need to make the building habitable." Because it had taken so long, and it was designed for a different group of people.

06-00:59:14
Eardley-Pryor: Yeah. I imagine, over fourteen years disciplines change.

06-00:59:17
Bell: Yes. Yes. So I said, "Come on, let's be reasonable." So I got my way and we spent the money. And as a result, from my own experience, it was about three months' downtime from when we started packing up to when we were fully operational again. Because we could come in and plug and play.

06-00:59:39
Eardley-Pryor: That's a pretty fast transition to move an entire lab.

06-00:59:41
Bell: Yes, it's a fast transition. But it's a result of thinking through the process, which is something that I see as not always done properly here. And when you do complex projects, you have to think about what happens first, what happens second, all the way to the end.

This is very much like planning for a drama or a theater performance, right? So you have to have the sets in the right place; the curtain goes up; the actors come on the stage, they do their thing; and at the end of the show, the curtain comes down. Well, you have to map out the whole thing from start to end.

06-01:00:22
Eardley-Pryor: I like that you make a dramaturgical analogy to—what I'm hearing is—thinking through things like an engineer.

06-01:00:30
Bell: Yes. Exactly. Right. And it comes naturally to me.

06-01:00:36
Eardley-Pryor: Yeah. I imagine that was a benefit of having a chemical engineer at the deanship at the College of Chemistry at that moment.

06-01:00:42
Bell: Right. Yes, yes. So it worked to the benefit of the College.

06-01:00:46
Eardley-Pryor: How, if you don't me asking—I imagine in, again, such a facilities-dependent college that the opening of new spaces, the negotiation of spaces being a contentious process. How did you deal with those issues?

06-01:00:57
Bell: Yes. Well, that was always hard. In the early part of my deanship I discovered that promises had been made by my predecessor without thinking through fully the consequences, and particularly the cost. And so here I am saddled with promises that need to be kept, with no resources to do this. And so I had to scramble. At one point I went to a new faculty hire, Jean [M.J.] Fréchet, and said, "We know we promised you"—we have at that point something like 80 percent of his labs done and moved in—"I want to delay by a year completion of the labs, because I don't have the money." And he blew up—you know, a Frenchman and very temperamental and blew up and said, "This is impossible!" His reaction got me upset. I said, "Okay, okay. Let me go see." And so we tightened the belt one more notch and we found the money to make it whole. Because it's important that promises are met.

06-01:02:15
But unfortunately, the start of the deanship was also a period where the state was tightening the budget, and the university was over-budgeted, and the College had overspent in the prior administration because we weren't looking carefully enough at expenditures. And so I had to tighten the screws, and that got everybody upset, particularly the chemists, who were used to having their way.

06-01:02:41
Eardley-Pryor: Do you think that that was elevated in part because you were a chemical engineer and not a chemist?

06-01:02:50
Bell: Yes, it was. Because the traditional perspective, particularly amongst older members of the College, was that Chemistry rules the roost, so to speak. And Jud had not encountered these problems to the same extent, because there had been enough money to cover problems. I didn't have that luxury. And my style, maybe, at the time was a little more roughshod than his. I was sharper with people, and that got them pretty upset. It got to a point where I had to confront the chemistry faculty and have a faculty meeting with them—a meeting of everybody there and me—to talk about why we couldn't go forward with the way we were doing things in the past.

06-01:03:44
Eardley-Pryor: How did that meeting go?

06-01:03:46
Bell: It was tense. It was difficult for me. But in the end, the department chair, Paul [A.] Bartlett, thanked me for being honest and open with his colleagues, and then things settled down.

06-01:04:02
Eardley-Pryor: Tell me, if you would, about fundraising. The capital campaign for Tan Hall had not yet been completed. You're talking about these challenges of limited resources in the wake of the financial recession that happened in the early nineties and the consequences of having to deal with that, in the wake of it. You've been so successful in finding capital to do your research program, but finding money for administrative issues seems like a different animal.

06-01:04:30
Bell: It's a very different animal.

06-01:04:31
Eardley-Pryor: Tell me a little bit about how they're different, and how you were able to be successful.

06-01:04:34
Bell: So what really helped me was having a person in charge of development, Jane [L.] Scheiber, whom Jud had hired as his assistant. And she was just fantastic—a very personable individual, Cornell [University] graduate. Her husband, Harry [N.] Scheiber, was in the law school, so she knew what academe was all about. And with her help and her contacts, we managed to gather up money. She was really the front person who was responsible for identifying donors. I would come in and tell them about the College and get them interested. But in the end, working together with her, we got the remaining money. And that was very effective.

06-01:05:25
Eardley-Pryor: What are some of the differences in the experience of being a dean versus chairman of a department?

06-01:05:31
Bell: So as a chairman of a department, you're closer to your colleagues, and they're smaller in number. So I went from having, on order, twenty colleagues to being responsible for seventy people, and then all the staff of the College, which is a much larger group. So there's that. There are also the cultural difference. I remember staff members in Chemistry basically telling me that in the past they'd always been able to tell the dean what they, Chemistry, wanted to do, and the dean accepted it—because largely they were chemists, so it was all part of that family. And I would say no, because we had restraints on staffing budgets and what you could spend. And they were not in the habit of being told no.

06-01:06:27
Eardley-Pryor: What kind of challenges did that lead to?

06-01:06:30
Bell: Oh, it led to one senior faculty member slamming the door and leaving my office because I told him he couldn't get a raise for his secretary—because she was not qualified. He hadn't been told that. He considered himself very prominent, and, you know, this was a personal affront.

06-01:06:50
Eardley-Pryor: In the wake of those kinds of personal conflicts, how do you then move forward to continue a working relationship?

06-01:06:59
Bell: Well, you have to swallow your pride to some extent. This also got into a retention issue with the same individual. Actually, what helped was something neither one of us could have predicted. He had a graduate student who was a little off mentally, and their relationship had not worked out, and so she had become a former student. And she decided to go after him with a gun.

06-01:07:39
Eardley-Pryor: My goodness!

06-01:07:42
Bell: Fortunately, she was verbal with her threat and somebody picked it up. So as soon as I heard about it, we set up a protective barrier around his whole area. And eventually she was arrested by the Berkeley Police in downtown Berkeley, where she had a pistol. And the bullets were separate from the pistol—it wasn't loaded. But we had her held in a hospital. This was in my first year as dean. It was a nerve-racking period. And the question is, on what basis do you hold her? So we held her once and then we held her a second time—these are three-week holds, by law—and eventually I think her parents, if I recall, helped by taking her east. So she was physically taken out of the area, so the threat diminished.

06-01:08:43
Eardley-Pryor: My goodness!

06-01:08:43
Bell: But, you know, these are the extreme cases that you run into.

06-01:08:47
Eardley-Pryor: And in the wake of that crisis that you went through with this individual, this other faculty member, that helped—?

06-01:08:55
Bell: So he was appreciative of the fact that I went out of my way to help him, and literally protect him. I felt, even if I don't like the person and I don't agree with him, that I do have a responsibility for him and his group as part of the College. And that's true of every administrator.

06-01:09:22
Eardley-Pryor: Some of the other issues that you had mentioned came up during your time as dean of the College of Chemistry included renovations on campus.

06-01:09:29
Bell: Right.

06-01:09:30
Eardley-Pryor: Perhaps retrofitting seismically, and also just general renovations.

06-01:09:32
Bell: Well, that [seismic retrofitting] came later, but doing what I called "rolling renovations," because we had constantly people who were being seduced to leave. We had, for other reasons, a need to retrofit laboratories where the equipment was aging, the infrastructure was aging. And so we did two things. We had an NIH [National Institutes of Health] grant, which had been applied for by a couple of the chemists, including a previous dean. We used that to retrofit parts of Latimer Hall. And then we had retention monies, part of which were used to retrofit labs; we had recruitment monies which were used to renovate labs. So little by little we renovated a whole floor of Latimer Hall.

06-01:10:24
Now what made this possible is, at the time we could use college labor—people in the machine and woodworking, metalworking shops who were skilled enough that they could put in walls and doors and do electric work, at a price that was a half or lower than what you'd do with union labor. And the university kind of winked at this, and then they said, "Well, you shouldn't be doing this more than a certain dollar value," and we crept around it. Now just this year the final straw has been broken, and poor Doug [Douglas S.] Clark, our current dean, has to do everything with union labor.

06-01:11:04
Eardley-Pryor: So part of the way that you were able to make these renovations happen at Latimer Hall and other places was, in part, because you could use non-unionized members that were already working in the College?

06-01:11:14
Bell: Yes, right. You had to be clever and use whatever you had that you had some control over to do the renovation—and not let the architects and engineers bamboozle you into doing everything their way.

06-01:11:27
Eardley-Pryor: One of the things you mentioned in part of those renovations was recruitment money, retention money. I wanted to hear you talk a little bit about the role that Berkeley Labs, the Lawrence Berkeley National Laboratories, played in facilitating your job as an administrator.

06-01:11:43
Bell: Well, the main thing it helped with was money for recruitments—startup money. So when you start up a new faculty member, today it's anything from $1 [million] to $2 million—and that includes equipment, renovations to laboratory space, money for people, summer salary for two years. So it's a package. And to accommodate that package, you have to have money. The university has a canonical amount that they give you that's far below this number. And so you go looking for pots of money and rocks that you pick up looking for gold. And it used to be that the lab was very accommodating. Unfortunately, that's changed, too. The Lab today is less accommodating.

06-01:12:33
Eardley-Pryor: Why so?

06-01:12:34
Bell: Because it's under financial pressure as well, and it has its own agenda of things that it wants to accomplish that are not necessarily aligned with the needs of the College of Chemistry—although often enough, we've succeeded.

06-01:12:54
Eardley-Pryor: Can you think of an example?

06-01:12:55
Bell: The one example that's really a nice one is the hire of Berend Smit, who is a senior—[phone rings]—oh, excuse me.

06-01:13:06
Eardley-Pryor: Sure. We can pause this here.

[Break in recording]

06-01:13:10
Eardley-Pryor: Okay, Alex. You were talking about the hiring of Berend Smit?

06-01:13:14
Bell: Yes. So this came during the period of 2005-'06. For a year and a half, I was interim chair.

06-01:13:22
Eardley-Pryor: Of the department?

06-01:13:23
Bell: Of the department. And this became necessary because Arup Chakraborty, our chair at the time, was moving to MIT. We wanted Jeff Reimer to be the next chair, but he had agreed to take a sabbatical in Germany, so we needed an interim chair. And we approached one person who said no. So after thinking about it, I said, "Okay, I have the experience, I know what it's all about, I'll do this for a year, year and a half." So I took that on.

And at that point we had an opening for a senior person, and we identified a very brilliant young physicist—younger physicist, mid-career physicist—a physical chemist, Berend Smit, who had two positions: He was director of a theory institute in Lyons, France, and was a faculty member in chemical engineering at the University of Amsterdam. Since I knew of him from the work that Doros Theodorou and I had done, it became a natural for me to negotiate with him.

06-01:14:28
Eardley-Pryor: And this was in looking to replace someone who did theoretical work, as Arup had left.

06-01:14:33
Bell: Arup had left. Actually, Berend's work was closer to Doros' work. So I communicated with him by phone, and then we invited him to visit. To make a long story short, we found a common voice. But he had a competing offer from, Oxford University. To counter this offer, we made it clear to him that he would be very much welcome, we wanted him to be a part of the Lab. Consequently, I worked with Steve [Steven] Chu, who was director of the Lab at the time, to find the funding for him and to make this all possible. So that's where the Lab became very useful to us.

06-01:15:21
Eardley-Pryor: Enabling their interest in having him be a part of things, as well as the department's interest in having him.

06-01:15:24
Bell: Right. Uh-huh. Yes.

06-01:15:27
Eardley-Pryor: That's a good example. As you served as interim chairman in this 2005-2006 period, what are the challenges you would face that were different when you had become chair for this long, extended period versus an interim position?

06-01:15:41
Bell: I had a lot more experience by this time with administration, so I really didn't have any major difficulties. The one difficulty I did have was with the person who was dean, Charles [B.] Harris, who was a physical chemist, a very brilliant guy, but very set in his ways about what constitutes quality. So when we had a senior retention come up during this period as well—

06-01:16:15
Eardley-Pryor: Someone that was trying to be plucked away by another institution?

06-01:16:17
Bell: Yes, plucked away by Georgia Tech [Georgia Institute of Technology]—he didn't particularly feel that it was important to respond. And I felt that this is a prominent member of our faculty, an NAE [National Academy of Engineering] member—yes, we should respond. And I was doing everything possible to make the case. And I wasn't getting much traction, so I really leaned heavily on him, knowing that I can offend him and it doesn't matter to me, because my career doesn't depend on him.

06-01:16:54
Eardley-Pryor: The benefits of being tenured and having had the experiences. And now only in an interim position.

06-01:16:57
Bell: Right, right. I eventually convinced somebody—let's see, what was his title—a Vice Provost at the time, that this was a good idea. In fact, he had been rebuffed—oh no, that was an earlier retention of the same person—he had

been rebuffed by the Budget Committee, and I told him that, you know, "You go back and fight the Budget Committee." Which he did—fortunately, for us.

06-01:17:25
Eardley-Pryor: And you were able to keep this retention?

06-01:17:27
Bell: Yes, yes.

06-01:17:28
Eardley-Pryor: Why was it so important to you, and why did Charles Harris disagree?

06-01:17:34
Bell: It was his personal assessment of the individual's work, which he didn't think was worth the amount of energy and effort. This was a $2 million retention package, whereas I felt that the person was important to the department and we should retain him.

06-01:17:56
Eardley-Pryor: Does this in some ways speak to what you had spoken of earlier, this intellectual arrogance between chemists versus chemical engineers?

06-01:18:01
Bell: I think that's some of it, yes. Even worse, I think it's not even making the effort to understand what chemical engineering is about as a department. If you start out with virtual ignorance of who we are and why we do the things we do, and why it's legitimately different from Chemistry, you're off to a bad start as dean.

06-01:18:29
Eardley-Pryor: And you felt that he did not understand those differences?

06-01:18:31
Bell: He did not understand the differences, unfortunately.

06-01:18:33
Eardley-Pryor: Could you talk a little bit about what you see as the most significant differences between chemical engineering and chemistry?

06-01:18:42
Bell: There's kind of a fuzzy boundary between the two disciplines. Chemists deal with fundamental issues. How does chemistry work? Today, more and more of chemists' research deals what can you do with synthetic chemistry that involves that have certain properties? They may or may not be functional and useful, although more and more there's a move towards this. An excellent example of that is Omar Yaghi's work on what are called molecular organic frameworks—MOFs for short—which can be used as adsorbents for taking water out of air, providing water in arid parts of the world, et cetera, et cetera. Chemists are also engaged in pushing the boundaries of what can be learned as one move to shorter and shorter time scales. Here, a pertinent example

would be Steve Leone's work on femtosecond spectroscopy of species involved in combustion.

Chemical engineers, by contrast, are looking at properties of materials and processes with the idea of bending these and tuning them to an application all the time. So my work in catalysis, for example, is, of course, interested in the structure of catalysts and how they look, but only to understand how they work, and then how can I use that knowledge to make them work better?

06-01:20:00
Eardley-Pryor: So the role of fundamentals on each side of these disciplines—chemistry versus chemical engineering—the role that fundamental research plays is different?

06-01:20:08
Bell: Are different, yes.

06-01:20:09
Eardley-Pryor: Even though both are often dealing at fundamentals?

06-01:20:11
Bell: That's right. And that's why I say the boundary between the two disciplines is fuzzy. Therefore, you need to appreciate that, and what constitutes really high-end work in our domain. And it's different, necessarily. So when we're evaluating somebody for tenure or for promotion to full professor, what constitutes a high level of success in one domain doesn't necessarily represent that in the other.

06-01:20:41
Eardley-Pryor: And this issue came up during this retention?

06-01:20:42
Bell: Yes, that's where the tension came about.

06-01:20:50
Eardley-Pryor: Another thing that I want to talk about during your interim chairmanship in 2005-2006 is the creation within the department of the product development program. Can you talk a little bit about what that is?

06-01:21:01
Bell: Yes, certainly. At about this time, we had come to the recognition that more and more of our graduates were working for smaller companies here in the Bay Area or mid-sized companies that produced products rather than processes. So the process industry would be DuPont, Chevron, Shell, ExxonMobil, who produce tonnage quantities of fuels and chemicals, raw chemicals, and products such as polymers. Products are semiconductors, drug delivery devices, memory chips, sensors. They're very complex and sophisticated items, but they don't have a lot of chemicals in them—but it's how they function that makes them worthwhile and why people pay a lot of

money for them. And so there's more and more of this kind of activity, and it continues to this day.

So we thought that we should start a master's program on teaching students how to identify a product, what's its place in the marketplace, how do you design it, how do you sell it, and what skills are necessary which are complementary to process engineering. Now we also knew that MIT, since the mid-1920s, has had a very successful process design master's program, and it involves a year of coursework, plus some time, I think, over the summer and spring working in a company on projects. We wanted something comparable but distinct. I had the notion that you have to have product identification—you know, brand identification. So I said, "We're not going to emulate what MIT does, but we'll do our own thing."

06-01:23:01

Therefore, we started to think about this developing a product-oriented master's program. Jud King, who was instrumental here, said, "Well, I have an ideal candidate: Keith Alexander"—who was his graduate from many years before, who had worked in industry and then was working with McKinsey [& Company] on analyzing how various businesses work.

06-01:23:23

Eardley-Pryor: Oh, as a consultant?

06-01:23:24

Bell: Yes. And we hired him. He took early retirement and we hired him to run this program. The fact he is African American was also beneficial to our cause. And he's been remarkably successful in the ten years plus that he's been running this program.

06-01:23:44

Eardley-Pryor: And Keith has taken the helm of this program?

06-01:23:48

Bell: Yes, he's running the program. And so we started out with, I think, ten or so master's students; now we're at forty-five. And this program is covering his salary, plus a few million dollars a year for the university—not that much for us, unfortunately, because of the way the university structures things, but it gives us name recognition, as having a program distinctive and unique to Berkeley.

06-01:24:16

Eardley-Pryor: In thinking about this product-focus and moving a little bit away from the typical processing-focus that chemical engineering is known for, was there any pushback from other engineering departments on campus—electrical engineering, mechanical engineering that might be also interested in—?

06-01:24:34
Bell: No. We could have partnered with them, but instead we partnered with the business school. And so students in this program take several courses on running small businesses and finding money for startups, and how to identify the marketplace and the value of the product in the marketplace. The bottom line is that's been a very effective partnership.

06-01:24:59
Eardley-Pryor: The students that are coming into this master's program—is it often populated by students who have come through as undergraduates at Berkeley, or are they coming from outside?

06-01:25:07
Bell: There are a few who are our undergraduates, but mostly these are foreign students from Southeast Asia and other parts of Asia—and also American students who have an interest in working in this industry. So we have no problem with finding candidates, and very good ones. They take two one-semester-long courses on product development from Keith; they take some courses in the business school; and then they take some of our standard chemical engineering courses. Then they have a practicum in local industry. They can do it in drug delivery, semiconducting materials, and I think there's a third one—maybe food processing.

06-01:25:47
Eardley-Pryor: Oh, it's a learn-by-doing program, at the end of it?

06-01:25:49
Bell: Yes, right. Yes. And the industry provides the problems and a person who oversees the work.

06-01:25:55
Eardley-Pryor: And those industries that you are partnering with the program—are they also paying for the privilege?

06-01:26:01
Bell: They're also contributing some money to us. Right. Yes.

06-01:26:04
Eardley-Pryor: And that's the way it's able to self-sustain?

06-01:26:05
Bell: Yes. And some of the young people then get employed by these industries.

06-01:26:08
Eardley-Pryor: That sounds like a great program.

06-01:26:09
Bell: Yes, it is a great program. So it has name recognition.

06-01:26:14
Eardley-Pryor: When you were interim chair, what are some of the things that you remember either being challenging or that you're really proud of, in that time you had back at the helm of the department?

06-01:26:24
Bell: Well, one of the challenging things was with a promotion case. I don't want to go into the details, but I had a colleague who challenged what I thought should be done and went around me to the campus administration. This made for a difficult situation, which Dean Heathcock and I had to tamp down.

06-01:26:43
Eardley-Pryor: That seems to be—I wouldn't say common. But something that has happened throughout your career is challenges and you standing your ground, believing in what you believe in, and keeping that.

06-01:26:55
Bell: Yes, I do. Yes, yes. Yes, I listen to people who are in opposition to me, but if I think they're being unreasonable and not willing to reason with me towards some common understanding and then threaten me, I say, "Well"—you know, figuratively—"if you're going to pull a gun on me, you better be prepared to shoot."

06-01:27:24
Eardley-Pryor: Yes. With a frightening example of someone who had a gun here, in the past, as you just mentioned.

06-01:27:28
Bell: Yes. Right. Yes. So I believe in standing my ground on principle.

06-01:27:36
Eardley-Pryor: I'd love to hear about your career also in the Academic Senate and talking about your administrative roles in there. To start off on that, I'm interested in, how and why did you get involved in the Academic Senate?

06-01:27:49
Bell: Well, I like complex problems and I've enjoyed administration. I made a conscious decision when I stepped down as dean that I didn't want to continue in campus administration.

06-01:28:02
Eardley-Pryor: Why?

06-01:28:03
Bell: Because it was a point where if I went up to, say, the Chancellor's office in some capacity, I couldn't anymore do the kind of research with the intensity and involvement that I have. And I've watched people attempt to do it, and yes, they do it—even chancellor Chang-Lin Tien, under whom I served, was doing it; you know, running back to his lab at 10:00 p.m. to talk to graduate students—but it wasn't the same thing. I talked to some of the graduate

students; they saw him fleetingly. You fool yourself that you're doing research if you try to do this. So it was a choice. I really enjoy working with students and young people, I'd say, more than I do solving large, complex administrative problems, which I know I can do.

06-01:29:00
Eardley-Pryor: So you weren't willing to let administrative work eat any more of your research time?

06-01:29:05
Bell: Right. Right. So I decided to stay in the department, be a full professor—which is, I think, the best position any of us have here at Berkeley. But then, the Academic Senate. Okay. Some committees on the Senate deal with real problems, like the budget, and policies about how faculty are dealt with and so forth. Also, as you become more senior, as a faculty member you're expected to do Senate service if you want to keep getting promotions, so there's a carrot out there, as well. And in fact, those who, for whatever reason, chose not to do Senate service also choose to have lesser salary increases—that's the de facto outcome.

06-01:29:58
Eardley-Pryor: So faculty Senate involvement is tied to pay-step raises?

06-01:30:03
Bell: Hmm?

06-01:30:03
Eardley-Pryor: The steps process in pay raises, it is correlated?

06-01:30:07
Bell: Not formally. Not formally. But it's a written expectation by the Budget Committee that when you're step ten or above scale, as I am, that you're expected to serve. Now you can serve as an administrator or you can serve in the Academic Senate. But service doesn't mean being an editor of a journal or a consultant.

06-01:30:33
Eardley-Pryor: Which you also were.

06-01:30:33
Bell: Which I've also done, right, and I also continue. So I thought that the Senate could be an interesting thing to do. I talked to John [M.] Prausnitz, who had served, including on the Budget Committee, and he was a big advocate of this as a way of getting involved with the campus and other brilliant people whom we have here in other departments. I've always valued his input. And so that's what I decided to do.

06-01:31:01
Eardley-Pryor: As you were looking at the way the faculty Senate is structured, where did you see yourself wanting to be involved?

06-01:31:08
Bell: So every year, all of us—every faculty member—gets a request: Where would you like to serve? And I filled out the form early on and I said—somewhere around 2009—I said I'd like to serve on CAPRA, the Committee on Academic Planning and Resource Allocation.

06-01:31:27
Eardley-Pryor: And why that committee, for you?

06-01:31:28
Bell: Well, because that's the committee that sees the whole all the costs of the operation of the university. And as we're facing more and more constraints, I thought it would be interesting to look at that and see how do we protect faculty interests, which is what CAPRA is supposed to do.

06-01:31:47
Eardley-Pryor: I see. CAPRA's responsibilities are to do what?

06-01:31:51
Bell: To review the budgets of all parts of the Chancellor's office. To have budget hearings to address budgetary issues that come up with the departmental reviews or other things that are happening spontaneously and give advice to the Chancellor.

06-01:32:15
Eardley-Pryor: So it's an advisory role, on behalf of the faculty?

06-01:32:18
Bell: Yes. So I joined that committee. I found that yes, there are all sorts of issues that are interesting there. I spoke up. I know how to speak clearly and to the point, and so my voice was heard. And then I was asked to co-chair CAPRA, and eventually I just chaired it the last year.

06-01:32:44
Eardley-Pryor: And you served as co-chair and then chair between 2010 and 2013?

06-01:32:49
Bell: Right, yes. Yes. I found this responsibility very interesting, because we hit the period there where the campus was facing two issues, two primary issues. One is the cost of renovating the Cal [California] Memorial Stadium, which the Regents had said to the Chancellor, "Either you tear it down, you renovate it, or you play football somewhere else"—not there, because of the high liability, since the San Andreas Fault runs through the stadium. And so Birgeneau, being a big football fan—

06-01:33:33
Eardley-Pryor: [Birgeneau,] who was Chancellor at the time?

06-01:33:35
Bell: Yes, Chancellor at the time—said, "Well, we're gonna renovate it—and not only renovate it, but we're gonna build a training facility on the outside,"

because our training facilities—which is true—were really decrepit and well beyond their lifespan.

06-01:33:51
Eardley-Pryor: When were the Regents making these demands on the Chancellor?

06-01:33:54
Bell: This was, I think, 2004-'05.

06-01:33:59
Eardley-Pryor: Okay, so before the financial crisis?

06-01:34:00
Bell: Oh, yes. Yes, before the financial crisis. So the plan was that, yes, we are going to go ahead with this. And the way we're going to raise money for it—and this is a half-a-billion-dollar project—the two parts together—the way we'll raise money for this is that we'll have an endowed seating program, or ESP. There will be 3,000 seats available in this grouping. You can buy certain seats for $25,000; you can buy others for $250,000—the more elegant seats.

06-01:34:36
Eardley-Pryor: These are expensive seats.

06-01:34:37
Bell: These are expensive seats, yes. They could be paid for the way you pay for a mortgage—you know, over time. Except unlike a mortgage, the buyer can decide at some point that did not want his or her seat anymore, and stop paying. You can't use the seat, but you're not obligated to pay out the full amount.

06-01:34:57
Eardley-Pryor: And then the university's in the lurch of finding new seatholders?

06-01:34:58
Bell: Yes, they can take the seat and sell it to somebody else. Right. That was part of the program. The other part was a fund functioning as an endowment, or FFE for short. These were going to be donations given to the intercollegiate athletics program which would be invested and make money, and that fund would grow, and a small part of that would be used to offset the debt that had been undertaken.

06-01:35:34
Eardley-Pryor: So these are the two ways that this half-billion-dollar retrofitting and construction project would happen?

06-01:35:36
Bell: Right, these were the two major ways. And of course, then ticket sales are the third way. Well, this sounded good. The Regents bought into this and it was implemented. Then the budget crisis hits in 2007-'08, and guess what? The ESP sales don't come anywhere near what was projected. There are claims

made that we're sold more seats than in fact we have. This was uncovered by faculty here who made a big stink of it in the press. The endowment fund is growing, but it's not growing anywhere near the rate that it needs to grow. And now we have construction started—after we delay for a year because of the tree-sitters.

06-01:36:28
Eardley-Pryor: Oh, is that right?

06-01:36:28
Bell: Yes—which increased the cost of construction. And okay, construction is started, we're committed—the bonds are acquired. What are you going to do? You're not going to tear down a half-built stadium.

06-01:36:46
Eardley-Pryor: And you already have bond commitments.

06-01:36:48
Bell: Yes, bond commitments. So you're committed. You're stuck.

06-01:36:53
Eardley-Pryor: Where in this timeline of these events transpiring do you get involved, either in this issue peripherally or on CAPRA?

06-01:36:58
Bell: Okay, so I get involved while I'm on CAPRA. John Wilton was the Vice Chancellor for Finance and Administration at that time. I liked the gentleman, although not everybody did. He came from the World Bank. At one point when he was having trouble with all of this, he felt that he needed some faculty input, so he invited me to his office as CAPRA chair, and we hit it off. He said, "I want you to work with me and a team that I've selected from the Business School." He told me that he has asked Bill [William] Fuchs, Richard [H.] Stanton, and Nancy [E.] Wallace, all three business school faculty, all of whom have some knowledge about real estate and financing and so forth to do a financial analysis of IA's [Intercollegiate Athletics] budget. This group of faulty did undertake the project, which took the better part of a year.

06-01:38:00
Eardley-Pryor: Is Intercollegiate Athletics responsible for the retrofitting?

06-01:38:04
Bell: Yes. Athletics has the responsibility for paying the mortgage, which works out to be about $18 million a year—on a $20 million budget that they already had, part of which is financed by the campus—maybe $5 million or a little less than that was financed by the campus already. So this is a big bite. Selling seats, raising money, were not activities for which IA was known, and they were having a rough time doing it.

So, I ended up working with this committee. We met frequently. We met with the people at IA who were responsible for these things. To make a long story short, they issued a seventy-five-page report saying that IA's financial model wasn't working, was not going to work, and here's what you should be done. It involved scaling down the ambitions on seat sales, doing much more on fundraising, being much more aggressive on the sale of regular seats, and using the facility—renting it out for other large-scale events, up to the limits that the city of Berkeley would allow, as well as smaller event, so that the stadium could be used outside the seven weekends where we have football games at home.

06-01:39:22
Eardley-Pryor: It's a big price tag for seven events.

06-01:39:24
Bell: It's a big price tag, right.

06-01:39:25
Eardley-Pryor: What were some of these other events that you had in mind?

06-01:39:28
Bell: Well, I don't remember now what events we brought in, but they're concerts and things of that nature that were loud, and therefore the residents on the rim would protest if we had too many of them. So this was all set. I liked the plan. I wrote a report for CAPRA supporting the plan, and that was our official representation to the campus. While the plan was implemented, unfortunately—and this is after I left CAPRA and the Senate—it wasn't followed through.

06-01:40:04
Eardley-Pryor: After doing all this report and creating a budget for IA?

06-01:40:06
Bell: Yes. The plan wasn't followed through, in terms of raising the amount of money that was necessary. This problem came towards the end of Dirks' tenure as Chancellor—he followed Birgeneau and came before Carrol [T. Christ]. Unfortunately, nobody wanted to face the situation. So Chancellor Christ invited one more consultancy to come in and her this time. The consultant's report led her to recognize that IA doesn't have the capacity to raise the full $18 million, about half of which is for a seismic retrofit—the rest is enhancement of the stadium and the supporting facilities. In the final analysis, she's accepted that the campus will cover that part. That's a sizable chunk. And this is at the same time when she is dealing with winding down a $150 million structural deficit that the state told UCB that it had to get rid of.

06-01:41:11
Eardley-Pryor: Those are significant budgetary issues.

06-01:41:12
Bell: Yes. And so—

06-01:41:15
Eardley-Pryor: What do you think about that—that the campus is taking on that financial burden to support Intercollegiate Athletics?

06-01:41:21
Bell: Okay, so as an academic, I'm not really wild about this idea. Now if you have to see it from the administration's standpoint, of the fifty largest donors to the campus, twenty or so are passionate about sports, and a subset are passionate about football. If you start messing with the football team and the donor's passions, they get mighty upset—irrationally upset—and say, "Well, I'm not going to give money at all to the campus for anything, and I'll dissuade people from supporting Berkeley." I believe that this held enough sway that Chancellor decided the way she did.

06-01:42:03
Eardley-Pryor: Wow. So the donor fanaticism for Berkeley athletics has a trickle-down effect?

06-01:42:11
Bell: It has a trickle-down effect, yes.

06-01:42:13
Eardley-Pryor: That needs to be supplicated in order for the campus to function well?

06-01:42:17
Bell: Yes. And the way she's rationalized it, which I can buy, is that, well, no other unit on campus is fully responsible for seismic retrofit, so the campus should share. Well, okay, that's the way to swallow a bitter pill.

06-01:42:38
Eardley-Pryor: How do you think things would be different if the report and the support that the committee you served on with John Wilton and these other business school administrators—if that had been followed through, how do you think things would have been different?

06-01:42:51
Bell: Well, it would have made the amount of money that IA paid for what it got closer to a match. Yes. However, it was going to be very hard for IA to make that match, even under the best plan.

06-01:43:10
Eardley-Pryor: What were some of the other challenges that came up? I mean, the financial crisis reverberated in remarkable ways around the world, even politically in the United States. Here at Berkeley, and having to deal with that on CAPRA—as chair of CAPRA—what were the other issues that came up in the wake of the financial crisis?

06-01:43:26
Bell: So, yes. Let's see. George [W.] Breslauer was the EVCP [Executive Vice Chancellor and Provost] at the time and wisely sought CAPRA and Senate input on how to handle the budgetary crisis.

06-01:43:43
Eardley-Pryor: This was this $125 million deficit, or this is—?

06-01:43:45
Bell: No, this is just preceding this. This was a yearly budget crisis and cuts that we were experiencing from the state.

06-01:43:58
Eardley-Pryor: Okay. Yes. So I spoke with George in preparation for our talk today, and he had mentioned all of a sudden a $200 million budget deficit that the university had to face.

06-01:44:06
Bell: That's right. Right.

06-01:44:08
Eardley-Pryor: This is what you're talking about?

06-01:44:09
Bell: That's right. This is the cut we're talking about. So we met with him. He was very forthcoming. He had his financial people speak with us about, you know, what's the situation. And he had something like, I don't know, thirty, forty things that might be done that his people had come up with, each with its amount of money that it could save, each with some projection of problems it would cause in trying to implement. And it didn't take me long in looking at this list to say, this is impossible to deal with. We can't really advise you on the options one by one. So—

06-01:44:55
Eardley-Pryor: Because they're integrated? Is that what you mean?

06-01:44:56
Bell: No—because there are just too many options, and it's just not the way to start to look at a complex problem anyway. So I suggested to him that, in terms that he understood as a political scientist—I said, "You have to look at where's the greatest potential financial gain for you, and where's, at the same time, the greatest financial pain that you're gonna have to pay if you implement this change."

06-01:45:23
Eardley-Pryor: Strictly in terms of finances, or is the—?

06-01:45:25
Bell: The political pain of people yelling at you.

06-01:45:30
Eardley-Pryor: So financial gain and political pain are the metrics?

06-01:45:32
Bell: Right. As metrics, yes. Very simple-minded; however, you can use it to think about, well, if I do this, I'm gonna save a large amount of money. I have a certain displeasure factor I'm gonna have to deal with.

06-01:45:47
Eardley-Pryor: The political pain?

06-01:45:48
Bell: Yes, political factor. How big is that relative to doing something else? And we identified the maybe ten largest things that would provide money, and then helped George and his staff sort these through. Unfortunately, I don't remember the details.

06-01:46:03
Eardley-Pryor: So, let me just reiterate. What I think I'm hearing is finding, on this massive list of potential budgetary cuts, find the changes you could make with the most financial gain with the least amount of political pain that comes from it, and then reprioritize based on that.

06-01:46:16
Bell: That's right, yes. So you're trying to optimize—to see if you can get enough of a savings to meet your targets with the minimum amount of headache. George thought this was very clever as a way of looking at the problem. So this, again, is a reflection of what I would call engineering thinking.

06-01:46:41
Eardley-Pryor: How so?

06-01:46:42
Bell: Well, in the sense that as an engineer, you're asked to solve a problem, and you can come up with very fancy, extremely expensive and therefore non-feasible solutions, or you can try to be more clever and see how you reduce the cost and still be effective. But in administration, though, especially in constrained circumstances, no matter what you do, it's going to get somebody upset, right? And nobody wants to change the way they've been doing business all along. The longer they're employed here, the more they're wedded to the process they've been doing.

06-01:47:22
Eardley-Pryor: Even amidst a $200 million sudden deficit?

06-01:47:25
Bell: Yes, so this also rolls over to this campus shared services fiasco that we went through.

06-01:47:31
Eardley-Pryor: So that was the Operational Excellence, is that right?

06-01:47:34
Bell: That's called Operational Excellence, right.

06-01:47:36
Eardley-Pryor: Tell me what Operational Excellence's intentions were, and then how did they play out.

06-01:47:39
Bell: The intentions were to tighten the way we operate as a university. So everything from student services to financial services, repayment of travel expenses for faculty, purchasing—everything that involves money. We were going to improve the quality of service. Now the goal is laudable, because—you know, I've said to many people, while Berkeley is known as an outstanding institution for its academic achievements, it's not outstanding in terms of its effectiveness of administration. It's really been sloppy. And we could get away with this for years because there was enough money to cover the problems, but at this point there wasn't. So now you have to get more efficient.

06-01:48:31
Eardley-Pryor: In terms of fixing administration, management, staff orientations?

06-01:48:35
Bell: Yes. Make staff more efficient, make operations more efficient. So the idea that Birgeneau had was that we'll do this by consolidating. Now it's true, every college had its own financial operation, its own purchasing, which fed into the campus purchasing; there was a lot of duplication. We used to call them "shadow systems." The campus had a financial system; the college had a financial system; each faculty member kept track of his or her own finances, too, with their administrative assistant. And often these didn't coincide, so the faculty always assumed that their administrative assistant, since they were working for them, was right and everybody else was wrong, and we constantly had battles up and down the food chain.

06-01:49:30
Eardley-Pryor: Did this break down also between, not just colleges, but departments having their own financial—?

06-01:49:34
Bell: Yes, yes.

06-01:49:35
Eardley-Pryor: So this went all the way down, from faculty up to the very top, through the administration?

06-01:49:38
Bell: Yes, yes. And a lot of it is because all of these systems had been accreted over time by practices of the day and trying to make adjustments and living with what you have, right? It's like many old cities—you know, the plumbing eventually doesn't work. It breaks down. So the idea was, we were going to

consolidate all of this into one place physically and put it down on Fourth Street in Berkeley.

06-01:50:08
Eardley-Pryor: It seems like a sensible approach, from a top level.

06-01:50:11
Bell: Right. And you were going to save money—we're going to save $75 million a year by doing this—that was an estimate—and it would be much more like what a corporation does. So at some level, it makes sense—except that it now divorces all of these operational things from the faculty and the people who are bringing in the money. Each faculty member brings in their own money and wants to see it well spent and isn't trusting, automatically, the university to do things in their best interest.

06-01:50:43
Eardley-Pryor: So, there's human costs to this.

06-01:50:45
Bell: Yes. So despite all of that, and concerns—and I served on a committee, the Operational Excellence committee, on behalf of the Senate—

06-01:50:54
Eardley-Pryor: As separate from your role in CAPRA?

06-01:50:56
Bell: Yes, yes. Yes. This was campus-wide—and with people from the administration serving on it, as well.

06-01:51:03
Eardley-Pryor: Was this part of the—you had mentioned to me something—the Gimlet committee that you and George Breslauer—

06-01:51:07
Bell: No, the Gimlet Committee was separate. That was advisory to the Vice Chancellor.

06-01:51:12
Eardley-Pryor: Was that [Gimlet Committee] in your facility as chair of CAPRA?

06-01:51:13
Bell: Yes. I was the chair of that committee, as well.

06-01:51:16
Eardley-Pryor: The chair of the Gimlet Committee?

06-01:51:17
Bell: Yes.

06-01:51:18
Eardley-Pryor: Well, let's pause for just a moment on Operational Excellence. Does it relate? Does Gimlet Committee relate to this?

06-01:51:24
Bell: Only indirectly. The Gimlet Committee was independent of Operational Excellence. Operational Excellence was a Chancellor's committee.

06-01:51:33
Eardley-Pryor: So all of this is happening for you at the same time, in this 2010-2013 period as chair of CAPRA, chair of the Gimlet Committee, and also serving on this Operational Excellence committee?

06-01:51:41
Bell: Yes, right. Yes. So things grew a little bit out of hand. And I also participated in the Campus Infrastructure Planning Committee, which fortunately met very infrequently.

06-01:51:55
Eardley-Pryor: That's a lot of administrative work in the midst of this financial crisis.

06-01:51:58
Bell: Right. So—Operational Excellence. My advice was: Don't do what you're planning to do, [which was] herd everybody into one place. Amongst other things, the people who are most competent are going to leave because you don't pay competitive salaries—you can do much better going to industry by a factor of two, sometimes and more. You're going to divorce people from the campus—that's why they've chosen lower salaries, because they can work on campus, have the campus spirit, have more flexibility in their work hours. Part of what's wrong here is not where the people sit, but the processes that they use—financial processes, computer systems that don't talk to each other, databases that aren't shared or are formatted completely differently.

06-01:52:49
Eardley-Pryor: So this consolidation into this one operational unit in one location would also require new software?

06-01:52:57
Bell: Yes, except this wasn't being done first. "We'll figure this out. We'll figure this out." This was the typical administrative response. And again, speaking as an engineer, I said, "This is completely wrong. You don't force people to move and undo years and decades of experience until you help them with the daily process and make that very smooth and make sure it works." Well, no, no, it was all done completely backwards, and the result was, it didn't work. And then I served on another committee that was evaluating from everybody's perspective why it didn't work and how it didn't work.

06-01:53:37
Eardley-Pryor: That sounds to me like people coming to complain before the committee.

06-01:53:39
Bell: Yes. That's exactly what it was. We listened to deans and other administrators complain. And eventually it all collapsed during Dirks's tenure as Chancellor. And even Dirks decided to scrap it—and at the cost of a lot of money that had

been spent on consultants to come in and tell you why you should do it and reaffirm the Chancellor's original—Birgeneau's—proclivity to do it, desire to do it. And counter to the advice of the faculty—you know, "We don't know anything," we were told—you know, "You just don't understand." It was just dead wrong.

However, the one thing that we did get right was the handling of IT [Information Technology]. This was consolidated. We have a very good Vice Chancellor for IT, and that has gone off very smoothly. Purchasing has worked out in the end, but only because now there are satellite groups. So there's one for this end of campus that works with physics—astrophysics, chemistry, and maybe one more unit here. Engineering has had ERSA, their own unit, so they kept that. And there will be others populated around the campus.

06-01:55:00
Eardley-Pryor: So it sounds almost like instead of a massive consolidation, there's now sort of a meso-scale consolidation that happened.

06-01:55:04
Bell: Yes, meso-scale consolidation. Yes. And that's starting to work. But it's had very large growing pains and expensive growing pains.

06-01:55:12
Eardley-Pryor: Yeah, expensive growing pains.

06-01:55:12
Bell: Yes. And it could have been avoided if people would have listened.

06-01:55:16
Eardley-Pryor: And thought like an engineer.

06-01:55:17
Bell: Yes, right.

06-01:55:19
Eardley-Pryor: Those are good administrative lessons to pull from that.

06-01:55:21
Bell: Right. Yes.

06-01:55:23
Eardley-Pryor: Also, your work in the Senate faculty included service in DIVCO, the Divisional Council.

06-01:55:31
Bell: Yes. Yes.

06-01:55:32
Eardley-Pryor: I have a note here that you served on that from 2013 to 2017.

06-01:55:36
Bell: That's right, yes.

06-01:55:37
Eardley-Pryor: Also another contemptuous time on campus, with shifts with executive chancellorships.

06-01:55:43
Bell: Right.

06-01:55:44
Eardley-Pryor: Talk a little bit, if you could, just as a framing—what is it that the Divisional Council does?

06-01:55:48
Bell: The Divisional Council comprises the chairs of all the committees, and then there are three elected members [who are] elected by the faculty as a whole. So I ran for one of these slots and was elected to serve.

06-01:56:06
Eardley-Pryor: And as chair of CAPRA, you would have also sat on DIVCO.

06-01:56:09
Bell: I started as chair of CAPRA and then became—I think I served one year in that capacity, and then another three years I was elected as a roving member.

06-01:56:21
Eardley-Pryor: I see. So after you had served in your role as chair of CAPRA, they said, "Let's keep Alex on this"—in DIVCO. So, you became elected to it that way?

06-01:56:29
Bell: Right. I became an elected member. And so that group met, I think, once every second week—that's right—at lunchtime.

06-01:56:41
Eardley-Pryor: And their purpose is?

06-01:56:42
Bell: And their purpose is to hear about all the committee reports, speak out about it, discuss it; hear from the chair about all the oncoming problems that the campus is facing—because the chair and vice chair are constantly in contact and conversation with the Chancellor and Vice Chancellor, and they bring these problems for reflection to DIVCO. Therefore, DIVCO is really the ultimate Senate voice of the faculty.

06-01:57:14
Eardley-Pryor: All of the chairs of the major committees within the Senate faculty are meeting in DIVCO and speaking, essentially, directly with the Chancellors?

06-01:57:23
Bell: Right, yes. And DIVCO once a year writes a report about all these activities and sends it to the Chancellor's office for comment.

06-01:57:31
Eardley-Pryor: And what were the major issues during this time that you served?

06-01:57:34
Bell: So now there were starting to be more financial issues for the campus as a whole in dealing with the structural deficit. There were also major, major issues with Dirks and his ability to administer—and principally, his seeming inability to hear the faculty and understand them and understand the Berkeley perspective. Now here's a faculty member, very prominent in Asian history, coming to Berkeley from Columbia University—so first of all, a private university to a public one—a very public one—and one where the faculty doesn't do well if the Chancellor speaks down to the faculty. You have to really find your proper voice here, so to speak, and understand this culture, which Dirks didn't do very well. And he, worse yet, brought in—let me get his name here—

06-01:58:41
Eardley-Pryor: Oh, Claude M. Steele?

06-01:58:42
Bell: Yes, Claude Steele—as his assistant from Stanford.

06-01:58:44
Eardley-Pryor: After George Breslauer had stepped down as Executive Vice Chancellor.

06-01:58:46
Bell: Yes, right. And because he [Dirks] had served with Claude, I think, at Columbia—but—anyway, they knew each other prior to their coming to Berkeley.

06-01:58:55
Eardley-Pryor: But they were both outsiders to the Berkeley culture?

06-01:58:56
Bell: Both outsiders. Claude also didn't understand the game—even though he's a wonderful person, I've talked to him—a very likeable person. They didn't understand how Berkeley works. And so they got buffeted by the faculty. And it got to the point where one of the deans had the confidence to go and tell the Chancellor, "Look, you need to resign, or next week you'll have a vote of no confidence."

06-01:59:29
Eardley-Pryor: From the faculty?

06-01:59:30
Bell: Yes. From the deans.

06-01:59:32
Eardley-Pryor: What were the major issues that these deans were raising with both Claude Steele and Nicholas Dirks?

06-01:59:39
Bell: The fact that they weren't trying to understand how to deal with Berkeley's problems and yet deal within the context of how this place operates.

06-01:59:49
Eardley-Pryor: Break that down into something more manageable for me. That sounds abstract.

06-01:59:54
Bell: Yes, sure.

06-01:59:55
Eardley-Pryor: What were the issues at stake?

06-01:59:57
Bell: Okay, so—you know—well, the sexual harassment came up independently of this.

06-02:00:05
Eardley-Pryor: What was that?

06-02:00:06
Bell: Well, faculty being charged with sexual harassment. And then the Chancellor dealing with this in a much more mild manner than the #MeToo movement and the outside world felt was appropriate—and, for that matter, campus faculty. And then having to back off on that.

06-02:00:30
Eardley-Pryor: Essentially, confronting tenured professors?

06-02:00:32
Bell: Right, yes.

06-02:00:33
Eardley-Pryor: And Nicholas Dirks and Claude Steele were not willing to—?

06-02:00:37
Bell: Be as hard as you needed to be. Now this is extremely tricky. I mean, I wouldn't want to be in their shoes. Yes. Let's see. Some of the other issues at the time—

06-02:00:51
Eardley-Pryor: You've talked about not understanding the culture of Berkeley, but that—

06-02:00:55
Bell: Actually, this doesn't have to do with the culture; this is knowing how to deal with this kind of issue appropriately. One big one which affected us was Steele raising the question: "Why is there a College of Chemistry? We don't

need a College of Chemistry. We'd be far more efficient if we folded the College of Chemistry together with the School of Physical and Biological Sciences. You get rid of one dean, save money, and consolidate operations," et cetera, et cetera, et cetera.

06-02:01:36
Eardley-Pryor: Well, I can imagine how the College of Chemistry would respond to that. What did the other colleges think about that?

06-02:01:41
Bell: Well, we didn't get much flak, because I think there's some envy of the fact that the College of Chemistry is a separate college. It has a worldwide reputation, a very successful college, and it's been around for 140 years—more. But the Chancellor was dead set on doing this, and so poor Doug Clark spent a year and a half fighting this.

06-02:02:10
Eardley-Pryor: He was dean [of the College of Chemistry] at the time?

06-02:02:12
Bell: Yes—fighting this by getting letters of support from Nobel laureates, from prominent people in the academic field, writing to the Chancellor, alumni writing. Unfortunately, it didn't seem to have enough of an effect. So I had been meeting periodically with Doug to share my experiences and my own thoughts about how to deal with the problems he was facing, since we know each other very well. And at one point he said, "I think we need to have a show of faculty support"—faculty within the College—and he said, "Would you be willing to write a letter?" He had decided that I should be the one who writes the letter. And I thought about it and I said, "Yes, sure. I'll write the letter." And this was at eleven o'clock in the morning. I went off to my office and spent the lunch hour drafting the letter, showed it to some of my senior colleagues in both departments, took their input, polished it up, and a day later he had the draft letter. He liked it. We got 95 percent of the faculty in the College to sign on.

06-02:03:30

Doug sent the letter off to the Chancellor. Well, that was finally the brick that killed it. And he stepped back—although he had a face-saving way, he said, "Well, okay, but we want to form an intercollegiate committee that will assess how these colleges can work better and more effectively together." He felt that we were missing certain opportunities. I pointed out that there were five huge funding opportunities where this College, working with others, has succeeded in getting tens of millions of dollars for the campus. What's the problem?

So needless to say, Dirks was not effective. He stepped down.

06-02:04:20
Eardley-Pryor: From my understanding, he stepped down just moments before the Senate faculty was going to call this vote of no confidence.

06-02:04:26
Bell: That's right, yes. And so at this point, Carol was acting EVCP [Executive Vice Chancellor and Provost].

06-02:04:34
Eardley-Pryor: And this is Carol [T.] Christ. You had already had experience working with her previously.

06-02:04:36
Bell: Oh yeah, yes.

06-02:04:38
Eardley-Pryor: What was that experience?

06-02:04:39
Bell: I worked with her when I was dean and she was Provost; it was a wonderful experience.

06-02:04:44
Eardley-Pryor: So this was in the mid-to-late nineties, during your deanship and she was then Provost?

06-02:04:46
Bell: Yes, that's right—'94 to '99. She was Provost at the time.

06-02:04:52
Eardley-Pryor: We haven't talked about it yet, but there was also a restructuring that happened while you were dean in how the provostships were reordered.

06-02:04:59
Bell: Yes, that was reorganized just as I was stepping in, but it didn't really affect me. I felt that while Carol did not understand the ins and outs of College of Chemistry, she respected the fact that it was a prominent college and listened carefully to what I had to say. We had a very good working relationship—no tension, very smooth.

06-02:05:26
Eardley-Pryor: When that reordering happened—under Chancellor Tien, at the time, I think—there were two different Vice Provosts, right?

06-02:05:33
Bell: Yes. Jud King had been one of them, for the professional schools and colleges—

06-02:05:36
Eardley-Pryor: And then Carol Christ—?

06-02:05:36
Bell: And everything else was under Carol's—or, well, it was under the aegis of the other person.

06-02:05:42
Eardley-Pryor: And when this reorganization happened from these two separate Provosts into a single Provost, Jud was no longer a Provost and Carol became the single Provost?

06-02:05:50
Bell: Yes, he became Executive Vice President of the University [of California], as a whole.

06-02:05:53
Eardley-Pryor: So he moved down to Oakland, to the [University of California] Office of the President, UCOP.

06-02:05:55
Bell: Yes, right.

06-02:05:59
Eardley-Pryor: Were there any challenges among other deans in this reorganization?

06-02:06:03
Bell: I have to say that I don't recall any challenges, no. No.

06-02:06:08
Eardley-Pryor: So you had a wonderful working experience working with Carol Christ back in the nineties while dean?

06-02:06:10
Bell: Yes, I had a wonderful working experience. We had quite a few retention cases to deal with, which were very costly. It was important that Tien was the Chancellor, because he understood engineering. He was a mechanical engineer. He understood engineering. He understood what the College represented – he was a fighter and I enjoyed working with him. At one point, we were trying to recruit Graham [R.] Fleming from the University of Chicago, and the university had failed several times to attract somebody from that university. This recruitment was going to be a multi-million-dollar proposition—to attract Graham from Chicago, a senior faculty member, very prominent. Tien said, "I love this. I've always wanted to fight Chicago." You know, it's like going to a football match. I said, "Great. Let's work together." And we did. We got money from the Paul and Ann Getty eventually, with the aid of Alex [Alexander] Pines, who knew both Gettys well. We pulled it off, and Carol helped all along the way.

06-02:07:27
Eardley-Pryor: That's great. So in the intervening time period, you are now at this future point in the 2010s, serving on DIVCO and working in the Academic Senate, and Carol has since returned to Berkeley after serving as president at Smith College.

06-02:07:46
Bell: Right. And now she finds that she is facing this financial problem.

06-02:07:52
Eardley-Pryor: This is in the wake of Dirks stepping down?

06-02:07:54
Bell: Dirks has announced that he was going to be stepping down. There's no new Chancellor yet, and the search committee hasn't even been formed yet by the president.

06-02:08:08
Eardley-Pryor: This is a real crisis for administration.

06-02:08:10
Bell: So it's a real crisis. He's letting her call the agenda more than himself. He participated in the discussions, but it was clear that she's running the agenda and helping him. Much to her credit, she wanted him to have a graceful step-down and retirement from the position—which everybody said, "Fine. If he's going, let him go gracefully." It became clear that she needed more frequent advice than she could get informally, so she decided to have biweekly breakfasts at the Faculty Club. And so we would get together in the Director's Room at eight o'clock in the morning and have breakfast with her and Dirks. And I was the one person on the Academic Senate who did not have responsibility for a committee or wasn't chair or vice chair.

06-02:09:09
Eardley-Pryor: This is as your elected role in DIVCO?

06-02:09:11
Bell: I was asked by the chair to do this—to represent the rest of DIVCO. So I agreed. For a year—my last year working with the Senate—I did this on a biweekly basis. And it was very good.

06-02:09:30
Eardley-Pryor: What were some of the topics and the issues that came up during these breakfasts?

06-02:09:32
Bell: Well, the topics were how to handle the IA debt, which she was working through; how to handle the structural debt—

06-02:09:44
Eardley-Pryor: Let me pause and ask about that. We had talked about the financial crisis creating a sudden $200 million deficit—or budget cut. What is the structural financial hole that you're talking about?

06-02:09:56
Bell: So this is that we are spending $125 million a year more than we're allocated in, coming from all sources.

06-02:10:06
Eardley-Pryor: Is that connected to the financial crisis?

06-02:10:09
Bell: Yes. And finally, the campus was told by Janet Napolitano, "You have to get rid of the debt."

06-02:10:17
Eardley-Pryor: The president of the UC [University of California system]?

06-02:10:18
Bell: Yes. And this was taken very seriously. And so the question is: Okay, we're not going to get rid of it right away, because it's a sizable fraction of our $3 billion-a-year annual budget—it's on the order of 4 percent—so let's chip away at it. And we chipped away at it. And then the final year, Jerry Brown forgave Berkeley the last $25 million. So we're out of the debt position, but we are much tighter than we had ever been before. So every new thing that comes along now, there's basically no money for it. And the way forward is to raise money through various strategic initiatives and other fundraising efforts—and the new campaign that will be launched shortly.

06-02:11:19
Eardley-Pryor: So how is that different from how the budget had operated historically at Berkeley?

06-02:11:24
Bell: It's the same, but more dependence on giving.

06-02:11:29
Eardley-Pryor: So development has a more—a higher role?

06-02:11:31
Bell: Yes, development, a higher role. So now Carol has agreed to raise money, I think, for 100 new professorships, each of which is, I think, a $5 million endowment—it's fairly sizable. But this would give the campus an ability to expand the faculty from 1,500 to 1,600.

06-02:11:58
Eardley-Pryor: What was the tenure of these breakfasts and working with Carol, in her role as this new Chancellor, dealing with these challenges? What was the tenure of these breakfast meetings?

06-02:12:08
Bell: It was very friendly, very effective. No tension.

06-02:12:15
Eardley-Pryor: Even in the midst of this crisis that's going on?

06-02:12:16
Bell: Yes. She was very open and candid in presenting what she saw and what's happening, what she's doing. She listened. She sometimes didn't agree with proposals, but she was never argumentative—which is a very good position to be in. And she has a wonderful ability to articulate the situation as she sees it—I think, more so than previous Chancellors—and to talk about the issues in

human terms, as well as the concrete, you know, financial and other things. So I'd have to give her an enormous amount of credit for being a very human administrator, and a very skilled one.

06-02:13:07
Eardley-Pryor: The other issue that I'm imagining coming up during this time was the [Hillary] Clinton-Trump election and the turmoil that's happening on campus, the freedom of speech issues that were happening. Were those also topics of discussion?

06-02:13:19
Bell: That was also coming up and needed to be dealt with. And as you recall, Yiannopoulos—Milo Yiannopoulos.

06-02:13:26
Eardley-Pryor: Milo Yiannopoulos.

06-02:13:26
Bell: Yes. This had been a failed event. When he came here under Dirks, there was a fire down by the student center and there was a lot of ugly press—although I was near the student union and I saw that there was basically nothing to talk about compared to the sixties, when we had real turmoil and the campus was covered with tear gas from a helicopter flyover. It was nothing near like that, so this was child's play. But nevertheless, it was bad press. And when she became Chancellor, she correctly said that we have to have an open voice for Republicans—the Young Republicans—as well as our liberals. And she provided a time and space. There were rules, which date back to the free speech movement, that got implemented. Anyone who wanted to speak was invited provided that they conformed to some basic rules about time and manner. When Yiannopoulos was invited again, the Chancellor spent a few million dollars providing protection for him. And so he came through this cordon of police, and it was a non-event. He spent fifteen minutes on Sproul Plaza joking with people and then he left.

06-02:14:32
Eardley-Pryor: After spending millions of dollars to make it possible?

06-02:14:34
Bell: Yes, yes. Well, we made it possible, but it was a financial cost for politically protecting the campus. And I think it was, in the end, the right result—the right choice, right decision. Expensive, but as a result, we haven't had anything else like this. Ann Coulter hasn't appeared, and Yiannopoulos hasn't come back. Where are they?

06-02:15:00
Eardley-Pryor: So that, you think, was the right kind of leadership that was necessary?

06-02:15:03
Bell: Yes. Right. So you have to be thoughtful, but also tough at the right moment.

06-02:15:10
Eardley-Pryor: That's great. What are some of the other issues that you were dealing with in these breakfasts? I'm imagining housing—the housing crisis.

06-02:15:17
Bell: We talked about housing—the fact that there's not enough housing in the Berkeley area—certainly for faculty and even worse yet for students—that's affordable, and the difficulties—

06-02:15:28
Eardley-Pryor: And staff, on that point, as well.

06-02:15:29
Bell: And staff, right. We didn't talk so much about parking, which has become an issue now with the proposals to tear down the Upper Hearst parking structure.

06-02:15:41
Eardley-Pryor: For the Goldman School [of Public Policy] to expand?

06-02:15:42
Bell: Yes, for the Goldman School. Right. There's a faculty meeting on May 1 to discuss that.

06-02:15:49
Eardley-Pryor: The parking issue is directly related to the housing issue. People live so far away because they can't afford housing near Berkeley.

06-02:15:52
Bell: It's all connected. That's right, yes.

06-02:15:55
Eardley-Pryor: So they have to drive in. So where do they park?

06-02:15:56
Bell: Yes, yes. My proposition to Carol is: Look, the university owns land, including People's Park and another park on this side of campus and other properties. We should long ago have been capitalizing on these and making money off of them. Why aren't we?

06-02:16:15
Eardley-Pryor: In what ways would you suggest making money and capitalizing on them?

06-02:16:17
Bell: Well, if you decommission People's Park as a place for transients and you built apartments on it, you'd be having income and the university would get the income. If you look at Columbia University, which owns large amounts of property on the West Side of Manhattan, they made oodles of money from it. And if you want something really large in this area, go back to Cambridge University, where the kings and queens donated lands to Cambridge, and they make millions off of them.

06-02:16:52
Eardley-Pryor: So do you think that has been heard—your suggestions?

06-02:16:56
Bell: Well, it was certainly heard. The question is: Is it practical to do? And the difficulties dealing with Berkeley politics and the local politics—and the willingness not—you know, the willingness [*to knock on door*] to go in and exercise eminent domain.

06-02:17:10
Eardley-Pryor: Yeah. We'll pause here.

Interview 7: May 3, 2019

07-00:00:00
Eardley-Pryor: My name is Roger Eardley-Pryor from the Oral History Center at UC [University of California] Berkeley. Today is May 3, Friday, of 2019. We are here for our final and seventh interview session with Alexis T. Bell, here in your office at UC Berkeley.

Alex, I wanted to start off this session, which will cover your personal and family life from around 1967 through the present—I wanted to start it off with a question about the importance of dancing and music in your life. In thinking about your relationships, what role has dancing and music played?

07-00:00:32
Bell: Right. So as I told you earlier, I grew up in a family where my mother was a ballet teacher in New York City. In my earliest recollections, we lived in an apartment which was at the back of her studio, so every day I would hear piano music for the ballet classes that she taught—classical music—and I saw a lot of young women and young men practicing ballet. Both my parents enjoyed classical music, and so I grew up throughout my childhood and youth hearing music.

Then later when I was at the university, at MIT [Massachusetts Institute Technology], I took up folk dancing—a completely different kind of music—while continuing to enjoy classical music. And with the help of one of my roommates, a young physics student, I started going on the weekends to folk dance gatherings. And so I did this through all my graduate school years. When I came out here I was single and found that this was a nice way to meet young people—similar interests, similar age—and so I began going to folk dancing sessions at International House and at the Harmon Gym.

07-00:01:48
Eardley-Pryor: Here in Berkeley?

07-00:01:49
Bell: Here in Berkeley, right.

07-00:01:50
Eardley-Pryor: And from my understanding, from what you have told me, that's also where you met your first wife—you fell in love through dancing, in a way.

07-00:02:00
Bell: That's right, it was through dancing that we met—although it was not one of these folk dancing events. Another young man who was a graduate student here in architecture who also enjoyed folk dancing invited me to a party on a Saturday night hosted by some Israelis who were his friends, and that's where I met Suzanne, who later became my wife.

07-00:02:24
Eardley-Pryor: And what was Suzanne's maiden name? What's her full name?

07-00:02:26
Bell: Suzanne Talmy was her maiden name—T-A-L-M-Y. And so we danced at the party and talked, and in the course of that she told me that she had the Talmy Dance Ensemble, a performing group here in the Bay Area, that performed Israeli dancing. And since I had done that in graduate school, I decided to come to some of her rehearsals. That was also a way to get to know her better. And I eventually joined her troupe and performed in a couple of places around the Bay Area.

07-00:03:05
Eardley-Pryor: I love that. So tell me about what these performances were like.

07-00:03:09
Bell: We would be invited by various Jewish groups to come and perform on a holiday or whatever other celebration there was—sometimes it was part of a bar mitzvah. So it was in hotels, both here in Berkeley and over in San Francisco. So I did this maybe half a dozen times in those couple of years.

07-00:03:32
Eardley-Pryor: And what were those years? When did you meet Suzanne?

07-00:03:35
Bell: I met her in 1970, so about three years after I had moved out here.

07-00:03:40
Eardley-Pryor: All right, so you're getting your research launched, your projects are underway, you have graduate students working with you.

07-00:03:46
Bell: That's right.

07-00:03:47
Eardley-Pryor: And in the meantime, on your free time, not on campus, you're off dancing.

07-00:03:51
Bell: That's right.

07-00:03:51
Eardley-Pryor: I love it.

07-00:03:52
Bell: Yes, yes. Yes.

07-00:03:53
Eardley-Pryor: So tell me, how did your and Suzanne's relationship evolve?

07-00:03:56
Bell: So as we got to know each other better through the dance rehearsals and performances, we realized that we shared other interests. She's also the

daughter of émigré parents—first generation American, same as I am—so this was something in common.

07-00:04:16
Eardley-Pryor: Where did her family come from?

07-00:04:18
Bell: Her father and mother both came from the border of Poland and Russia, from Europe, and emigrated to Chicago. And she grew up in Chicago and went to the University of Chicago. And then she moved out here with her first husband. And he had a carpet store in downtown Berkeley. By the time I met her, she was divorced and had two children.

07-00:04:47
Eardley-Pryor: What was that like, then, for you, wooing a woman who also had children already? What was that experience like for you?

07-00:04:56
Bell: Well, it was different than other experiences I had had with young women. But I cared a lot about her. The kids were nine and six at the time that we met—fairly young. Very pleasant young girls, very active, very animated. And so we eventually decided to form a family.

07-00:05:21
Eardley-Pryor: And what are the names of those young girls?

07-00:05:22
Bell: So the oldest is Carmi and the youngest is Nehama. Both are Hebrew names.

07-00:05:31
Eardley-Pryor: And so Carmi and Nehama became—eventually, when you created this family—became your stepdaughters.

07-00:05:35
Bell: That's right.

07-00:05:36
Eardley-Pryor: And when did you and Suzanne decide to create your union?

07-00:05:41
Bell: So we decided to get married in 1972; it was about two years after we had met. And we lived together for a short while in her home, and then jointly bought a house in the Rockridge area of Oakland, on Rockridge Boulevard. Not long after we bought the house in 1972, we got married there.

07-00:06:06
Eardley-Pryor: Tell me about the marriage. What was the wedding like?

07-00:06:07
Bell: So we had thought originally—or she had thought originally—of getting married in a synagogue, and so we went and talked to several rabbis in the

Bay Area here. And they said yes, we could do that, but since I'm not a Jew, I would have to convert. I thought about that and decided no, this doesn't seem right to me to convert to Judaism, since I'm not a practicing Jew. I'm not a practicing Christian, for that matter. So we put that off. And then we went searching and we discovered that in our neighborhood there was a Lutheran minister whom we had gotten to know—one of his daughters had done some babysitting for us—and he agreed to marry us. So the marriage vows were performed and exchanged in our house.

07-00:06:58
Eardley-Pryor: In the home that you bought in Rockridge?

07-00:07:00
Bell: Yes.

07-00:07:01
Eardley-Pryor: And this home, from my understanding of your telling, and also images I've seen online, is a beautiful house.

07-00:07:08
Bell: It's a beautiful house. It's a Craftsman-style house—Prairie Craftsman-style house—built in 1910. And this was the first house on Rockridge Boulevard that was developed at that time, when that parcel of land was opened up. And I have somewhere, or had somewhere, photographs that we obtained from the Oakland City Museum—

07-00:07:30
Eardley-Pryor: Of the house?

07-00:07:31
Bell: Of the house being completed. And there was the sales shack across the street, and you could look down the street and there was nothing but the hillside.

07-00:07:40
Eardley-Pryor: Oh, wow. When do you think those photos were taken?

07-00:07:42
Bell: They were taken in 1911. Yes.

07-00:07:45
Eardley-Pryor: That's pretty darn early.

07-00:07:45
Bell: We know the dates. Yes.

07-00:07:46
Eardley-Pryor: That's awesome. So tell me a little bit more about the ceremony. What was the event like? You said you had it at your home.

07-00:07:54
Bell: We had it at our home. It was a relatively short ceremony. We had Suzanne's family there from Chicago, my parents from New York City, and a lot of friends. And it was a very lively, good evening—or good afternoon.

07-00:08:11
Eardley-Pryor: I imagine there was dancing.

07-00:08:12
Bell: Yes, there was dancing. The biggest problem we had is that our neighbor decided to mow his lawn just as we were getting ready to say our vows. And so one of our friends went out and said, "Could you wait half an hour to mow your lawn? There's a wedding going on." And the neighbor was not too forthcoming and willing to help, but our friend convinced him that he should wait a half hour, it would be nice, we'd appreciate it.

07-00:08:39
Eardley-Pryor: That's great.

07-00:08:41
Bell: So you never know what's going to happen when you do these things.

07-00:08:42
Eardley-Pryor: That's the truth. Had your parents come out and visited before?

07-00:08:47
Bell: My parents? No. They'd met Suzanne once in New York, but they'd not come out to visit us here.

07-00:08:54
Eardley-Pryor: What was that like for you, to have them here near Berkeley?

07-00:08:57
Bell: Well, it was an interesting experience, because they were not too enamored of the kind of family that I was joining—of two, you know, growing kids. But they didn't stand in my way. They recognized that I was doing what I wanted to do.

07-00:09:15
Eardley-Pryor: What were their objections? What were their concerns?

07-00:09:17
Bell: Well, I'm an only son. They thought that I would marry a woman probably from their circle in New York—you know, a daughter of friends and so forth—more traditional expectations of their son.

07-00:09:33
Eardley-Pryor: Did they want you to marry another Russian émigré?

07-00:09:37
Bell: That was never put there explicitly, but I think if I had chosen to do that, that would have made them very happy.

07-00:09:45
Eardley-Pryor: So, were they also having some pangs that you had moved across the country to begin your career?

07-00:09:49
Bell: They had, particularly my mother. When I told her in '67 that I was moving to California and would be on the other side of the country, she was very upset and said, you know, "Why did you have to do that?" You know, "Couldn't you have accepted a position in Cambridge [Massachusetts]?" Because I was offered a position at MIT. And I said, "Well, I really felt a lot better out in California, and I like the independence, I like the spirit of the place." And so I proceeded. My father didn't raise any objections.

07-00:10:20
Eardley-Pryor: So as they came out, how did they get along with Suzanne's family?

07-00:10:24
Bell: They got along well. Different backgrounds, different experiences, but they were cordial. In the course of our marriage, they didn't see each other all that often. I think there maybe was another one occasion where both families were out at the same time.

07-00:10:42
Eardley-Pryor: So after your spring wedding in 1972, what was the next major event that happened for you and your family?

07-00:10:50
Bell: So the major event was the birth of my daughter—my own daughter. That happened a year later, in June. And that was a wonderful experience, seeing her born and bringing her home.

07-00:11:06
Eardley-Pryor: What are your memories of that—even the experience of Suzanne being pregnant and that early excitement period?

07-00:11:14
Bell: So as any new father, it's a kind of looking forward to having the child and being able to hold her—I didn't know it was going to be a her at the time, of course—but, you know, hold my child. And also some trepidation about what this means in terms of lifestyle and, you know, everything else.

07-00:11:34
Eardley-Pryor: What were some of your concerns on those points?

07-00:11:36
Bell: So how was I going to balance the responsibilities of being a father with work responsibilities, which were only growing with time? And that was going to be a challenge. But eventually things worked out well.

07-00:11:54
Eardley-Pryor: And what's the name of your daughter who was born?

07-00:11:57
Bell: Alisa.

07-00:11:57
Eardley-Pryor: Why did you pick the name Alisa?

07-00:11:59
Bell: I picked the name Alisa because it's a good name in both English and Russian.

07-00:12:05
Eardley-Pryor: What is it in Russian? What does it mean?

07-00:12:06
Bell: [pronounces with a Russian accent] Alisa.

07-00:12:08
Eardley-Pryor: Is there a meaning behind it?

07-00:12:09
Bell: There's no meaning, no. There's no meaning. And it was also something Suzanne felt—was, you know, comfortable with in both English and Hebrew.

07-00:12:19
Eardley-Pryor: Very nice. It sounds like Suzanne had, with the names of her daughters being Israeli, she had—but her family, coming from Poland, you mentioned?

07-00:12:28
Bell: Yes.

07-00:12:29
Eardley-Pryor: But there still was a really strong Israeli-Jewish sensibility to her.

07-00:12:33
Bell: So there were no Israeli relatives in her family, but there was a strong commitment to the Jewish traditions. And as a kid, she had studied Hebrew, and spoke it haltingly, but she understood Hebrew. And she was very enamored with Jewish tradition. And that's why she named her children—gave the two older girls—Jewish names.

07-00:13:00
Eardley-Pryor: Were those traditions something that you then brought into your home that you created together?

07-00:13:05
Bell: So I embraced it. I accepted it. I never fully participated in it, because it—you know, traditional religion was something not part of my makeup. She, after a little bit of resistance, embraced the Christian—small Christian part of me, in terms of holidays, and particularly Christmas. So we had a Christmas tree, which the kids—all three kids—loved, because they would get presents on Christmas morning. But at first there was a little hesitation on her part about having a tree.

07-00:13:42
Eardley-Pryor: And so menorah and tree in December?

07-00:13:44
Bell: Right, menorah and tree. And a seder in the spring, and so forth.

07-00:13:49
Eardley-Pryor: Oh, that's great. As a kid, I would have loved that. More celebrations at home.

07-00:13:53
Bell: Yes, more celebrations. More good food. Yes.

07-00:13:56
Eardley-Pryor: That's great. Well, I'm interested in you sharing some of your memories. Now that you've created this family, you have three daughters that you are living with at home, a wife, Suzanne—what were some of your early memories of that time, of living in Rockridge in the seventies?

07-00:14:13
Bell: So it was a very nice place to live. We didn't know at the time that BART [Bay Area Rapid Transit] would be coming in soon, which it did—a couple of years after we bought the property. So that enlivened the whole neighborhood and made it a very attractive place to live for people who wanted to commute in the Bay Area or across the bay to San Francisco. And it attracted a lot of food stores, restaurants, small shops—and all in the Rockridge area, around College Avenue, near what is now the Rockridge BART station.

07-00:14:50
Eardley-Pryor: And these things all sprung up in the wake of you moving there?

07-00:14:53
Bell: It sprung up in the wake of our moving there. We moved to Oakland rather than Berkeley because the taxes—real estate taxes—were lower at that time, and the prices on homes were a bit lower than they were in Berkeley.

07-00:15:06
Eardley-Pryor: Do you remember what you paid for that home in '72?

07-00:15:08
Bell: Yes, I do. It was offered for $45,000; I paid $42,500, and was very happy I got it at that price. And the house is worth considerably more today.

07-00:15:23
Eardley-Pryor: We can tell that story later, if you have time, if you're interested.

07-00:15:25
Bell: Sure.

07-00:15:26
Eardley-Pryor: What were some of the things that you did to make it more of a home?

07-00:15:30
Bell: So we repainted most of it ourselves. We had a couple of [couple-friends]—two other couples who lived within walking distance of us. These were friends of Suzanne's from her previous life, and they became our mutual friends. And we would get together every other, every third weekend and do home projects for each other. They helped—stripped down the old wallpaper, and patched parts of the kitchen and living room, and we did the same for them. And then we painted each other's homes. So this was a nice kind of social activity, as well as being very useful.

07-00:16:11
Eardley-Pryor: Yeah, that sounds really nice. Like being part of a community there.

07-00:16:14
Bell: Yes, right. So we did that. We did a lot of entertaining of friends and relatives in the home. Suzanne was a good cook and loved to entertain, and she was a very good hostess. And once I became department chair in '81, every Christmas we had a wonderful buffet table and drinks. And I made an eggnog from scratch using the *Time-Life* recipe book.

07-00:16:46
Eardley-Pryor: Wait, where did you find this?

07-00:16:48
Bell: *Time* and *Life*—you know, the magazines, *Time* and *Life.*

07-00:16:51
Eardley-Pryor: They had an eggnog recipe.

07-00:16:53
Bell: They had a recipe for—a barman's recipe book, yes.

07-00:16:57
Eardley-Pryor: That's fantastic.

07-00:16:57
Bell: Yes, for cocktails and things. So you started with raw eggs and cream and bourbon and sugar and mixed them in the right proportions. I had a heavy hand on the bourbon, so you got quite a kick from a glass of this eggnog.

07-00:17:16
Eardley-Pryor: That's great. Always the chemist, even at home.

07-00:17:17
Bell: Right, right.

07-00:17:19
Eardley-Pryor: That's wonderful. I would love to hear your experience, as your family's growing, now you have this new daughter that is yours; you've married into a family that already had two daughters—I'm interested to hear you talk about your experience of fatherhood in these, what I think, are fairly unique roles.

07-00:17:37
Bell: Mm-hmm.

07-00:17:37
Eardley-Pryor: And I'm interested in part personally, because my father, when he married my mother, she also had two children. They were around the same age, and then I showed up as the third child to this family. And it creates a really neat, unique dynamic.

07-00:17:51
Bell: Yes, it does. It does.

07-00:17:52
Eardley-Pryor: So I would love to hear what that experience was like for you

07-00:17:55
Bell: And it's not a simple dynamic. I always had a good relationship with my own daughter, and that was easy to form, because, you know, we got to know each other when she was just a child and as she grew up. With the two older daughters, it was more difficult. Carmi, in particular, was an extremely articulate ten-year-old and early teenager, difficult towards her mother, challenging her mother's authority; mother was afraid to push back. Nehama was more easygoing, but at times was bullied by her older sister. So this created some tension. And it lasted quite a while, until both older daughters were in their late teens, early twenties, when they finally settled down. They saw that life is not as simple as they might have imagined being teenagers. And the relationship evolved to the point where today, they're adult and living their own lives. We see each other regularly, and we have a warm and caring relationship.

07-00:19:11
Eardley-Pryor: Yes. That's beautiful that it ended that way, because those teenage years can be very tough.

07-00:19:16
Bell: They're very difficult, yes.

07-00:19:17
Eardley-Pryor: Especially trying to create a sense of authority as the father figure in your home—

07-00:19:23
Bell: Exactly. Right.

07-00:19:26
Eardley-Pryor: —with gals that might say, "But you're not my father."

07-00:19:29
Bell: Well, basically, yes, I got that pushback, and the mother was not fully supportive of—she wanted my authority; she wanted me to create order; but she was not able to sustain the order in my absence.

07-00:19:42
Eardley-Pryor: How did all that play out, then?

07-00:19:43
Bell: Well, it obviously created some tensions.

07-00:19:46
Eardley-Pryor: Particularly in those teenage years?

07-00:19:47
Bell: Yes, in the teen years.

07-00:19:49
Eardley-Pryor: I would think so.

07-00:19:49
Bell: And just as an aside, I had a colleague who at one point was having the same kind of stress with his son and daughter, who were in their early teens. He was pulling his hair out—he didn't think he would survive this. I said, "Cheer up. It gets better as they get older."

07-00:20:09
Eardley-Pryor: "You've just got to get through this."

07-00:20:10
Bell: "If you can survive five years until they get to twenty," you know, "you'll enjoy the experience."

07-00:20:16
Eardley-Pryor: Another memory that you shared with me was the sense of music around the home. Tell me what you mean by that.

07-00:20:21
Bell: Right. So Suzanne was a very good pianist. I'd say if she had practiced regularly and so forth, she could have been a concert pianist—that quality. So she loved to play for herself. She loved to get little musical groups together. She taught her middle daughter, Nehama—well, she didn't teach her how to play flute, but she played piano and flute. They played music together, which was lovely to listen to.

07-00:20:49
Eardley-Pryor: That's really nice.

07-00:20:50
Bell: So she liked music, she liked to dance. Even after we married, she continued running her dance group, even though I was no longer part of it. And then later she formed a musical group, a quartet that performed. And they were even on the radio—on KDFC.

07-00:21:14
Eardley-Pryor: How? How did that play out?

07-00:21:16
Bell: So they would go into San Francisco, record their half-hour session, and this would be broadcast.

07-00:21:24
Eardley-Pryor: That's really cool.

07-00:21:25
Bell: It was cool, yes. And she enjoyed doing it.

07-00:21:26
Eardley-Pryor: That is very professional quality.

07-00:21:27
Bell: Yes, it was professional quality, and it sounded very good. I heard the broadcasts. Yes.

07-00:21:32
Eardley-Pryor: And that must make you proud to hear.

07-00:21:34
Bell: Yes.

07-00:21:34
Eardley-Pryor: For the daughters, too, to say, "That's my mother on the radio playing music."

07-00:21:36
Bell: Yes, that's right. Yes. And even later in life, she joined the Oakland Symphony Chorus and sang—she had a very good voice—and continued doing that. Then, later, even later than that, she took up the harpsichord and bought a harpsichord that we had in the house and enjoyed playing that for herself.

07-00:21:58
Eardley-Pryor: Did you ever pick up any musical instruments? Was that something you did?

07-00:22:01
Bell: I picked up guitar when I was a high school student and played classical guitar—I took lessons in New York City—but then as I got to college, I had less time to practice and study. So I played folk guitar for a while, and

continued it here around the Bay for a while, until I got overwhelmed by the work that I do.

07-00:22:25
Eardley-Pryor: What do you mean, folk guitar?

07-00:22:27
Bell: So, folk music.

07-00:22:30
Eardley-Pryor: Like, part of the Israeli or the Balkan dancing?

07-00:22:32
Bell: No, this is American—you know, hillbilly, kind of Appalachian country music.

07-00:22:38
Eardley-Pryor: Oh, that's fun. So you could join in on some of these musical escapades at home?

07-00:22:42
Bell: Yes, yes.

07-00:22:43
Eardley-Pryor: That's lovely. Let's move on. Talk me through, after this point, where you became chairman of the chemical engineering department here at Berkeley from '81 to '91. What was going on in your home life with the gals? You mentioned they're going through their teenage years. Where did they go to high school? What were their experiences like?

07-00:23:03
Bell: So let's see. I'll take them in order of age. Carmi went to Head-Royce, a private school. She went for one year to Oakland High, which was the high school that would have been natural for her. We found that that was a disastrous choice. It's a mixed group of kids; she didn't fit in well. She's far too bright compared to the average student there, and she was miserable, and would want to stay home and not go to school. So we shopped around and found that Head-Royce would provide the right kind of balance. So, her last three years she went to Head-Royce.

07-00:23:48
Eardley-Pryor: And that's similar to you—you also went to a private high school.

07-00:23:51
Bell: I went to a private high school, so I knew something about what to look for. And she was happy there. Yes, that was a good choice.

07-00:23:59
Eardley-Pryor: Private high schools can be expensive. Did that become a strain for you?

07-00:24:04
Bell: Well, it became a strain. I paid for part of it. Her father was still paying child support, so part of that came out of the child support.

07-00:24:12
Eardley-Pryor: What was your relationship with him, as you had this family at home?

07-00:24:17
Bell: So I knew him. Suzanne always had rather harsh things to say about him and the separation. I saw him—I basically felt neutral towards him. I didn't have any animosity, unlike her. And I felt that the kids—the two girls, older girls—should have a continuing relationship with their dad. So, I never interfered in that. Whenever they wanted to see him, they were free to go.

07-00:24:46
Eardley-Pryor: What were Carmi's interests as she moved through high school?

07-00:24:50
Bell: She was interested in horses. And she got interested in equitation even before she got into high school. So she would at first play with plastic horses and organize jumping events and equitation events in the front yard with local kids. Then I think it was in camp that she first rode. And then we got her enrolled in a—I think it was a Saturday afternoon riding school (Pony Club) in Lafayette. We'd drive her out there, she'd take classes, and then come back. And eventually, again, through summer camp, she learned that the horses that were there in the winter could be stabled elsewhere—if parents and family were willing to pay for the price. So we pitched in, and she brought a horse home.

07-00:25:52
Eardley-Pryor: To your actual home in Rockridge?

07-00:25:53
Bell: Not to the home, no—to the stable. And we paid for the rent and the upkeep.

07-00:25:57
Eardley-Pryor: There's a stable nearby?

07-00:25:58
Bell: Yes, up in the Oakland Hills. And so she rode regularly. And that became her principal passion. She jumped and competed. And that led, as she grew older, to wanting to work around horses, which she did for several years. Then she went on with her career in software marketing, but eventually, as an adult, she bought a saddle-making firm in Britain. So the saddles are made in Britain, shipped over here, and sold both in the US and in Europe—she has a distributor in Europe, as well.

07-00:26:45
Eardley-Pryor: Wow. Do you know how she found out this company in the UK was selling?

07-00:26:49
Bell: This was during the period when she was in Boulder, Colorado. I don't recall how she heard about the company. I think it was through the stable where she was riding in Colorado—that she knew that there was a woman who was trying to get rid of this business she had, and Carmi was interested and bought it.

07-00:27:10
Eardley-Pryor: What brought her out to Colorado then?

07-00:27:12
Bell: So her going to Colorado was a result of having a relationship with a young man here who was in this marketing firm. He then left to go to Colorado; she decided to follow him to Boulder and settled in there with him. And then that relationship fell apart, and so we had to help her out financially and get her set up with a new place to live. And so eventually, she started working for another firm in Boulder and liked it there. It's a very nice place.

07-00:27:49
Eardley-Pryor: I lived there for a few years. It's a lovely place.

07-00:27:52
Bell: Oh, yeah, so you know what I'm talking about.

07-00:27:53
Eardley-Pryor: Yeah, how beautiful it is, right at the foothills.

07-00:27:56
Bell: Yes, it's a gorgeous place.

07-00:27:57
Eardley-Pryor: And a lot of open space.

07-00:27:58
Bell: A lot of open space, right.

07-00:28:00
Eardley-Pryor: So she continued riding?

07-00:28:00
Bell: Yes, she continued riding on a regular basis there, yes.

07-00:28:03
Eardley-Pryor: Sounds like it's a lifelong passion for her.

07-00:28:05
Bell: Yes. She bought this saddle company, and she had a house out there, but it became too expensive for her to run the company and pay for the house. So, she sold the house, folded some of that money into the company, and moved home.

07-00:28:25
Eardley-Pryor: To your home at Rockridge?

07-00:28:26
Bell: Yes, to live with us.

07-00:28:28
Eardley-Pryor: When did that happen?

07-00:28:30
Bell: That's a good question. It must have been somewhere in the mid-nineties.

07-00:28:34
Eardley-Pryor: Okay, so maybe ten or so years after she was done with high school.

07-00:28:37
Bell: Yes, yes. And so then she ran the company living at home. So, she didn't have the expense of an apartment and all the associated things. And she ran this company, which she still does.

07-00:28:55
Eardley-Pryor: That's great. And what's the story of Nehama? What was her experience through high school?

07-00:28:59
Bell: So Nehama went to Athenian School, which is in Danville. And she even toyed at one point of being a boarding student there, but we said, "That's too expensive, you're so close to home, stay home."

07-00:29:14
Eardley-Pryor: It's just at the base of Mount Diablo, is that right?

07-00:29:14
Bell: Yes.

07-00:29:16
Eardley-Pryor: It's a very well-regarded school.

07-00:29:17
Bell: It's a very well-regarded school. It's a lovely territory. So again here, the parents—you know, father and our family—shared the expense of that.

07-00:29:29
Eardley-Pryor: What drew her to there, as opposed to the school where her sister had attended?

07-00:29:32
Bell: That's a good question. I think it's not quite as rigorous—it's a more kind of open curriculum. I know that as she grew older, she became enthralled with their Outward Bound program. So Athenian has every student in their senior year have an Outward Bound experience, and she did that, and it just seemed to turn her on to that kind of way of living and doing, leading Outward Bound

trips. So when she finished that, she went to Prescott College in Arizona, which also has kind of an outdoors program. And she was there for four years, finished that, and then she worked for Outward Bound for several years.

07-00:30:19
Eardley-Pryor: After finishing at Prescott?

07-00:30:20
Bell: Yes, as a leader. Yes.

07-00:30:21
Eardley-Pryor: That's great. Where is Prescott in Arizona?

07-00:30:26
Bell: It's Prescott, Arizona. Where is it?

07-00:30:30
Eardley-Pryor: I'm imagining—is it near Phoenix or near the Grand Canyon?

07-00:30:32
Bell: No, it's up towards the mountains. It's up towards Sedona.

07-00:30:38
Eardley-Pryor: Oh, okay. That's a beautiful area.

07-00:30:39
Bell: Yes, it's a beautiful area. Yes. It's in kind of the foothills of the mountains.

07-00:30:43
Eardley-Pryor: And what inspired her to go to Arizona for her college?

07-00:30:47
Bell: Well, it was Prescott College. I don't quite remember how she found out about it, except that they do have a program for students who are interested in leadership in the outdoors world and living off the land.

07-00:31:01
Eardley-Pryor: Yeah. And then, from there she went and worked for Outward Bound afterwards?

07-00:31:03
Bell: Yes, yes.

07-00:31:04
Eardley-Pryor: That's really lovely. Well, moving through the 1980s, through this time where the girls—where Carmi and Nehama, at least—are moving through high school and then moving on through college in different places. We'll revisit this later, but in 1987, you had the first meeting with a woman named Tatiana.

07-00:31:23
Bell: Right.

07-00:31:24
Eardley-Pryor: What was the context for that? We'll revisit the broader stories, but—

07-00:31:27
Bell: Yes, okay. So as I've mentioned in other contexts, I started to go to the Soviet Union first—later Russia, when it transitioned, but in '87, this would have been still the Soviet Union, the last days—through the Russian-American collaboration on catalysis, my research field. So they had a meeting in '87 in Akademgorodok, which is part of Novosibirsk, at the Boreskov Institute of Catalysis. And I came there. It was an international meeting. There was a small delegation from the US, and I was scheduled to be one of the speakers. Tatiana was in charge of the business operation of the meeting—so handling all the finances, making sure that the restaurants were paid, making sure that everybody got to the right hotel, and so forth.

And so here was this very attractive woman—blond, in white slacks and a white shirt, white shoes—with her nose up in the air and very busy and preoccupied. And so my contact with her was just casual, business-like. I remember one of my friends, Gary [L.] Haller, from Yale University, remarked—well, everybody noticed her—all the guys noticed her—and he remarked, "Beautiful woman, but she's totally unapproachable"—and made that comment about her. So that was largely the contact that year.

07-00:33:10
Eardley-Pryor: Well, we can revisit that story as we move along to it. But with relation to that, I'm wondering what your memories are of the experience of glasnost, at the end of days of the Soviet empire. You'd been going there since the seventies—

07-00:33:24
Bell: Since 1974, right.

07-00:33:26
Eardley-Pryor: You had these connections, and over that decade of time, pretty significant changes happened, especially in the wake of your visit in '87.

07-00:33:32
Bell: Right, yes.

07-00:33:33
Eardley-Pryor: What are your memories of Soviet glasnost?

07-00:33:35
Bell: So if you start with the earliest trips in the seventies, it was clear that everybody spoke with you cautiously, and it took some while to establish a rapport and a sense of trust before people would speak more openly and even sometimes critically about the regime and the circumstances. But as I remember, one fellow in Moscow told me—when I was becoming candid with him about what I saw—he said, "Well, I can't talk to you openly. I'm not my own person."

07-00:34:13
Eardley-Pryor: What did you take that to mean?

07-00:34:14
Bell: Well, I know what it means. In other words, he doesn't want to say something that might be reported that he said by someone who overheard him or by me, you know, inadvertently, and this would get back to the cadres in his country—it would create trouble for him. And so there was a sense of tension and so forth, even though people were very hospitable—we never had a hard time there during this period. So as we transitioned from that to glasnost—which is, you know, openness and more freedom and candor—you got people beginning, tentatively, to speak more openly, more critically about their situations. But nothing like what you have here in Berkeley. It's a far cry, still.

07-00:35:05
Eardley-Pryor: That would make a lot of sense. Another memory I'm interested to hear you talk about is, in 1989, the Bay Area experiences the Loma Prieta earthquake. What are your memories from that moment?

07-00:35:17
Bell: So I was chairman at the time. I was in my office—this is in the late afternoon—and all of a sudden, the whole building starts to shake—and Gilman Hall, on the second floor, starts to shake, very much so. And when it didn't stop after about five, six seconds, I started to think, this is serious. So I dove under my desk and, you know, ducked and covered, as they say, until it stopped shaking. It was the better part of a minute. And then I got out, looked around. Well, I'm intact, and the ceiling hasn't fallen down. The door is still there and, you know, nothing disastrous. I went next door, where a colleague of mine was, David [S.] Soong, and said, "How are you?" "Okay." He is an émigré from Taiwan, and his parents—elderly parents—were living in San Francisco at the time. So he calls his mom, got through to her, and his mom says, "I think something serious happened, because the stairs on the adjacent apartment dropped off."

07-00:36:25
Eardley-Pryor: Wow.

07-00:36:28
Bell: And so David dropped everything, hopped in his car, and went to San Francisco. So that's one experience.

I went home. And at the time, we had a couple, who are Suzanne's cousins, I think, visiting us from Israel. And the wife was working part-time in the city, so the husband took off to pick her up after her work. And he was on the Bay Bridge when the earthquake hit.

07-00:36:59
Eardley-Pryor: Wow. When the earthquake hit?

07-00:37:01
Bell: Yes. But he was past the part where the bridge had collapsed, so he was westward. And he said, "I never drove so fast as I did that day to get off the bridge."

07-00:37:13
Eardley-Pryor: Wow.

07-00:37:15
Bell: Yes. So he had had experience serving in the Israeli Defense Force and knew what it was like to be under shells and under pressure, and he drove as fast as he could, picked up his wife, and then turned on the radio and discovered he couldn't come back, because the bridge had collapsed. So he went all the way around the bridge—you know, the other side—and came back to our place several hours later, and was just terrified.

07-00:37:46
Eardley-Pryor: Yeah. And, of course, before cell phones, there's not a lot of communication.

07-00:37:48
Bell: Yes.

07-00:37:49
Eardley-Pryor: I mean, it was just radio and word of mouth, essentially, where you'd get information.

07-00:37:51
Bell: Right. We had another friend who had her family here in Berkeley who used to be a nurse. And she was driving home when she heard about the collapse of the freeway here in Oakland. And so she raced over there—because there was a call for anybody with medical skills—she raced over there and scrambled up on the freeway and to help evacuate people from the crushed cars.

07-00:38:24
Eardley-Pryor: Oh my goodness.

07-00:38:25
Bell: So these are the experiences that I recall from that period.

07-00:38:30
Eardley-Pryor: Did anyone in your family have any damage or any impact?

07-00:38:32
Bell: No, nobody had any damage.

07-00:38:34
Eardley-Pryor: Nothing in the house?

07-00:38:35
Bell: No damage to the house. Rockridge is on a rock ridge—it's named for that reason—and the house was not damaged at all.

07-00:38:43
Eardley-Pryor: That's good to hear. Were there long-term consequences from that—the scares that happened from that Bay Area earthquake?

07-00:38:50
Bell: I think it made people more cautious and anxious about earthquakes. There was a lot of airtime on the radio and television spent on preparedness for the next one. This was the most significant one since 1906. I had been through some smaller ones here, but nothing like this in '89. And of course, that all peters out with time, as people's memory fades. But immediately after, there was a lot of concern. It's surprising that there wasn't more damage done.

07-00:39:29
Eardley-Pryor: It seemed like, at Berkeley, a lot of the buildings were then reinforced in the wake of this.

07-00:39:35
Bell: They were, many years later. So in this College, in early 2000, the earthquake retrofits were done.

07-00:39:45
Eardley-Pryor: Oh gosh, a good decade later?

07-00:39:47
Bell: Yes, yes. That's how long it takes—to get the money, to get the planning, et cetera. Yes.

07-00:39:52
Eardley-Pryor: But the Loma Prieta earthquake was the impetus for creating those retrofits?

07-00:39:55
Bell: Was the impetus, yes. The university went through and assessed all its buildings. This building was assessed as being good, because it's built in 1918, so that's twelve years after the big one here. And it's built of heavy stone blocks, so it's not going anywhere. Latimer Hall, though, needed reinforcements, so they put a set of cement-like things on the outside—you know, a girdle. And Hildebrand Hall, which is even newer, was the poorest of the bunch, because it was built in the sixties, when people thought that you could use prestressed concrete as a lightweight, cheaper way of construction. And it turned out to be completely wrong.

07-00:40:46
Eardley-Pryor: So they had to do even more retrofits for that?

07-00:40:48
Bell: They had to do more reinforcing. They put steel braces inside the building.

07-00:40:52
Eardley-Pryor: Wow. In the early 1990s, both Carmi and Nehama have moved off to—away from home at that point.

07-00:41:01
Bell: That's right.

07-00:41:02
Eardley-Pryor: And Alisa is still at home.

07-00:41:04
Bell: So Alisa finished high school in '92 and started up a relationship with a young man at the time. That led to her having a baby in '93.

07-00:41:20
Eardley-Pryor: Tell me more, the story of that. I imagine that being a challenging time for everyone.

07-00:41:24
Bell: This was a very challenging time for both of us—both parents. She had been a very quiet kid, in contrast to her two older sisters—and not rebellious, but when she turned rebellious, it was in a big way. She decided that she didn't want to live at home. Okay. So, we got her an apartment in West Berkeley.

07-00:41:51
Eardley-Pryor: She decided that she didn't want to live at home in high school, or in the wake of finishing high school?

07-00:41:55
Bell: In the wake of finishing high school.

07-00:41:57
Eardley-Pryor: And where did she go to high school?

07-00:41:58
Bell: She went two years to Athenian and two years to Berkeley High. So she finished in Berkeley High.

07-00:42:08
Eardley-Pryor: Athenian wasn't the style for her?

07-00:42:11
Bell: It wasn't the style for her. She had trouble keeping up with the homework. She felt more comfortable at Berkeley High, and so we let her do that.

07-00:42:20
Eardley-Pryor: When did she become pregnant then?

07-00:42:22
Bell: Let's see—when she was nineteen. So she finished [high school] when she was eighteen. So, the following year.

07-00:42:29
Eardley-Pryor: And she was still living at home then?

07-00:42:31
Bell: No, no. She was now living independently.

07-00:42:32
Eardley-Pryor: Oh, I see. And she chose not to go to college?

07-00:42:35
Bell: She chose not to go to college and started working. But she became pregnant. Now this was a big deal—unexpected for everybody—and this—

07-00:42:47
Eardley-Pryor: What was your reaction?

07-00:42:48
Bell: Well, it threw me for a loop for a while—sort of, at first, I was emotionally upset about my child deciding to do this, and then recognizing it's a fait accompli: you're not going to reverse it, so what do you do next? You know, many parents—or some parents—would reject their daughter for not playing according to the rules. I decided, quite on the contrary, that she's still my daughter, I care about her; I embraced her and said, "I'm gonna support you and make sure you and your child are whole." So a child was born. The relationship that she had with the young man fell apart. He was a total flake. Anyway, I knew that in advance but couldn't convince her. And so she and the kid, Rayven, moved in with us.

07-00:43:42
Eardley-Pryor: Rayven's the name of the child?

07-00:43:43
Bell: Yes, right. It's the first grandchild. They moved in with us. And by then, Carmi was living in Boulder. And this is when Suzanne got it in her bonnet that she didn't think the Bay Area was going to last—we had gone through the earthquake four years earlier—that "Nostradamus had predicted that the West Coast would fall off the face of the Earth," and that—

07-00:44:16
Eardley-Pryor: Was she serious about the Nostradamus piece?

07-00:44:18
Bell: Yes. Yes. She became serious. Yes. She wanted me to read his predictions, and I refused to do this. And that "we're all going to go to hell in a handbasket here," and that "we should all leave the Bay Area."

07-00:44:33
Eardley-Pryor: Why do you think that that developed for her?

07-00:44:36
Bell: Some sort of deep-seated anxieties and uncertainties. And she was easily susceptible to things like this.

07-00:44:48
Eardley-Pryor: Do you think in some ways this had any relationship to her becoming—surprisingly—a grandmother?

07-00:44:54
Bell: I don't think so. I think this is independent. I mean, she had a lot of anxieties and concerns about herself and not having accomplished what she thought she should have accomplished. And it's all tied in with her relationship with her parents. And she has an older sister, whom her parents expressed greater affection for than for her. She was more rebellious than her older sister and didn't feel comfortable with, particularly, her mother. There was a lot of tension.

07-00:45:35
Eardley-Pryor: Gosh, we're such complex people.

07-00:45:36
Bell: We're complex people, right.

07-00:45:38
Eardley-Pryor: And so this transition that Suzanne has happens in the midst of Rayven being born?

07-00:45:42
Bell: Right. Yes. It's closely related. You know, there were ups and downs before this, but this doesn't help. And so she wants me to leave the university and work somewhere else—where else isn't clear. I'm not about to leave this place.

07-00:46:02
Eardley-Pryor: Well, you had just finished your chairmanship of the department at this point, as well.

07-00:46:06
Bell: Yes, that's right. And—

07-00:46:07
Eardley-Pryor: So it is a transition period for you.

07-00:46:09
Bell: It's a transition period for me, yes—getting back into the normal routines of being a faculty member—and now she wants to leave the area and so forth and is really serious about this. So this put a lot of stress on me. It ended up with her convincing Alisa to leave, which I was not very happy about, and created stress between Suzanne and myself.

07-00:46:34
Eardley-Pryor: Suzanne convinced Alisa and Rayven to leave?

07-00:46:37
Bell: Yes, to move to Boulder, because the older sister was there.

07-00:46:40
Eardley-Pryor: Because Carmi was already there?

07-00:46:41
Bell: Yes. So we ended up buying a condominium for Alisa. She did move in there, and she settled in and got work and started living there and supporting herself—except for the cost of the housing, which we provided. And so that continued. That was the onset, for me, of a growing sense that we don't understand our—we have different objectives in life and a different sense of direction. And it was a long period of not feeling as comfortable or as harmonious as we had been before.

07-00:47:30
Eardley-Pryor: After twenty years?

07-00:47:31
Bell: Yes. Yes.

07-00:47:32
Eardley-Pryor: Wow. That's a big change for you.

07-00:47:34
Bell: Yes.

07-00:47:35
Eardley-Pryor: What was it like to have a granddaughter in your home, have a baby at home again?

07-00:47:38
Bell: Oh, it was wonderful. I love her. Yes. Yes. I enjoyed holding her and cuddling her and talking to her. Yes. I like little kids, so that was wonderful. I enjoyed that. In fact, I was sorry that Suzanne encouraged Alisa and Rayven to leave. Yes.

07-00:47:59
Eardley-Pryor: Did you ever entertain thoughts of looking at possible work opportunities in Colorado or in Boulder or elsewhere?

07-00:48:05
Bell: No, no. No. I've traveled a lot around the country, been to other universities, and there has never been a place that was so attractive to me that I wanted to leave Berkeley. And I've told many people that, you know, Berkeley is not perfect, by far. We have lots of stresses and strains here due to finances. It's only gotten worse with the series of governors and legislatures we've had. But what remains constant are the people—the quality of the people. And that's what brought me out here to begin with; that's what's kept me here; and that's what will keep me here. I really feel very privileged to be a part of the faculty here. I tell everybody that being a full professor at Berkeley is the best you can do in the academic world. The kinds of students we attract, the kinds of visitors we have, the fact that you're, so to speak, at the belly button of the

world—everybody wants to come to Berkeley and visit and see you and talk to you. You're constantly engaged intellectually. So no, I never entertained ideas of—seriously—of leaving.

07-00:49:21
Eardley-Pryor: The year that Alisa and Rayven moved out to Boulder to be with Carmi, around 1994, I also know that was the year that you began your time as dean of the College of Chemistry.

07-00:49:31
Bell: That's right.

07-00:49:32
Eardley-Pryor: So that's certainly a re-upping commitment [to staying at Berkeley].

07-00:49:33
Bell: Yes, yes. And a new level of commitment that's higher than being department chair—more people that you're responsible for, a bigger operation, more complexity—all of it.

07-00:49:44
Eardley-Pryor: Yeah. The fundraising for Tan Hall was happening at this point for you—I mean, there's more work to be overseen as dean at that time, too.

07-00:49:52
Bell: Yes. Yes, yes. And maintaining a research program at the same time—because I didn't want to let go of that.

07-00:49:57
Eardley-Pryor: I imagine this time period, this mid-nineties period, being extremely challenging for you.

07-00:50:03
Bell: It was extremely challenging balancing all of these things and maintaining sanity. The home life was not contributing to that. I was being reminded that I work too much and I'm a workaholic—which is true, but it didn't help to have it rubbed in. And that I don't do enough—you know, although I supported her family all through their teenage years and into adulthood. But in the modern American perspective of what is a dad supposed to do—you know, spend more time with the kids, playing and taking them to outings and so forth—yes, I probably didn't do enough of that.

07-00:50:52
Eardley-Pryor: What did you do to help keep yourself balanced in this time period? What were your avenues for solace?

07-00:50:59
Bell: So my avenues were to refocus on what I wanted to accomplish professionally. I loved my research, so I could always dive deep into that and engage. There are good people here to spend time with at lunchtime and late

afternoon, just jawboning. To stay balanced was a challenge—you know, I felt myself, like, on a board with a log in the middle, and then I didn't want to fall off, so I had to constantly maintain my balance. Not lose my sense of humor—that helped. I have a good imagination; I can imagine all sorts of crazy fantasies—which I don't act out, but it's good to clear the head.

07-00:51:52
Eardley-Pryor: Around this time, in this mid-nineties period, I understand that Nehama also came home.

07-00:51:58
Bell: Yes. Nehama did.

07-00:51:59
Eardley-Pryor: What was her experience that she—when she had left home?

07-00:52:01
Bell: Okay. Nehama had finished college, worked for several years, then decided to do her world tour. She had saved up some money, and she went off to first Thailand, Greece, Israel—Europe, where she either had friends or an interest to go—and then finally came home. While she was in Greece, she fell in love with the island life, which is not hard to understand—it's a really lovely place. She spent some time on the island of Paros, which is in the Cyclades chain of islands, where Mykonos is. There she met a guy there who was a windsurfing instructor, and she took lessons from him.

07-00:52:47
Eardley-Pryor: That sounds romantic.

07-00:52:48
Bell: So it was romantic. They started up a summer romance. She came home, and then she decided she'd go back and test the quality of the romance. So she went back. And Theo is his name—she became partners with him. And eventually she got pregnant. So a year after the first grandchild is born, the second one is on the way.

07-00:53:15
Eardley-Pryor: You're a grandfather again.

07-00:53:16
Bell: Yes, I'm a grandfather again. Mother is panicked, flies out to Greece to help her daughter deliver.

07-00:53:24
Eardley-Pryor: Oh, she had the baby there?

07-00:53:25
Bell: She had the baby there.

07-00:53:26
Eardley-Pryor: Because she was living there. That makes sense.

07-00:53:27
Bell: Yes, yes. Then the two came back and lived with us, as the relationship there with the father started to fall apart. He's likable, I know him well. But he's very much a kind of an island macho guy who didn't want to be told what to do. He wanted to tell his woman what to do—you know, very Greek attitudes. And this didn't sit well with Nehama, and so that created friction, and eventually they split.

07-00:54:00
Eardley-Pryor: And Nehama returned to Oakland?

07-00:54:02
Bell: She returned to home—home base again—you know, as did everybody—and lived with us and with her child for a while.

07-00:54:11
Eardley-Pryor: Was there overlap between when Alisa and Rayven—newborn Rayven—were there and this return of Nehama and her child?

07-00:54:17
Bell: No, I think she came back after Alisa and Rayven had moved to Boulder. Yes. I'm a little fuzzy on the dates, because there's so much coming and going of the kids in and out of the house.

07-00:54:25
Eardley-Pryor: It sounds like it.

07-00:54:26
Bell: So she lived with us for a while.

07-00:54:35
Eardley-Pryor: And what's the name of that second grandchild, of Nehama's child?

07-00:54:39
Bell: Aria.

07-00:54:41
Eardley-Pryor: That's a beautiful name. Music again.

07-00:54:43
Bell: Yes. Right. It's a very nice name, and she's a lovely young woman. And so she lived at home. And then—let's see. Aria finished high school here in the Bay Area, in a private school—I don't remember the name of that one—and then went to college in Baltimore for three years.

07-00:55:10
Eardley-Pryor: This would have been in the 2000s if she was born in the mid-nineties?

07-00:55:14
Bell: Right, yes. She went to college there for three years in film studies, and then wasn't doing so well with her grades, so she was asked to leave. And so she

bounced—this is Aria—bounced around between Greece and friends in Europe and occasionally coming to the West Coast to see grandmother and see friends here. But eventually she has settled down and has taken courses in film studies in Los Angeles at UCLA [University of California Los Angeles] and is going to use those credits, with her credits from the Baltimore school, to eventually get her BA.

07-00:55:52
Eardley-Pryor: Oh, good for her.

07-00:55:54
Bell: So I think she's settling in finally.

07-00:55:56
Eardley-Pryor: She sounds like she's an adventurous spirit.

07-00:55:58
Bell: She is.

07-00:55:58
Eardley-Pryor: Much like her mother.

07-00:55:59
Bell: Not unlike her mother, right. Yes. With a Greek, you know, streak in addition. Yes.

07-00:56:07
Eardley-Pryor: What was the trajectory that Alisa and Rayven had? You mentioned they moved to Boulder.

07-00:56:13
Bell: They moved to Boulder. Alisa met a young man there eventually, and they married in 1999. Anthony is his name. He worked there in Boulder, and then he got an opportunity to go to Indiana, yes, outside of Indianapolis. So they moved there, lived there for a while. And then he was working for BMW as the head of the repair service. And he has a bachelor's degree, I think, from [the University of] Arizona in business management, and doing well. They moved then to Pittsburgh, Pennsylvania, where he got a promotion, and he was now running all of the repair services for BMW in the city of Pittsburgh—big dealership. And so they then together had two kids: Kobe who's the younger, and Tehya, the older.

07-00:57:24
Eardley-Pryor: More grandchildren.

07-00:57:27
Bell: More grandchildren. And they were together a total of—let's see—I think it's eighteen years, before he decided he wanted a younger woman. So he met a younger woman in Chicago on a business trip and started a flirtation, and I'm not privy to all of the details, but from what I can gather from my daughter, he

eventually decided that that's what he wanted. And when she heard that, she said, "You're out of the house"—she kicked him out.

07-00:58:04
Eardley-Pryor: And this is while she was in Pittsburgh?

07-00:58:06
Bell: She's still in Pittsburgh.

07-00:58:07
Eardley-Pryor: Oh, she lives in Pittsburgh?

07-00:58:09
Bell: Yes, yes. This happened a little over a year ago. So—yes, so it would have been 2000 when she got married—eighteen years. And so here she is with one adult daughter who's already in Atlanta, on her own—so that's fine—but two young kids, thirteen and fifteen, who still need to be raised, in a new house—they moved into a new house—a big mortgage, and no job. So she panicked. I was helping her out for a few months, and her separated husband was paying alimony. But that was just barely making ends meet.

Now fortunately, she started to work for the construction outfit that built the house where she was living. The company buys parcels of land and it then develops them and sell houses as there's a demand for them. So she had been working for them part-time, and the owner and his wife are very, very kind people. They took pity on her. And eventually they offered her a job as a consolidator. What that means is that when a customer comes in and says, "I want to buy a house," they pick out the style, they pick out the lot, and then the consolidator works with them for the better part of a year to figure out, you know, where do you want the door, what color door do you want, shingles, roof—you know, all the innards, wiring, all the details. It turns out that this is a wonderful job for her, because she's very detail-oriented and she's very personable, and she can do a lot of this from home.

07-00:59:58
So she started a year ago April doing this, and she's paid a nominal salary—not much—but then she gets, I think, 1 or 2 percent of the sale of the house as a commission.

07-01:00:11
Eardley-Pryor: Oh, that's nice.

07-01:00:12
Bell: And she gets half of it when they break ground and half of it when the house is finished. So she's now rolling into the period after a year where she, at steady state, will have twelve to fourteen houses a year that she's getting commission off of—and these are houses that are selling between $1 [million] and $2 million apiece.

07-01:00:33
Eardley-Pryor: What a great opportunity for her.

07-01:00:35
Bell: So it's a fantastic opportunity that just came at the right moment. So she's becoming independent. She loves the work. And she spends her time between working on this and taking the kids to soccer practices and track meets and, you know, all the rest.

07-01:00:52
Eardley-Pryor: Yeah, with teenagers at home.

07-01:00:54
Bell: Yes, yes.

07-01:00:55
Eardley-Pryor: Oh, that's really lovely. That's nice to hear that. I'd love to hear you talk about how your life progresses in the midst of this time. In the mid-nineties there's a lot of chaos, it sounds like, happening.

07-01:01:06
Bell: Yes.

07-01:01:07
Eardley-Pryor: Work stresses have escalated, in the sense that you are now dean, as well as maintaining a very extensive research program

07-01:01:11
Bell: Right, right.

07-01:01:12
Eardley-Pryor: And the home life—it sounds to me, as you are explaining it, your relationship with Suzanne is becoming more and more strained.

07-01:01:21
Bell: It's becoming more strained, yes. Yes. We're starting to, you know, go separate directions. And at that point, it wasn't clear to me what I was going to do or where this would end up. I was basically existing and keeping everything in place, because that's all I could do on a daily basis—there was no space to really ruminate about the future.

07-01:01:46
Eardley-Pryor: Or what you wanted from life.

07-01:01:47
Bell: Yes, and what I wanted in the future.

07-01:01:50
Eardley-Pryor: So it's in the context of that moment for you, where you revisit Russia in 1997.

07-01:01:59
Bell: That's right, yes. Another conference.

07-01:02:00
Eardley-Pryor: Ten years after this conference you had in '87.

07-01:02:03
Bell: Right. And so there's a memorial conference for the first director [of the Boreskov Institute of Catalysis]; I'm invited to be a plenary speaker. I go over there and again meet Tatiana, who was part of the organizing committee, as she was through all these years. And as at many of these conferences, they have a dinner—a buffet dinner—and then dancing, to either live music or to recordings and, you know, there's a disc jockey there.

07-01:02:37
Eardley-Pryor: Is this something that typically happens at Russian conferences?

07-01:02:39
Bell: Yes, it does. Yes. It's very typical.

07-01:02:42
Eardley-Pryor: Not something typical in the United States.

07-01:02:43
Bell: It's not typical at all in the United States.

07-01:02:45
Eardley-Pryor: Why do you think that's a part of Russian conference experiences?

07-01:02:48
Bell: Well, Russians like to have a good time. Many young people grow up doing social dancing and continue into their adult life. And it's just an accepted way to socialize—unlike the US, which is more reserved and more, I'd say, you know, English tradition-bound, so we don't do this as much.

07-01:03:14
Eardley-Pryor: More staid, especially in the academy.

07-01:03:15
Bell: More staid. Much more staid in the academy. You'd never do this here. If you said I want to get a live band and music and so forth, this would not be considered good form for spending public money, or private money.

07-01:03:31
Eardley-Pryor: I could understand why going to conferences in Russia has their appeal, then.

07-01:03:34
Bell: Yes, they have an appeal. Right. So I ended up dancing with her [Tatiana]. The second day, I think, there was an outing on a boat into the Ob Sea—it's a manmade lake near the institute [Boreskov Institute of Catalysis]—and a picnic there and more chance to talk and visit with people. And by the end of

that period, I had gotten to know her a little better. I was intrigued by her and found her a very intelligent, fascinating person. But we parted.

07-01:04:13
Eardley-Pryor: At the end of the conference, that was, "Goodbye. Thank you. It was great chatting"?

07-01:04:16
Bell: That was it, yes. Oh, yes, I should say, one other thing happened at the conference—one of her colleagues approached me already partially drunk and said, "You know, I have the perfect person for you if you need a postdoc. She's fifty, she is divorced. Yes, she has two children, but they're grown up. And she's very good at doing research." And this turned out to be Tatiana that he was advertising to me. So I was a little taken aback and said, "Thank you, but at this moment, I'm not looking for a postdoc." So that was that. That was '97.

In '98, a year later, there was a mutual friend of ours, Yurii [Shaevich] Matros, who had been at the institute—he had been a director of one of the laboratories on reaction engineering—and left, moved to St. Louis and opened up a consulting firm.

07-01:05:19
Eardley-Pryor: From the catalysis institute in Siberia, he went to St. Louis?

07-01:05:21
Bell: Yes, St. Louis, right. And he calls me. He says, "I'm turning sixty. I'd like to have a conference in my honor, and I'm organizing it." All right.

07-01:05:36
Eardley-Pryor: Yurii sounds like a real character.

07-01:05:38
Bell: An entrepreneur.

07-01:05:39
Eardley-Pryor: Yeah.

07-01:05:39
Bell: Right. And I said, "What's the theme?" He told me the theme. I said, "Well, I'm not active in this area. Thank you, but I don't think so. I've just been there last year." "Okay." A few weeks later, he calls me again with the same sales pitch. Again I turn him down. A few weeks later, he says, "Listen, I really want you there. We're gonna have a wonderful party in my honor—you know, lots to drink, good food, dancing," and so forth. At this point I'm starting to feel it's awkward to keep turning him down, so I said, "Okay, I'll come."

Part of the attraction was that it was going to be in St. Petersburg, which is a city I had not visited—I had only been there once before, but not really visited well. So, "Okay." I go there and the first day of the conference there's a welcoming reception in the evening in the Yusupov Palace.

So Yusupov's background—Felix Yusupov was a member of the royal family, and not at all enthralled with [Grigorii] Rasputin and the wife of the tsar, who were starting to run the politics—or influence the politics—this is the early part of the twentieth century. So in 1916, he organizes a scam to invite Rasputin to come for a late supper—

07-01:07:11
Eardley-Pryor: At his palace?

07-01:07:13
Bell: At his palace—that will be in the basement, and he'll introduce Rasputin to his wife, who was a very attractive woman in her twenties at the time, with the idea that there may be some flirtation. So Rasputin comes; they try to drug him, but the arsenic is diluted enough that he doesn't keel over; and so it ends up with their shooting him in the back. And he stumbles out of the basement, out in the yard there at night—cold night—and starts to fall down, and he's shot again. And now, you know, the deed is completed. Yusopov and his conspirators they pick up the body, throw it in the Neva River—break a hole in the ice, put him down under, and figure that's that. Unfortunately, the next day, his body surfaces through another hole in the ice, he's recognized, and now there's a police inquiry. And so forth. So the end of the story is that Yusupov has to leave Russia. He escapes with his life and wife—

07-01:08:19
Eardley-Pryor: Oh, he survived all of that?

07-01:08:20
Bell: Yes, he survived that—and his wife—and they go off to Paris. And he died in 1967.

07-01:08:26
Eardley-Pryor: Rasputin died in '67?!

07-01:08:28
Bell: No, no, no. Rasputin died in '16. He was shot.

07-01:08:30
Eardley-Pryor: Okay. That's what I was saying. "He popped up from the ice and was alive?!" No.

07-01:08:34
Bell: No, no, no. He was really stone-cold dead.

07-01:08:37
Eardley-Pryor: So Felix, the—

07-01:08:39
Bell: Felix Yusupov moved to Paris and passed away in '67.

07-01:08:43
Eardley-Pryor: Oh my goodness.

07-01:08:43
Bell: So he gets to be a good old man. Yes.

07-01:08:45
Eardley-Pryor: He avoids the revolution and—

07-01:08:48
Bell: Yes, yes. He avoids the revolution and all of the discomforts, yes.

07-01:08:51
Eardley-Pryor: My goodness.

07-01:08:52
Bell: But anyway—so we meet in this basement and—

07-01:08:56
Eardley-Pryor: Where the beginning of the end for Rasputin occurred?

07-01:08:58
Bell: Yes, where the beginning of the end was for Rasputin.

07-01:09:02
Eardley-Pryor: Now, I've seen pictures of the outside of the palace—

07-01:09:04
Bell: Oh, it's beautiful.

07-01:09:04
Eardley-Pryor: It's stunningly gorgeous.

07-01:09:06
Bell: It's a stunningly gorgeous palace, and I've been through it as a tourist in years past, and subsequent.

07-01:09:10
Eardley-Pryor: It feels like almost the Russian version of what Versailles would be.

07-01:09:15
Bell: Yes. Yes, it runs along the Moika Canal for quite a distance. It's a huge palace. So I come down to this reception. There's a clutch of women I know from the Boreskov Institute of Catalysis, so I go over to say hi. And from the middle of them comes Tatiana, saying, "Oh, hi! I didn't realize you would be here." So I said, "Yes, I didn't think I was going be here, either."

07-01:09:42
Eardley-Pryor: Did you know that she would be there?

07-01:09:43
Bell: I didn't know that she would be there. And she didn't want to be there, either. She had refused her girlfriends encouraging her to come. And eventually, what persuaded her is that her younger sister lives in St. Petersburg, so she took the opportunity to come free of charge to visit her sister. Okay. So we talk and have a drink and then everybody departs. The next day is the conference. That evening there is a reception at a restaurant with good food, again, a show, and after that, dancing—social dancing.

07-01:10:22
Eardley-Pryor: It is Russia, after all.

07-01:10:22
Bell: Yes, it is Russia, after all.

07-01:10:24
Eardley-Pryor: There will be dancing.

07-01:10:24
Bell: Right. And so I am seated at the head table—a little boring, because I've got to talk to a lot of people. And I see in front of me, two tables ahead, is Tatiana's back in a long, black gown, which I later learned she borrowed from her younger daughter. And then the music starts to play and I said, ah, now's my chance! I'll go over and talk to her and we'll dance. So we started dancing, and then after the music broke, I sat down at her table with another Tatiana who was her colleague from the same institute, and we ended up spending the evening together, and I never went back to the head table.

And we had such a good time dancing and talking and feeling good about each other that at the end of the evening—her responsibility was to put everybody on buses to take them back to the five hotels where they were all situated—I said, "I'm gonna stay behind. Let's go for a walk." You know, this is, I don't know, eleven o'clock at night in St. Petersburg. So she said, "Okay. I have some favorite places I'll show you."

07-01:11:38

And so we walked along the bridges between the canals. And she took me to a street called the Ulitsa Rossi. [Carlo di Giovanni] Rossi was an Italian architect who built palaces in the time of Catherine the Great, and there's a street which is really perfectly proportioned, so that it looks like the sides are parallel, even though they're, you know, coming this way. And then at the end of the street is a statue of Catherine the Great surrounded by her favorites—you know, all lying down, looking up at her feet. And so we went through and counted all the guys who were at her feet.

And then it was time to go home, so I said, "Well, thank you. I think I know my way back." She said, "Do you know really which way it is?" I pointed this way; she said, "No, it's that way." And so then she got nervous and decided that she better walk me back to my hotel, which she did. I thanked her and embraced her, and then I put her in a cab and paid for the cab to take her to her hotel.

07-01:12:54
Eardley-Pryor: Well, this sounds like the most romantic, delightful evening.

07-01:12:57
Bell: It was a really romantic and delightful evening—you know, beautiful city, all lit up at night; beautiful woman—you know, walking and seeing all these sights. I had had a very nice evening dancing with her.

07-01:13:10
Eardley-Pryor: Sounds like a formal dinner—I mean, long black gowns are not something typically worn.

07-01:13:14
Bell: Yes, yes.

07-01:13:15
Eardley-Pryor: So you're both dressed to the nines in St. Petersburg.

07-01:13:17
Bell: Yes, yes. Yes.

07-01:13:18
Eardley-Pryor: It just sounds beautiful.

07-01:13:19
Bell: Yes, it was beautiful—and completely unexpected. Yes. So the next morning—

07-01:13:25
Eardley-Pryor: Were you just kind of feeling swept away with it all?

07-01:13:26
Bell: Yes, yes. The next morning I decided, well, I'd like to see this woman again, and I invited her to go to the ballet, because I had tickets that night for the Kirov Ballet, which is very famous. And she said, "Oh, sorry, I can't. I'd love to, but I agreed to see my sister." Fine. So then what's plan B? Plan B was to invite her to the Hermitage Museum, which I had been to once before but wanted to go back to.

07-01:13:58
Eardley-Pryor: This next day, she's off visiting her family, which is a really lovely thing. That's why she was there to begin with, she says.

07-01:14:05
Bell: Mm-hmm.

07-01:14:05
Eardley-Pryor: And what are you thinking throughout this whole time? Are you just sort of caught up in the moment?

07-01:14:11
Bell: Yes, I'm thinking, well, I've got to figure out another way to have a date with this woman. So that was plan B, was to invite her to the Hermitage. Then, on the spur of the moment—since that took up the morning—we had still some time until the evening, when there was the formal ceremony celebrating Matros' sixtieth and then another party, and that was going to be the end of the conference—I've got to see her again, so I cooked up the idea to go to the museum—which we did, and then—

07-01:14:45
Eardley-Pryor: Had you been to that museum before?

07-01:14:46
Bell: Yes, I had been once before. Yes. I think it was in '87, actually. And so afterwards I invited her to have lunch with me; we had lunch at a small restaurant. Then we parted and got all dressed up for the evening. I showed up at the—it's a building that belongs—it's a small palace, but it belongs to the Russian Academy of Sciences, and that's where we had the conference. So I came and gave a toast to our host and said nice words about him. And then—

07-01:15:21
Eardley-Pryor: You said, "After the third time being invited, here I am, here".

07-01:15:23
Bell: Right, yes. He's a short guy whom I compared to Peter the Great—and, you know, building, doing great things for science and so forth—which got a real kick out of him. And then we went to another party. And it wasn't clear where I was supposed to sit, but I certainly didn't want to sit at the head table. So at this point Tatiana comes over and says, "Would you like to sit with the Russian girls?" And I said, "Sure"—you know, I knew all of them. So she invited me and we made room and sat with her. And then we danced later that evening again, had a wonderful time.

And now it's time to say goodbye, because she's taking the train to Moscow to see her older daughter. So I said, "I'll walk you to the train. I'll see you off." She said, "Oh, you don't have to do that. It's late"—blah, blah, blah. I said, "No, I want to do this." So I walked her back to the hotel, and got her things together, and then we went off to the train station and embraced and hugged and then she parted. And I didn't know when I'd see this—you know—

07-01:16:35
Eardley-Pryor: What were you thinking? What were you feeling?

07-01:16:37
Bell: Well, I was really struck by her, enamored, felt very close to her—you know, a wonderful series of days together—but, you know, a sense of loss, because you don't know what's going to happen next. Oh, yes, and she was trepidatious about the fact that I was going to walk myself back to the hotel this time—which I did.

07-01:17:01
Eardley-Pryor: Why? Because you didn't know the directions?

07-01:17:03
Bell: I knew the direction this time. I told her, but she was still trepidatious. And in fact I walked back. I stopped—because I had had a fair amount to drink that night—walked and stopped in a small store—like a 7-Eleven—to get something to drink. And I paid in rubles, but I didn't realize that there were new and old rubles at the time. And I gave old rubles; I got my change in new rubles, and I was kind of looking at the stuff, not quite figuring out, you know, did I get the right change or not? And I realized at that moment that the people standing around in the store started to think that, you know, he's not one of us. And I decided I'm going to take my water and to hell with the change and get out of here before they start asking me questions. So that was one little awkward moment, but I—

07-01:17:55
Eardley-Pryor: What was the reputation of St. Petersburg at this time, in 1998?

07-01:18:03
Bell: Oh, it was called "the bandit city."

07-01:18:04
Eardley-Pryor: Why?

07-01:18:05
Bell: Because people would get mugged. There were thugs in the city. It was a dangerous place for Russians to be, much less foreigners.

07-01:18:16
Eardley-Pryor: Part of its transition away from the collapse of the Soviet Union?

07-01:18:18
Bell: Yes, there was kind of a lawlessness there for a number of years. And two of the participants in the conference, in fact, were mugged. So there was reason to be concerned.

Anyway, I got back to my hotel. The next morning, I'm putting my things together, because I'm leaving that day, and I get a phone call—unexpectedly—and it's Tatiana calling me from Moscow, saying, "I didn't sleep all night. I was worried about whether you got back to the hotel safely or not. I want to make sure you're okay." So I said, "Thank you, I'm fine. I'm just going to pack my things, go to the Russian Museum, see the collection of Russian art, and then get in a taxi and go home." And I put down the phone and I said, hmm, that's very nice that she called. That means that she's not indifferent to me.

07-01:19:10
Eardley-Pryor: Not indifferent?

07-01:19:11
Bell: Yes.

07-01:19:13
Eardley-Pryor: That's great. That also seems very Russian to me.

07-01:19:16
Bell: It is. And so then I was not going back to California from there; I was going to Baltimore to another conference—a US conference. And when I came there I found another Russian there, Vadim [B.] Kazansky, from Moscow. I knew him and I had visited him once before. I decided, I'm going to cook up a reason to go back to Russia and then see if she can make her way to Moscow. So to make a long story short, I did that. And the end of the story is that he invited me to Moscow in October and he helped me arrange for the visa and so forth. And I went there and we spent five days together—one day at his institute and four and a half days being together with Tatiana and doing a lot of things. And as we later said, those were the five days that turned the world around, for her and for me.

07-01:20:22
Eardley-Pryor: That's where your love really bloomed.

07-01:20:24
Bell: That's where our love really bloomed, yes.

07-01:20:26
Eardley-Pryor: That's a beautiful story of connection.

07-01:20:28
Bell: Yes. Mm-hmm.

07-01:20:29
Eardley-Pryor: I mean, here are these two people in their fifties—I would think, at this point, early fifties—

07-01:20:34
Bell: Yes, she was fifty-one and I'm fifty-four, fifty-five. Yes.

07-01:20:39
Eardley-Pryor: And suddenly having these teenage love feelings.

07-01:20:42
Bell: That's right. Yes. Very much so. Yes.

07-01:20:44
Eardley-Pryor: Like you were born again, in a different way.

07-01:20:45
Bell: Yes, born again, for both of us. And we hit it off immediately. She has a great sense of humor. I speak Russian fluently enough that I can humor her and tell her stories and tell her jokes. And we get along just fabulously.

07-01:21:04
Eardley-Pryor: That had to be quite a relief and a shift from what was left for you in California.

07-01:21:08
Bell: Yes, a complete shift—complete, you know, opposite direction—180 degrees from what I had at home.

07-01:21:15
Eardley-Pryor: Well, tell me a little bit of background—tell me a little bit about Tatiana. Where does she come from? What was her childhood like?

07-01:21:21
Bell: So she was born in '47, right at the end of the Second World War. Her father was a veteran of the Soviet army; he had fought through all the Second World War. He, in fact, enlisted on June 22, 1941, when war was declared by Germany on the Soviet Union, and I he was, I think, eighteen—just finished high school at the time.

07-01:21:47
Eardley-Pryor: Wow.

07-01:21:47
Bell: And so he fought through the whole Second [World] War. Of his battalion, five percent survived, so it's a real miracle that he came out of this alive and not injured seriously. He met his wife-to-be at the front. She had been living in the Ukraine, and when the Germans started to bomb that part of Russia, she was working for a bank. So, she and another young woman took all the money that was in the bank and carried the sacks out and headed east, to get away from the front. And eventually she, too, joined the Chemical Corps of the Soviet army. And so the two young people met at the front.

07-01:22:43
Eardley-Pryor: Tatiana's father was also in the Chemical Corps?

07-01:22:46
Bell: He eventually got into the Chemical Corps. He wasn't in the tank division; he was in the artillery—not the artillery; in the infantry.

07-01:23:01
Eardley-Pryor: Oh, wow.

07-01:23:02
Bell: Yes.

07-01:23:02
Eardley-Pryor: It is a miracle that he survived the war.

07-01:23:03
Bell: It's a miracle that he survived. He didn't have to go into Berlin—he was in Prague. What saved him in the end was that his mother arranged through his

friends for him to be transferred to Moscow so he could go to university studies in the military and become a chemical engineer in the chemical warfare area.

07-01:23:25
Eardley-Pryor: Wow.

07-01:23:26
Bell: So that's what he did for the rest of his life. Tatiana was born in the Ukraine, because the family couldn't afford to live in Moscow. So she was born there. And her mother was living there with relatives for two years, and then the father moved all the family to Moscow. They lived there for, I think, six years. Then everyone moved to Kirov, which is a city a thousand kilometers northwest of Moscow, where he became the director of a biological warfare laboratory.

07-01:24:04
Eardley-Pryor: Wow. Do you know anything about the research he was doing?

07-01:24:07
Bell: Well, it was all about infectious diseases and how to deliver them. No, he never talked about this, and Tatiana never knew any details, because he wouldn't share these with the family. But she lived in a compound behind barbed wire. You had to have a pass to get in, and then another pass and two more layers of barbed wire to get into the labs. But that's where she went through her high school years.

07-01:24:32
Eardley-Pryor: What a wild place to grow up.

07-01:24:34
Bell: Yes. And she as a teenager took dance classes, ballet classes, gymnastics. She went ice skating on the frozen river in the wintertime. She's very athletic, and became an all-Soviet Union athlete in gymnastics.

07-01:24:57
Eardley-Pryor: Wow.

07-01:24:57
Bell: She performed all over the Soviet Union with her team. So her father had, on one business trip, gone to Novosibirsk to talk with people there, and he found that there was a new university there that was built in the late fifties, and a blossoming science city—not unlike Los Alamos would have been in its early days. And so when she finished high school and was thinking about college, he encouraged her to think about going to Siberia. And he told her how to get there, where to go when she got off the airplane, and how to register. And so she took her entrance exam when she got there, got in, and settled in—and lived there for thirty-seven years.

07-01:25:51
Eardley-Pryor: My goodness.

07-01:25:51
Bell: Yes.

07-01:25:52
Eardley-Pryor: And she ended up finishing her degree, also, in—

07-01:25:54
Bell: Yes, she got her degree in chemistry. Then she entered the institute [Boreskov Institute of Catalysis], did her graduate work there, got her doctoral—the equivalent of a doctoral degree, it's called a candidate's degree—and went to work at the institute.

07-01:26:08
Eardley-Pryor: In catalysis?

07-01:26:09
Bell: Yes, yes.

07-01:26:10
Eardley-Pryor: So she comes from a family of chemical engineering, she becomes an expert in catalysis, and that's where you two cross paths for the first time?

07-01:26:15
Bell: Right. Yes, that's right.

07-01:26:19
Eardley-Pryor: So, in the wake of this wild, romantic encounter that you have in '98 and arranging for yourself to get back there to really find out, "Is this real or not, is this happening?"—where did things go? Where do you go from there when you have a life back in California, she's still in Siberia?

07-01:26:37
Bell: Right. So one of the things that kept us together is daily communication by email. I would write her, before going home, a page or two in Russian—but it's a transliteration, because I don't have a Cyrillic keyboard. And she would write me also at night, but the time difference of fourteen hours, meant that I would get it the following morning. So I'd start my day with a letter from her; she'd start her day with a letter from me.

07-01:27:09
Eardley-Pryor: And every day you could write, you would write these letters?

07-01:27:11
Bell: And every day we wrote to each other. So we have something like several thousand of these letters that we wrote to each other over the course of four years.

07-01:27:20
Eardley-Pryor: That's really beautiful. What were the things that you wrote to each other about?

07-01:27:24
Bell: Oh, it was everything, from our life history, growing up as a child, memories, what we thought about each other, incidents that happened at work, incidents that happened in life—you know, it's like a dinner table conversation, except it was all done by email. And occasionally—very occasionally—phone calls, because at that time they were expensive. And then we would arrange to see each other—for no more than a week or two—two was, I think, the longest time we had together anywhere. So I would go there—I went in December, in the middle of winter, to Siberia. We went [cross-]country skiing—you know, out in the fields there.

07-01:28:15
Eardley-Pryor: Were you just making excuses to deliver lectures or attend symposiums?

07-01:28:19
Bell: Yes, I would give a lecture there every time I went—you know, that was the excuse—but I'd spend most of the time with her.

07-01:28:26
Eardley-Pryor: So pursuing your love interest, but at the same time also creating these new work opportunities—these research connections.

07-01:28:31
Bell: That's right, yes. Yes. We went skiing together here in the Sierra several times. We met in—where else? Denver. We met in Boston. We met in New York. We met in Paris. Belgium—Brussels.

07-01:28:48
Eardley-Pryor: That's a worldwide romance.

07-01:28:49
Bell: Yes, it was literally a worldwide romance. So there were twenty of these trips. And we know that there were twenty because each time, she would give me a gift of a framed piece of stone—it's called *yashma*, the stone—it's a local stone—but it's as if somebody had painted it. And I think if you turn around, there are a couple of the stones on my desk. No, I think I put them in the bookcase, but we can look at them later. But we have one from each trip. And most of them now—all but two—are at home, on the wall of our house. So she gave me that. I gave her discs of classical music, which I would buy here on Telegraph Avenue. And in fact, ironically enough, there was a music store called Rasputin.

07-01:29:44
Eardley-Pryor: I've been there. That's great.

07-01:29:46
Bell: Yes. And they had a classical section.

07-01:29:48
Eardley-Pryor: So you would go to Rasputin music store to deliver—

07-01:29:49
Bell: Right. To buy her music—

07-01:29:53
Eardley-Pryor: After having this reconnection, in the basement where Rasputin was ended?

07-01:29:55
Bell: Was killed, yes. You see, all these interesting connections.

07-01:30:00
Eardley-Pryor: That's really a great connection.

07-01:30:01
Bell: Yes. Anyway, so I would bring her music, and I bought her also a cassette player so she could listen to these discs. And she gave me these framed stone paintings. And so we had twenty-one of these trips back and forth. I think she totaled up that we spent 250 days together in four years.

07-01:30:30
Eardley-Pryor: The four years was the time period that this—?

07-01:29:54
Bell: Yes, a cumulative time period. Somewhere at home she has a list of all these trips and the dates. And then it became clear, as the years went by, that we really cared for each other. It wasn't clear where it would end for either of us, but as time went on, it became more and more clear for me that this is what I wanted and I had to let go of my old life.

07-01:30:58
Eardley-Pryor: And what was that process like?

07-01:30:59
Bell: Well, that was very difficult—for obvious reasons—you know, ending nearly thirty years of marriage. But at the appropriate point, I wrote a letter to my wife, which I shared with her, and explained why I wanted to leave. And so for a short period, I continued to live in the house but in a separate room. And then I found an apartment in Jack London Square and moved out completely.

07-01:31:29
Eardley-Pryor: In downtown Oakland?

07-01:31:30
Bell: Yes. That was sometime in 2000. And then roughly a year later, we finalized the divorce. And then there was a whole process of doing that, obviously. And as soon as the divorce was final, I offered my hand to my new spouse.

07-01:31:50
Eardley-Pryor: Tell me about that experience.

07-01:31:52
Bell: So as soon as the court papers were filed, a day later, I called her and I said, "Now I'm a free man, and I'd like you to become my wife." This is by phone. She was back home—

07-01:32:04
Eardley-Pryor: Is this something you had talked about before together?

07-01:32:07
Bell: I had told her in an email that I was getting divorced—had planned to divorce—and it really got her all excited, because she never thought that that would happen. In fact, there's a funny incident—she wrote an email to her daughter paraphrasing what I had said and said, "What does this mean?" And by accident, she sent it to me rather than to her daughter. So I got this and I didn't know—what is she talking about? And then finally we figured out what had happened. So we had a laugh over that. Yes. But she still didn't know what I planned to do after I was divorced, and so she was a little surprised. It was what she really wanted, although she never articulated it—you know, never put any pressure on me.

07-01:32:59
Eardley-Pryor: And so you called her and, from her point of view—"surprise!"

07-01:33:03
Bell: Yes. And she immediately said, "Yes." And then it was a matter of working out the mechanics. I started working with an immigration lawyer—who was also helping her oldest daughter, Anna, who was living already in Los Angeles—trying to get her set up.

07-01:33:28
Eardley-Pryor: So one of Tatiana's daughters was already in California?

07-01:33:29
Bell: Yes. She came a year earlier.

07-01:33:33
Eardley-Pryor: That creates an easier incentive to make the move to the West Coast of North America.

07-01:33:35
Bell: Right. Yes, it helped a little bit. Right. And so I worked with the immigration lawyer, who himself was a Russian émigré. And so we decided that, you know, "Get her over here, but don't marry her right away," he said. "Yeah, I know you're in a hurry. Let a month go by, then get married." And we worked out all the paperwork that had to be filed to get this process started for her to get a green card. And so then we sat nervously for the better part of a year waiting for all of that to transpire.

07-01:34:10
Eardley-Pryor: Why not marry right away?

07-01:34:12
Bell: Oh, he thought that it would be too obvious the reason that she had come over. He didn't want to make it so obvious to the immigration people that she came over to get married—he wanted it to be plausible that she came over and then she met me and then we got married.

07-01:34:28
Eardley-Pryor: Huh. And that would somehow help the immigration process?

07-01:34:30
Bell: This was—yes—what he assumed.

07-01:34:33
Eardley-Pryor: So after you had found out from—the green card did get processed, she was able to get that?

07-01:34:37
Bell: Yes.

07-01:34:38
Eardley-Pryor: Is that when you got married officially?

07-01:34:42
Bell: Yes. Well, we had started laying the groundwork for this before she came over, so I sort of knew the process that we would go through. And then I went to a conference, yet again, in Moscow, and was there for part of a week. And we knew that she was going to come back with me. And so at the end of the week we threw ourselves a party in the very famous restaurant in the center of Moscow called the Aragvi. Aragvi is a river in Tbilisi, in Georgia. It's the main river that runs into the city—the city where my father was born. And it's the name of a Georgian restaurant. It's very famous because it was [Joseph] Stalin's favorite place to go with his Communist party buddies. And we managed to rent his personal dining room on the second floor.

07-01:35:41
Eardley-Pryor: Wow.

07-01:35:43
Bell: So it's a good-sized room—maybe one and a half times the size of this room. Near the ceiling is a frieze with very stylized bulls and these heroic men and women wrestling with the bulls, and people playing musical instruments. And then there's this tiny door with a balcony. So we opened that up, and you can go out and look down on the main dining room. The story is that Stalin liked to go out on that little balcony and see who's here from the party and who's sitting with whom.

07-01:36:18
Eardley-Pryor: Ah, keeping tabs.

07-01:36:18
Bell: Yes, so he could keep tabs on the people. So we had a wonderful dinner there.

07-01:36:25
Eardley-Pryor: That sounds like a neat space to have the celebration.

07-01:36:26
Bell: It was a neat space. Twenty people. We brought the wine—we bought Georgian wines in Moscow from a wine dealer. As is the tradition, she asked one of her classmates, who was also from the institute—a director at the institute—to be the *tamada*, which means the toastmaster in Georgian. And so he started going around the table, and he would designate who's next, and each person had to propose a toast and drink to our health. And so we did that, and we finally came to a fellow named Gennady Panov, who looks a little bit like [Anton] Chekov—he has a little beard here, and is somewhat retiring. And he said, "Well, okay. I'm gonna tell you a story, and then a toast." And so I'm going to translate this for you.

07-01:37:32
He said, "Well, there was a village, and in the village there was a couple who had a very beautiful daughter who was turning eighteen. And the father decided he needed to talk with the girl, so he invited the girl to talk with him. And he said, 'Look, daughter. I know you're turning eighteen. You're very attractive. Very soon, young men will come courting and want to take you out. And they'll say wonderful things to you; they'll take you for a walk; they'll buy you flowers, bring you candy. That's all wonderful,' he said. 'But beware that men are after something else. And be careful—by all means. You don't want to shame your family, yourself, your whole extended family.' The daughter says, 'Daddy, thanks. I understand.' So a month later she comes back and says, 'Dad, you were perfectly right. There is a young man. He came around and he took me out on walks and he bought me flowers and he brought me candy and he said all sorts of sweet things.' She said, 'But dad, don't be worried. I threw myself on *him*, and I shamed *his* family and *his* whole extended family and him before he had a chance to do anything to *me*!'"

So the moral of the story is, he wanted us to throw ourselves at each other and shame each other. The table just broke out laughing.

07-01:39:04
Eardley-Pryor: Cheers to that.

07-01:39:05
Bell: Yes. And everybody drank up.

07-01:39:08
Eardley-Pryor: That sounds like an awesome night.

07-01:39:09
Bell: So we see him—he's just retired and moved to live with his daughter outside of Seattle.

07-01:39:16
Eardley-Pryor: Oh, lovely. He's here in North America?

07-01:39:18
Bell: Yes, and we just talked to him last weekend by Skype.

07-01:39:22
Eardley-Pryor: Oh, that's great.

07-01:39:22
Bell: Yes. And we continued talking with him and his wife by Skype, even when they were living in Russia. So it's a good story.

07-01:39:31
Eardley-Pryor: Being mindful of time here—I know that you have a meeting to get to—I do want to hear another story. We can't revisit all these wonderful travels you and Tatiana have had—these global, international travels, including back in Russia. But speaking of marriage, I understand your wedding ceremony was a civil ceremony in Reno, Nevada.

07-01:39:50
Bell: That's right.

07-01:39:51
Eardley-Pryor: Around 2003 or so?

07-01:39:53
Bell: That's right.

07-01:39:54
Eardley-Pryor: But just last year [2018], on one of these travels to Armenia, there was another ceremony that you shared. Can you tell the story of that?

07-01:40:00
Bell: Yes, sure. So I had always wanted to go to the Caucasus, where my parents were from, and particularly to Georgia, where my dad was from. We had had a chance to do that once before, but this time, in 2018, the friend of ours, Gregorii Karapetyan, offered to meet us in Russia, in Armavir, which is the city where my mother was born, and then drive with us to Vladikavkaz, which is a city right on the border of the Caucasus Mountains; drive us over the mountains to Tbilisi, the capital of Georgia; and then a week later, after we had stayed in Tbilisi and enjoyed the sights, he'd meet us in Yerevan, the capital of Armenia. So Tatiana started to think about this trip, and she said, "Well, would it be possible for me to be christened and then to have a church wedding? I'd like to be wedded to you in a church."

07-01:41:10
Eardley-Pryor: She had always wanted a church wedding?

07-01:41:11
Bell: Yes. She always wanted a church wedding. She had never had one. And she had this notion that if we had a church wedding, after each of us passed on, it would be guaranteed that we would meet in heaven.

07-01:41:27
Eardley-Pryor: That's beautiful.

07-01:41:28
Bell: So I said, "Okay, let's see if we can do this." So with Gregorii's help—we refer to him as Saint Gregory, because he helped us in all these ways—she got christened on a Saturday, and on Sunday we had a church wedding.

07-01:41:47
Eardley-Pryor: And where did the wedding take place?

07-01:41:48
Bell: The wedding took place in the Armenian Apostolic Church in Armavir, which turns out to be the same church where my mother had been christened in 1902, when she was born.

07-01:42:00
Eardley-Pryor: Wow.

07-01:42:01
Bell: And it's a church that my relatives from her side had attended, because if you walk around the church, there are gravestones with their names on them. So it's part of the family heritage.

07-01:42:13
Eardley-Pryor: So the same building where your mother was christened over a century earlier—

07-01:42:16
Bell: That's right, a century earlier.

07-01:42:18
Eardley-Pryor: —Tatiana gets christened; and you share your wedding ceremony, renew your vows?

07-01:42:20
Bell: Right, right. So this was a wonderful experience. And then we drove over the mountains. We spent a wonderful week in Georgia with people we had met before. Let's see, the name of the woman is Katya Bogdanova. She's Georgian, and—she's in her sixties—has a wonderful sense of Georgian history and how it relates to Russian history, and she's a walking encyclopedia. We became very close friends with her. So she walked us around the city and showed us the area where my father's father had had his business and his house. Unfortunately, it no longer stands, but we found the street. She showed us many other famous places, and we had nice dinner meetings with her and visited some places outside of the city.

07-01:43:24

Then we went by taxi from that capital to the next capital, south—had a wonderful week in Yerevan. And there, Tatiana and I became the godparents of our friend, for his two teenage daughters, fifteen and thirteen. So another church ceremony in Echmiadzin, which is the center of the Armenian Church. And the bishop there performed the ceremony, which was very unusual—he doesn't usually get down to that level of activity. So, a wonderful day. One more day in the city, and now it's time to start heading home. And the same evening that we're planning to go and start heading home, we had set up a dinner party for our Russian host, who is now in Armenia—Armenian heritage—Karapetyan, another gentleman whom we had met who was there too; and Artsvi Bakhchinyan, who was the Armenian fellow who had written the story about my mother's ballet background.

07-01:44:47

All right. So, packing up, getting ready to go to dinner, I decide to look at the flight schedule to see if our flight on the small Turkish airline from Yerevan to Istanbul is on schedule. I can't find it in Flight Tracker. So I look and look and look. I find a flight with the same number the next day, but this doesn't seem right. So we go downstairs. I start to be interviewed for my experiences in Armenia; Tatiana goes to the front desk, finds out that the flight has been cancelled, and it is indeed flying Sunday, not Saturday morning. So now there's a big panic, because we have to connect in Istanbul to a business class flight back to the States. So with the help of our friends, three cell phones, running back to get my passport to—have to give that information—we manage to buy a ticket from Tbilisi to Istanbul and hire a car to take us overnight between Yerevan to Tbilisi.

07-01:45:57

Okay. Well, to make a long story short, there's this horrendous trip in the nighttime, when it's raining, it's dark, no illumination on the road, and the road's full of potholes—the driver's afraid to break an axle. But what is it, six or eight hours later, we finally get to the airport.

07-01:46:18

Eardley-Pryor: I imagine you haven't slept on this cross-mountain journey.

07-01:46:20

Bell: We didn't sleep. I just catnapped in the front seat. Get there, get on the airline, and everything's fine. Good flight—except we're not going to the airport where our flight to the US is going to depart. There's Atatürk Airport, which is the main one in Istanbul, and there's another, smaller one thirty kilometers away.

So this is supposed to be about a $40 cab ride. A guy, as we come out bleary-eyed and not quite knowing what to do next, comes running over and says, "I'm the equivalent of a Turkish Uber driver, and I will take you to the other airport." "Fine, thank you. How much will it cost?" He told me a price and I said, "Well, I don't have enough lira—Turkish money. Let me go to the ATM." "Oh, no, no. Don't bother with that. The exchange rate is too high. I'll take you to a gas station; you'll get a much better rate."

07-01:47:13

So we get in his car, start driving, and he's driving very rapidly. And I'm seeing Turkish road signs, nothing in English. I can't tell where the hell I am, but it certainly doesn't feel like I'm going to Istanbul. Eventually we pull into a gas station and he says, "Here's the ATM." It's all in Turkish, of course. I don't understand it. I had forgotten what the exchange rate is. He puts in a number and the ATM refuses it, because he's exceeded the limit on my card. So we went down and he got to just the limit, which was, I think, two hundred bucks, got the money, and he took it. We drive into Istanbul and he says, "Well, I can't take you to the airport, because I'm not licensed to go into the airport."

07-01:48:00
Eardley-Pryor: After all that?!

07-01:48:00
Bell: After all that. "You'll have to take a cab." All right. We get out, he flags a cab, and he says, "That'll be another $100." I said, "No, no. You told me it was gonna be $100 overall, and I don't have any more money, so that's it, buddy." He gets angry with me, and Tatiana's getting really upset. So we put our luggage in the cab and I wave at him—you know, get lost, basically. And it's only later that I realized that not only did I pay $100, but I paid another $100 over that, because he had taken out as much money as he could on my card. But—

07-01:48:40
Eardley-Pryor: Did you make the flight, though?

07-01:48:41
Bell: But we made the flight. So this was a small price to pay, yes.

07-01:48:46
Eardley-Pryor: What a wild week.

07-01:48:47
Bell: But it was a wild weekend, yes.

07-01:48:49
Eardley-Pryor: And a crazy end to what sounded like a wonderful experience.

07-01:48:52
Bell: It was a wonderful trip, yes. A wonderful trip. Wonderful people that we met everywhere. Yes. And it was great to go back and see these people.

07-01:49:01
Eardley-Pryor: Yeah. Well, I love the story of how your experience in Armenia ties together your family history in such a way to the present. I mean, that's just a beautiful.

07-01:49:11
Bell: Right. Yes, so it closes the circle completely. Yes.

07-01:49:14
Eardley-Pryor: That's great. Well, closing the circle, this is the final session of your oral history. Are there any parting thoughts that you'd like to share at the end—thinking about legacy, thinking about your accomplishments, thinking about what you might wish to accomplish still?

07-01:49:31
Bell: Yes. So I consider myself very fortunate to have spent my career here at Berkeley. It was by brute luck and awkwardness that I got to be here, as I told you early on in this story. But people have been very kind and accommodating and received me with open arms here. I've enjoyed wonderful relationships with all of my colleagues. I've had an opportunity to be an academic leader in administration, have been fortunate to have very good people to work with in that capacity. And so it's a real privilege.

It's also been a wonderful opportunity—this fifty-plus years—to do exciting science with very bright young people, and I continue to attract good young men and women. And it's just a thrill. And I look forward to continuing to do that for at least the next several more years.

It's also been a life experience of all these things that have happened to me outside of the university with my private life, of the ups and downs, maintaining perspective and balance, learning how to get off the floor when I'm knocked down and not get knocked out. And so I've shared that with friends; I share that with my spouse; and I hope we all learn from that.

07-01:51:09
Eardley-Pryor: I have learned a ton from your stories that you've shared here, and I just want to say it's been such a privilege. Thank you very much.

07-01:51:15
Bell: Well, thank you, Roger. It's been great fun working with you.

07-01:51:17
Eardley-Pryor: Thank you, Alex.

07-01:51:18
Bell: Yes.

[End of Interview]

Appendix A: Supplemental documents

Curriculum Vitae

Alexis T. Bell

Department of Chemical and Biomolecular Engineering
University of California, Berkeley
Berkeley, CA 94720-1462
Voice: 510-642-1536 Fax: 510-642-4778
bell@cchem.berkeley.edu

Professional Preparation
B.S., Chemical Engineering, Mass. Inst. of Tech., Cambridge, Massachusetts, 1964
Sc.D., Chemical Engineering, Mass. Inst. of Tech., Cambridge, Massachusetts, 1967

Appointments
Academic Appointments
Assistant Professor of Chemical Engineering, UC Berkeley, 1967–1973
Associate Professor of Chemical Engineering, UC Berkeley, 1973–1976
Professor of Chemical Engineering, UC Berkeley, 1976–present
Principal Investigator, Chemical Sciences Division, Lawrence Berkeley National Laboratory, 1975–present
Assistant Dean, College of Chemistry, UC Berkeley, 1979–1981
Chairman, Department of Chemical Engineering, UC Berkeley, 1981–1991; 2005–2006
Dean, College of Chemistry, UC Berkeley, 1994–1999
Theodore Vermeulen Professor of Chemical Engineering, 2007–2009
Dow Professor of Sustainable Chemistry, 2009–

Editorial Duties
Editor in Chief, Chemical Engineering Science, 2006–2011
Editor in Chief, Catalysis Reviews - Science and Engineering, 1985–
Editor, Proceedings of the National Academy of Sciences, 2011–
Regional Editor, Particuology, 2014–
Member, Editorial Advisory Board, Journal of Physical Chemistry A/B/C, 2016–

Honors and Awards
(items in **bold** highlighted by Dr. Bell)
R.A. Glenn Award for best paper, Fuel Division, American Chemical Society, 1978; Curtis W. McGraw Award for Research, American Association of Engineering Education, 1981; Professional Progress Award, American Institute of Chemical Engineers, 1983; Donald L. Katz Lecturer, Department of Chemical Engineering, University of Michigan, 1984; Paul H. Emmett Award in Fundamental Catalysis, The Catalysis Society, 1985; **Elected to the National Academy of Engineering, 1987**; Elected Fellow of the American Association for the Advancement of Science, 1988; B.F. Dodge Lecturer, Department of Chemical Engineering, Yale University, 1988; Langmuir Lecturer, Colloid and Surface Chemistry Division, American Chemical Society, 1992; R. H. Wilhelm Award in Chemical Reaction Engineering, American Institute of Chemical Engineers, 1992; Reilly Lecturer, Department of Chemical Engineering, Department of Chemical Engineering, University of Notre Dame, 1994; Fellow, Japan Society for the Promotion of Science,

1994; Hoyt Hottel Lecturer, Department of Chemical Engineering, Massachusetts Institute of Technology, 1994; Shell Visiting Fellow, Department of Chemical Engineering, Cambridge University, 1997; Brdička Lecturer, J. Heyrovsky Institute, Prague, Czech Republic, 2000; L. K. Doraiswamy Lecturer, Department of Chemical Engineering Iowa State University and National Chemical Laboratory, Pune, India, 2000; ACS Award for Creative Research in Homogeneous or Heterogeneous Catalysis, 2001; Award for Excellence in Academic Research, Northern California Section of AIChE, 2001; Louis Pirkey Lecture, Department of Chemical Engineering, University of Texas, Austin, TX, 2002; William J. Lowerie Lectures, Department of Chemical Engineering, Ohio State University, Columbus, OH, 2002; **Honorary Professor, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia, 2002**; Merck-Sponsored Distinguished Lecturer in Chemical and Biochemical Engineering, Department of Chemical and Biochemical Engineering, Rutgers University, Piscataway, NJ, 2003; Robert Burwell Lecturer, North American Catalysis Society, 2003; Warren McCabe Lecturer, Department of Chemical Engineering, North Carolina State University, Raleigh, NC, 2004; Kelly Lecturer, Department of Chemical Engineering, Purdue University, West Lafayette, IN, 2005; AIChE William H. Walker Award for Contributions to the Chemical Engineering Literature, 2005; Michel Boudart Award for the Advancement of Catalysis given by the North American Catalysis Society and the European Federation of Catalysis Societies, 2007; Giuseppe Paravanno Award for Excellence in Research in Catalysis, given by the Michigan Catalysis Society, 2007; **elected member of the American Academy of Arts and Sciences, 2007**; **identified as one of the "One Hundred Engineers of the Modern Era" by AIChE, 2008**; **elected member of the National Academy of Sciences, 2010;** Distinguished Lecturer, University of Utah, 2012; Cornelius Pings Lecturer; University of Southern California, 2012; Plenary Lecturer, International Congress on Catalysis, Munich Germany, 2012; ACS George A. Olah Award for Research in Hydrocarbon or Petroleum Chemistry, 2013; Harry Fair Memorial Lecturer, School of Chemical, Biological, and Materials Engineering, The University of Oklahoma, 2013; inaugural Olaf A. Hougen Lecturer, Department of Chemical and Biological Chemistry, University of Wisconsin, 2013; **Selected by the Chinese Academy of Science as an Einstein Professor, one of 20 such chosen from all areas of science internationally, 2013**; Robert L. Pigford Lecturer, Department of Chemical and Biomolecular Engineering, University of Delaware, 2014; Richard S. Mah Lecturer, Department of Chemical and Biological Engineering, Northwestern University; Vladimir Ipatieff Lecturer, Department of Chemistry, Northwestern University, 2014; Izatt-Christensen Lecturer, Chemical Engineering Department, Brigham Young University, 2015; Palke Lecturer, Department of Chemistry and Biochemistry, University of California, Santa Barbara, 2015; Blue/Green Lecturer, Chemical Engineering Department, University of Michigan, 2015; **Awarded an Honorary Professorship of the Boreskov Institute of Catalysis, 2018**; North American Catalysis Society Award for Distinguished Service in the Advancement of Catalysis, 2018; elected a foreign member of the **Russian Academy of Sciences, 2019**.

Publications
Over 740 publications on various aspects of heterogeneous catalysis and chemical reaction engineering. H index = 123 and 64,467 citations according to Google Scholar.

Alexis T. Bell graduate students and post-doctoral researchers, 1972–2019

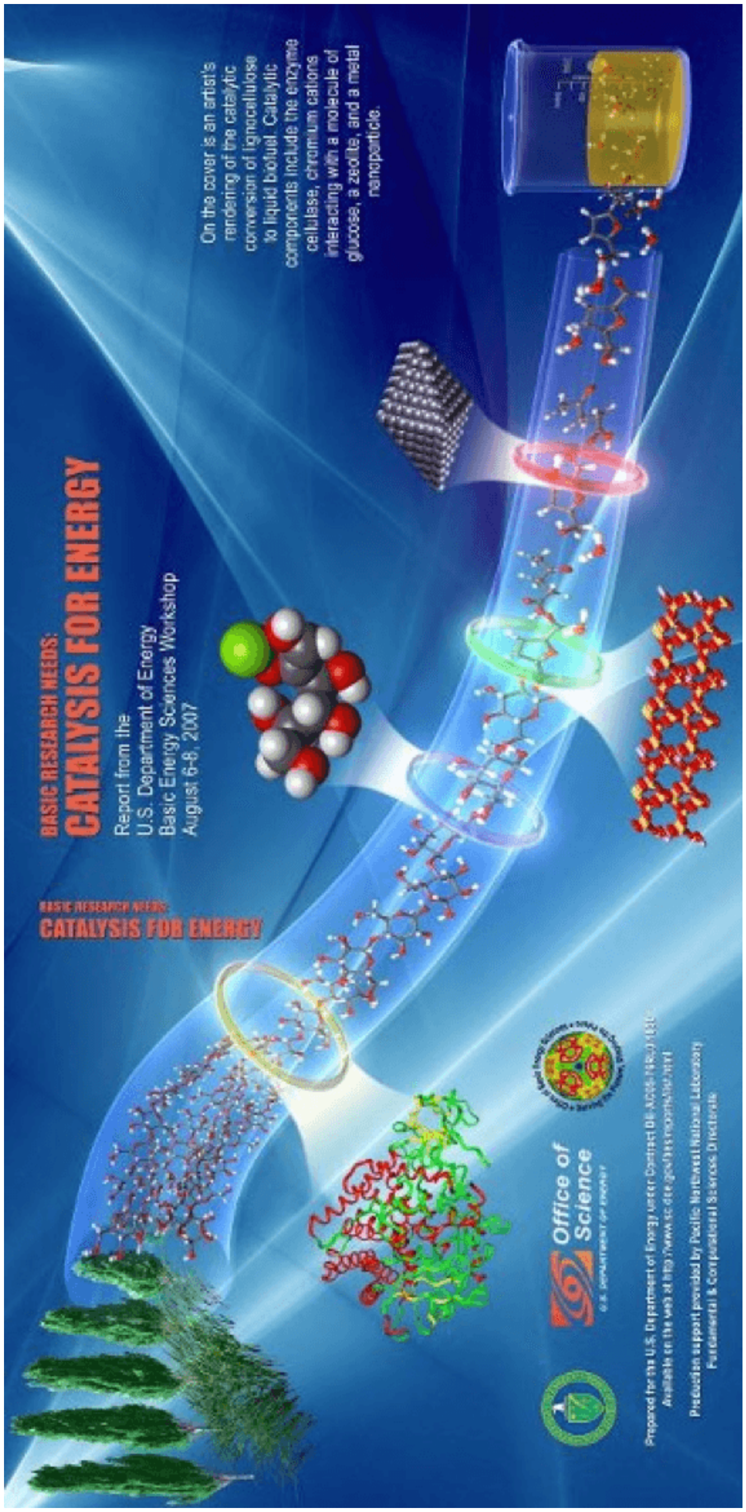
Name	*Degree*	*Year*
Mr. Kam H. Kwong	MS	1972
Dr. Jack W. London	PHD	1972
Dr. Lloyd C. Brown	PHD	1973
Dr. Kim D. Colter, M.D.	MS	1974
Dr. Hiroaki Kobayashi	PHD	1974
Dr. Terry A. Ring	MS	1974
Mr. Keith M. Conklin	MS	1975
Dr. Edwin L. Force	PHD	1975
Mr. Charles N. Ludvik	MS	1975
Dr. Pasupati Sadhukhan	PHD	1975
Mr. Wayne A. Bollinger	MS	1976
Mr. Dragutin Peric	MS	1976
Mr. Thomas A. Ries	MS	1976
Mr. Michael J. Veraa	MS	1976
Mr. Paul V. Hinman	MS	1977
Dr. D'Arcy H. Lorimer	PHD	1978
Mr. Gordon G. Low	MS	1978
Mr. Kylan I. Tanner	MS	1978
Mr. Minoru Uchida	MS	1978
Mr. John W. Vinzant	MS	1978
Dr. John G. Ekerdt	PHD	1979
Mr. Shamim A. Gandhi	MS	1979
Mr. David R. Johnson	MS	1979
Mr. Newell D. Taylor	MS	1979
Mr. Peter D. Buzzard	MS	1980
Mr. William G. McKee	MS	1980
Dr. David P. Mobley	PHD	1980
Mr. Edward C. Myers	MS	1980
Mr. Abdelkrim Salhi	MA	1980
Dr. Sadie S. Salim	PHD	1980
Dr. Ronald J. Jensen	PHD	1981
Dr. Carl S. Kellner	PHD	1981
Dr. Bruce Savatsky	PHD	1981
Mr. James A. Baker	MS	1982
Mr. Arthur A. Chin	MS	1982
Dr. Timothy J. Frederick	PHD	1982
Dr. William C. Hecker	PHD	1982
Mr. Gurdeep S. Ranhotra	MS	1983
Dr. William J. Cannella	PHD	1984
Dr. Ronald A. Dictor	PHD	1984

Dr. Robert F. Hicks	PHD	1984
Dr. James A. Klein	PHD	1984
Dr. Charles W. Paul	PHD	1984
Dr. David Stern	PHD	1984
Dr. Philip Winslow	PHD	1984
Dr. Nutan K. Pande	PHD	1985
Dr. Mark G. Reichmann	PHD	1986
Dr. Jeffery S. Rieck	PHD	1986
Dr. Richard P. Underwood	PHD	1986
Dr. Deborah S. Jordan	PHD	1987
Dr. Marc E. Levin	PHD	1987
Dr. Alon V. McCormick	PHD	1987
Dr. Grant H. Yokomizo	PHD	1988
Mrs. Judith B. Bourzutschky	MS	1989
Dr. Stephen J. Lombardo	PHD	1990
Dr. Richard R. Rosin	PHD	1990
Dr. Raymond L. June	PHD	1991
Mr. Kenneth S. Lee	MS	1991
Dr. Gregory T. Went	PHD	1991
Dr. Kevin J. Williams	PHD	1991
Dr. Phillip A. Armstrong	PHD	1992
Dr. Janet M. Griffiths	PHD	1992
Dr. Kamala R. Krishna	PHD	1992
Colonel Robert F. Mortlock, PhD	PHD	1992
Mr. Mark J. Sandoval	MS	1992
Dr. Laura J. Dietsche	PHD	1993
Dr. David M. Ginter	Pdoc	1993
Mr. Nicholas P. Kenaston	MS	1993
Dr. Dong-Keun Lee	Pdoc	1993
Mr. Rusty M. Pittman	MS	1993
Dr. Jingly Fung	Pdoc	1993
Dr. Dean B. Clarke	PHD	1994
Dr. Christophe David	MS	1994
Dr. Randall Q. Snurr	PHD	1994
Dr. Geoffrey M. Wise	PHD (co)	1994
Dr. Reha M. Bafrali	PHD	1995
Dr. Craig S. Gittleman	PHD	1995
Dr. Sarah C. Larsen	Pdoc	1995
Mr. Edward J. Maginn	PHD (co)	1995
Mr. Arif Qureshi	MS	1996
Dr. Bernhardt L. Trout II	PHD	1996
Dr. Hee Chul Woo	Pdoc	1996
Dr. Adam W. Aylor	PHD	1997

Dr. Jason N. Carstens	PHD	1997
Dr. Stephen Su	PHD	1997
Dr. Marc-Olivier Coppens	Pdoc	1998
Dr. Ian A. Fisher	PHD	1998
Dr. Lisa J. Lobree	PHD	1998
Mr. Bryan Olthof	MS	1998
Mr. Tobin C. Schilke	MS	1998
Ms. Jun Yang	MS	1998
Dr. Mark J. Rice	PHD	1999
Dr. Douglas Shephard	Pdoc	2000
Dr. Shuibo Xie	Pdoc	2000
Dr. Kaidong Chen	Pdoc	2001
Dr. Kwang Deog Jung	Pdoc	2001
Dr. Kyeong Taek Jung	Pdoc	2001
Dr. Chanho Pak	Pdoc	2001
Mr. Larry J. Chen	MS	2002
Dr. Sun Hee Choi	Pdoc	2002
Dr. Chika Nozaki	Pdoc	2002
Dr. Morris D. Argyle	PHD	2003
Dr. Hong Xing Dai	Pdoc	2003
Dr. Wan Zhen Liang	Pdoc	2003
Dr. Jason A. Ryder	PHD	2003
Dr. Benjamin R. Wood	PHD	2003
Dr. Andrew W. Holland	Pdoc	2004
Dr. Baron G. Peters	PHD	2004
Dr. Michael D. Rhodes	PHD	2004
Dr. Sudip Mukhopadhyay	Pdoc	2004
Dr. Owen Evans	Pdoc	2004
Dr. Ian J. Drake	PHD	2005
Dr. Dmitry Karshtedt	PHD	2005
Dr. Nicholas L. Ohler	PHD	2005
Dr. Shuwu Yang	Pdoc	2006
Dr. Shaji Chempath	Pdoc	2006
Dr. David A. Durkee	PHD	2006
Mr. Guangtao Li	MS	2006
Dr. Konstantin A. Pokrovski	PHD	2006
Dr. Amber Stephenson	PHD	2006
Dr. Mark T. Zerella	PHD	2006
Dr. Jason L. Bronkema	PHD	2007
Dr. Rustam Z. E. Khaliullin	PHD	2007
Dr. Evan Rumberger	Pdoc	2007
Dr. Yihua Zhang	Pdoc	2007
Dr. Xiaobo Zheng	Pdoc	2007

Dr. Beata Kilos	Pdoc	2008
Dr. Ting Chen	Pdoc	2009
Dr. Arthur Esswein	Pdoc	2009
Dr. Vladimir Galvita	Pdoc	2009
Dr. Anthony J. Goodrow	PHD	2009
Dr. Joseph J. Zakzeski	PHD	2009
Mr. Michael Zboray	MS	2009
Dr. Daniel Neal Briggs	PHD	2010
Dr. Fuat E. Celik	PHD	2010
Dr. Tae Jin Kim	Pdoc	2010
Mr. Georges G. Siddiqi	MS	2010
Dr. Jennifer Strunk	Pdoc	2010
Dr. Pingping Sun	Pdoc	2010
Dr. Chidambaram Mandan	Pdoc	2010
Dr. Andrew Behn	PHD	2011
Dr. Arne Dinse	Pdoc	2011
Dr. Anastasia Grigorieva	Pdoc	2011
Dr. Ferenc Somodi	Pdoc	2011
Dr. William Vining	PHD	2011
Dr. Sean Dee	PHD	2012
Dr. Sasisanker Padmanabhan	Pdoc	2012
Dr. Vladimir Shapovalov	Pdoc	2012
Dr. Paul Zimmerman	Pdoc	2012
Dr. Zhenmeng Peng	Pdoc	2012
Dr. Boon Siang Jason Yeo	Pdoc	2012
Dr. Evan M. W. Rumberger	Pdoc	2013
Dr. Andrew "Bean" Getsoian	PHD	2013
Dr. Sebastian Werner	Pdoc	2013
Dr. Michal Bajdich	Pdoc	2013
Dr. Anton Mlinar	PHD	2013
Dr. David Hanna	PHD	2014
Dr. Zhang Zhai	PHD	2014
Dr. Marie Louie	Pdoc	2014
Dr. Krsitopher Enslow	PHD	2014
Dr. Yun Cai	Pdoc	2014
Dr. Shannon Klaus	PHD	2015
Dr. Lena Trotochaud	Pdoc	2015
Dr. Gregory Johnson	PHD	2015
Dr. Jason Wu	PHD	2015
Dr. Balakrishnan Madhesan	Pdoc	2015
Dr. Eric Sacia	PHD	2015
Dr. Diana C. Tranca	Pdoc	2015
Dr. Amber Janda	PHD	2015

Dr. Joeseph Gomes	PHD	2015
Dr. Andreas Hauser	Pdoc	2015
Dr. Mu-Jeng Cheng	Pdoc	2016
Dr. James Dombrowski	PHD	2016
Dr. Shaama Sharada	PHD	2016
Dr. Rachel Licht	PHD	2016
Ms. Alice Ye	MS	2016
Dr. Shaama Sharada	PHD	2016
Dr. Ying Lin Louie	PHD	2016
Dr. Youngkook Kwan	Pdoc	2016
Dr.Yi-Pei Li	PHD	2016
Mr. John Howell	MS	2016
Dr. Meenesh Singh	Pdoc	2016
Dr. Jason Goodpaster	Pdoc	2016
Dr. David Sranko	Pdoc	2016
Dr. Sankaranaryana Shylesh	Pdoc	2017
Dr. Alexander Wang	PHD	2017
Dr. Deepak Jadhav	Pdoc	2017
Dr. Joaquin Resasco	PhD	2017
Dr. Alejandro Garza	Pdoc	2018
Dr. Ezra Clark	PHD	2018
Dr. Neelay Phadke	PHD	2018
Dr. Julie Rorrer	PHD	2019
Dr. Christianna Lininger	Pdoc	2019



Cover art for *Catalysis for Energy*, a report from the US Department of Energy's Basic Energy Sciences Workshop, held August 6–8, 2017, and edited by Alexis Bell and Bruce Gates. Dr. Bell conceived of this cover art, which depicts the catalytic conversion of lignocellulose to liquid biofuel. The catalytic components include the enzyme cellulose, chromium cations interacting with a molecule of glucose, a zeolite, and a metal nanoparticle.

UNIVERSITY OF CALIFORNIA, BERKELEY

BERKELEY • DAVIS • IRVINE • LOS ANGELES • MERCED • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

Alexis T. Bell
Professor of Chemical Engineering
Dow Professor of Sustainable Chemistry
DEPARTMENT OF CHEMICAL & BIOMOLECULAR ENGINEERING
BERKELEY, CALIFORNIA 94720-1462
TEL: (510) 642-1536
FAX: (510) 642-4778
e-mail: bell@cchem.berkeley.edu

March 15, 2016

NICHOLAS DIRKS, CHANCELLOR
CLAUDE STEELE, EXECUTIVE VICE CHANCELLOR AND PROVOST
Office of the Chancellor
University of California, Berkeley
200 California Hall # 1500
Berkeley, CA 94720-1500

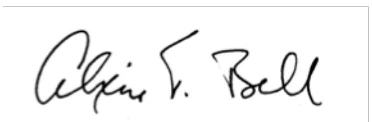
Dear Chancellor Dirks and Executive Vice Chancellor and Provost Steele:

We are writing to express our deepest concern with the proposal to disestablish the College of Chemistry. The cost-savings resulting from this action are likely to be very small relative to the size of the campus deficit, especially if we take into account that the College of Letters and Science and the College of Engineering would require additional staff to administer the large research programs of the two departments of the College of Chemistry. We firmly believe that the likely damage to the reputation and function of the Departments of Chemistry and Chemical and Biomolecular Engineering would be devastating.

The College of Chemistry, in existence since 1872, is regarded today as the preeminent academic unit in the world devoted to teaching and research in chemical sciences and technology. The internationally recognized distinction of the College faculty is reflected in its record numbers of Nobel Laureates, recipients of the National Medal of Science, and members of the National Academy of Sciences, the National Academy of Engineering, and the American Academy of Arts and Sciences. Both departments comprising the College are top-ranked in national and international evaluations. Because of the excellence of its faculty and their pioneering research, the College of Chemistry has been consistently successful in attracting top students from California, as well as from other states and nations, and it is one of the first destinations of recent doctoral graduates seeking postdoctoral research. The outstanding reputation of the College also makes it possible for both departments to attract the world's best scholars to its faculty and compete thereby with top private universities, including MIT, Harvard, Columbia, Cornell, Princeton, Stanford and Caltech. In short, the College of Chemistry has established its brand as the best of its kind in the chemical sciences in the world.

We urge you to rule out the possibility of changing the current configuration of the College. Based on conversations with colleagues here and at other institutions, we sense a very real danger that transferring the two departments comprising the College to two other Colleges would seriously damage the unique prominence of both departments and would make Berkeley significantly less appealing for future students and faculty recruits. We also foresee the very real possibility of a significant number of mid-career faculty members moving to other institutions. Retaining faculty members against "raids" by other leading universities is a costly and risky enterprise that would in all likelihood quickly overwhelm any possible saving envisioned by a reduction in the size of the administrative staff. We also note that many faculty members in both departments already collaborate extensively with colleagues in other Colleges on campus and have played leading roles in major initiatives (QB3, EBI, JBEI, JCAP). Thus, the notion that realignment would foster latent opportunities for new intellectual interactions is, in our view, unfounded. On the contrary, by placing Chemistry in the College of Letters and Science, and Chemical and Biomolecular Engineering in the College of Engineering, there will be an administrative impediment to the numerous joint research programs that are staffed by faculty and students from both College of Chemistry departments.

In summary, we call to your attention that you recognize the likely damage that would ensue from disestablishing the College of Chemistry and that instead, you work with Dean Douglas Clark and faculty members of the College to enhance the efficiency and effectiveness of its service to the University, the State, and the nation. We are confident that working as a team we can address the structural deficit of the campus in creative ways that will ultimately contribute to further strengthening the University. We stand ready to participate and to help in any way that we can.



Alexis T. Bell
Professor, Chemical & Biomolecular Engineering

Carlo Alesandrini
Lecturer, Chemical & Biomolecular Engineering

Keith Alexander
Adjunct Professor, Chemical & Biomolecular Engineering

Richard Andersen
Professor, Chemistry

John Arnold
Professor, Chemistry

Nitash Balsara
Professor, Chemical & Biomolecular Engineering

Anne Baranger
Adjunct Professor, Chemistry

Paul Bartlett
Professor Emeritus, Chemistry

Robert Bergman
Professor, Chemistry

Harvey Blanch
Professor Emeritus, Chemical & Biomolecular Engineering

Kristie Boering
Professor, Chemistry, Earth and Planetary Sciences

Carlos Bustamante
Professor, Physics, Chemistry, Molecular & Cell Biology

Elton Cairns
Professor of the Graduate School, Chemical & Biomolecular Engineering

Jamie Cate
Professor, Molecular & Cell Biology, Chemistry

Joseph Cerny
Professor of the Graduate School, Chemistry

Colin Cerretani
Lecturer, Chemical & Biomolecular Engineering

David Chandler
Professor of the Graduate School, Chemistry

Christopher Chang
Professor, Chemistry, Molecular & Cell Biology

Michelle Chang
Associate Professor, Chemistry, Molecular & Cell Biology

Shannon Ciston
Lecturer, Chemical & Biomolecular Engineering

Douglas Clark
Professor, Chemical & Biomolecular Engineering

Ronald Cohen
Professor, Chemistry, Earth & Planetary Sciences

Jennifer Doudna
Professor, Molecular & Cell Biology, Chemistry

Michelle Douskey
Continuing Lecturer, Chemistry

Danielle Ercek
Assistant Professor, Chemical & Biomolecular Engineering

Felix Fischer
Assistant Professor, Chemistry

Graham Fleming
Professor, Chemistry

Matthew Francis
Professor, Chemistry

Phillip Geissler
Professor, Chemistry

Naomi Ginsberg
Assistant Professor, Chemistry, Physics

Simon Goren
Professor Emeritus, Chemical & Biomolecular Engineering

David Graves
Professor, Chemical & Biomolecular Engineering

Jay Groves
Professor, Chemistry

Charles Harris
Professor of the Graduate School, Chemistry

Robert Harris
Professor of the Graduate School, Chemistry

John Hartwig
Professor, Chemistry

Martin Head-Gordon
Professor, Chemistry

Teresa Head-Gordon
Professor, Chemistry, Bioengineering, Chemical & Biomolecular Engineering

John Hearst
Professor Emeritus, Chemistry

Clayton Heathcock
Professor Emeritus, Chemistry

Darleane Hoffman
Professor Emerita, Chemistry

Enrique Iglesia
Professor, Chemical & Biomolecular Engineering

Alexander Katz
Professor, Chemical & Biomolecular Engineering

Jay Keasling
Professor, Chemical & Biomolecular Engineering, Bioengineering

Sung-Hou Kim
Professor of the Graduate School, Chemistry

C. Judson King
Professor Emeritus, Chemical & Biomolecular Engineering

Jack Kirsch
Professor of the Graduate School, Chemistry, Molecular and Cell Biology

Judith Klinman
Professor of the Graduate School, Chemistry

Yuan Lee
Professor Emeritus, Chemistry

Stephen Leone
Professor, Chemistry, Physics

William Lester
Professor of the Graduate School, Chemistry

Jeffrey Long
Professor, Chemistry, Chemical & Biomolecular Engineering

Scott Lynn
Professor Emeritus, Chemical & Biomolecular Engineering

Thomas Maimone
Assistant Professor, Chemistry

Brian Maiorella
Adjunct Professor, Chemical & Biomolecular Engineering

Marcin Majda
Professor, Chemistry

Michael Marletta
Professor, Chemistry, Molecular & Cell Biology

Peter Marsden
Lecturer, Chemistry

Richard Mathies
Professor of the Graduate School, Chemistry

Bryan McCloskey
Assistant Professor, Chemical & Biomolecular Engineering

Ali Mesbah
Assistant Professor, Chemical & Biomolecular Engineering

William Miller
Professor of the Graduate School, Chemistry

Evan Miller
Assistant Professor, Chemistry, Molecular & Cell Biology

C. Bradley Moore
Professor Emeritus, Chemistry

Luciano Moretto
Professor, Chemistry

Rollie Myers
Professor Emeritus, Chemistry

Daniel Neumark
Professor, Chemistry

Eric Neuscamman
Assistant Professor, Chemistry

John Newman
Professor Emeritus, Chemical & Biomolecular Engineering

Steven Pedersen
Senior Continuing Lecturer, Chemistry

Norman Phillips
Professor Emeritus, Chemistry

Alexander Pines
Professor, Chemistry

John Prausnitz
Professor Emeritus, Chemical & Biomolecular Engineering

Eran Rabani
Professor, Chemistry

Clayton Radke
Professor, Chemical & Biomolecular Engineering

John Rasmussen
Professor Emeritus, Chemistry

Kenneth Raymond
Professor of the Graduate School, Chemistry

Jeffrey Reimer
Professor, Chemical & Biomolecular Engineering

Mary Ann Robak
Lecturer, Chemistry

Richmond Sarpong
Professor, Chemistry

Kenneth Sauer
Professor Emeritus, Chemistry

David Savage
Assistant Professor, Molecular and Cell Biology, Chemistry

Richard Saykally
Professor, Chemistry

David Schaffer
Professor, Chemical & Biomolecular Engineering, Bioengeinnering, Molecular and Cell Biology

Gregory Schoofs
Lecturer, Chemical & Biomolecular Engineering

Steven Sciamanna
Lecturer, Chemical & Biomolecular Engineering

Charles Shank
Professor Emeritus, Chemistry

Kevan Shokat
Professor, UCSF, Chemistry (UCB)

Berend Smit
Professor, Chemistry, Chemical & Biomolecular Engineering

Gabor Somorjai
Professor of the Graduate School, Chemistry

Andrew Streitwieser
Professor Emeritus, Chemistry

T. Don Tilley
Professor, Chemistry

Ignacio Tinoco
Professor of the Graduate School, Chemistry

Dean Toste
Professor, Chemistry

Ravindra Upadhye
Lecturer, Chemical & Biomolecular Engineering

Peter Vollhardt
Professor, Chemistry

David Wemmer
Professor, Chemistry

Marjorie Went
Lecturer, Chemical & Biomolecular Engineering

Birgitta Whaley
Professor, Chemistry

Evan Williams
Professor, Chemistry

Ke Xu
Assistant Professor, Chemistry

Ting Xu
Associate Professor, Materials Science & Engineering, Chemistry

Omar Yaghi
Professor, Chemistry

Peidong Yang
Professor, Chemistry, Materials Science & Engineering

Wenjun Zhang
Assistant Professor, Chemical & Biomolecular Engineering

Alexis T. Bell with his grandfather Aslan and uncle Henri Troyat

ARMENIA & KARABAKH ARTS AND CULTURE COMMUNITY

Prof. Alexis Bell: A Descendent of Circassian Armenians Visits Homeland

JULY 19, 2018

by **The Armenian Mirror-Spectator**

By Artsvi Bakhchinyan

Special to the Mirror-Spectator

YEREVAN — While working on my study "The Armenians in World Choreography Art" I learned that Olga Tarassova (1902-1982), the sister of famous French writer of Armenian origin Henri Troyat, was a ballet teacher in New York City. In 2009, through an online search, I succeeded in finding Tarassova's son, Alexis Tarassov Bell, a professor of chemical engineering at the University of California, Berkeley, and asked him to provide me information about his mother. Bell sent me biographical data and valuable photographs. In October 2011 while in San Francisco I had a chance to meet him in person and enjoy his and his Russian wife, Tatyana's, hospitality.

Bell was born in 1942 in New York City. He received his BS and ScD degrees from the Massachusetts Institute of Technology in 1964 and 1967, respectively. During the course of his career he has established himself as a leading scholar through his scientific contributions to the field of catalysis and chemical reaction engineering, in recognition of which he has received many professional awards and has been elected to the National Academy of Engineering (1987), the American Academy of Arts and Sciences (2007), and the National Academy of Science (2010). He has also been awarded an honorary professorship in the Siberian Branch of the Russian Academy of Sciences (2001) and an honorary professorship of the Broeskov Institute of Catalysis in Novosibirsk Russia (2018).

Alexis and Tatiana Bell

In early June of this year the Bells visited Armenia. This was their second trip to Armenia. My conversation with Alexis is about his ancestors and his links to the Armenians.

Artsvi Bakhchinyan: So, Alex, nice to meet you in Armenia. You are an established scholar, known in academic circles in the US, you teach in Russia, China and

other paces, but for the Armenians you are associated with your family roots going back to Armenia, more concretely – Tsghna village of Nakhijevan, now in territory of Azerbaijan. Your uncle Henri Troyat-Lev Tarasov was quite famous in Armenia; some of his novels have been translated into Armenian. You are a person of mixed background. Although the connections with the Armenian roots were not so close, however, what can you tell about it?

Alexis Bell: Most of what I know about my Armenian roots comes from speaking with my mother when I was a child. Her father's family came from the Circassian Armenians (Cherkesogays in Russian, gay is hay – Armenian) who lived in Caucasus mountains for centuries until the middle of 19th century, when they descended to what is today Armavir in Russia and helped in establishment of the city in 1839. My mother was born in Armavir, her parents were mixture of Circassian Armenians, Armenians from what is today Krasnodar, as well as some German, Georgian and Russian blood from my grandmother's side. We have seen Abesolomov house in Tbilisi: my grandmother Lidia was from that family. Going one generation back, my maternal grandfather Aslan and his wife spoke mainly Circassian, not Russian. In fact, my great-grandmother knew very little Russian. But they were part of Armenian church. By religion they were Armenians, by language — Circassians and Russians. This is the background through which I am related to the Armenian culture. My father, Vladimir Belsitzman, was born in Tbilisi in 1900 and grew up speaking Russian and Georgian. Both sides of his family were Jewish immigrants, who had moved to Georgia from Russia several generations earlier.

Artsvi Bakhchinyan: So we can say you have Caucasian roots. How they reflected on your personality?

Alexis Bell: I think it is expressed in my openness towards the people, a feeling of communality in Caucasian music and dance, certainly, with food, because I experienced it since my childhood, as my father was a very good cook. He liked to prepare both Caucasian and Russian dishes.

Artsvi Bakhchinyan: I know your mother was a parishioner of the Gregory Illuminator Armenian Apostolic church in New York City.

Alexis Bell: When I was born, mother had me christened in Armenian Church but I don't remember visiting that church more than on one occasion. When we did go to church that was not by insistence of my mother, but to celebrate Easter.

Artsvi Bakhchinyan: **What memories you have from your grandparents Aslan and Lydia?**

Alexis Bell: I remember my maternal grandparents very well. I first met them in 1945, when I was 3 years old, and then saw them subsequently every two to three years, when my mother and I visited France. My grandfather, Aslan, liked to tell stories about his life in Russia, about his house in Moscow on the corner of Skatertnaja i Medvezhii pereulok, and raising horses, some of which he sold to the czarist army. He even remembered the names of the horses that he himself owned. One consequence of grandfather's love of horses was that my mother became an avid horsewoman in her early teens and rode until the family left Russia. Both my grandfather and grandmother always dressed well and more or less formally. What I remember most about my grandmother, Lydia, were her elaborate hair arrangements, which she did every morning, and the smell of her powder. She was also very much the head of the household. Every morning she gave her housekeeper a list of groceries that needed to be bought for the day or next couple of days, since the only way to preserve perishables was either a small ice box or putting things out on the balcony located just outside the kitchen. Afternoon tea was a family event, which involved pouring a small amount of "zavar" (brewed tea leaves) from the teapot sitting above the samovar and then adding hot water and, of course, there were also some sort of jam or sweets to accompany the tea. On those occasions when mother and I spent a month with the family in France, a house was rented in either Britanny or the Cote D'Azur, so that all members of the family could live under one roof. Here too, grandmother was in charge and enjoyed tremendously having her three children and five grandchildren with her.

Artsvi Bakhchinyan: There are few Cherkesogays. Have you ever met others? Whom?

Alexis Bell: No, unfortunately, I never met any Cherkesogays, other than the immediate members of my family.

Artsvi Bakhchinyan: You bear also your mother's family name — Tarassoff. Part of this family remained in Russia. The name of Russian businessman and political activist of Armenian descent Artyom Tarasov who died last year was quite famous. Were you in touch with your family members in Russia?

Alexis Bell: Tatiana and I learned about Artyom Tarasoff a few years ago. I wrote emails to him on a couple of occasions explaining our relationship, but he never responded. Somewhat later, Tatiana obtained his cell phone number from a friend of hers. She called him and explained how I am related to him and said that we would like to meet him on one of our trips to Moscow. He said that he would enjoy doing so but could not tell us when he might be able to do so, since he was ill with cancer and was in the hospital when he received our call. Unfortunately, that was the last contact we had with him. To the best of my knowledge, he was the only Tarasoff of whom we are aware in Russia.

Artsvi Bakhchinyan: While migrating to Europe Aslan

Tarasoff's family stayed for awhile in Constantinople and obtained Armenian nationality in 1920 translating their family name into Torosyan. Do you have your mother's Armenian passport?

Alexis Bell: I think I may have my mother's Armenia passport. If I find, I will send you a copy.

Artsvi Bakhchinyan: Olga Tarasova is one of the "heroines" of my study "The Armenians in World Choreography Art." How a Russian immigrant managed to have three ballet schools in such a megapolis as New York City?

Alexis Bell: My mother had a strong character and did not want to be idle once she married. So, shortly thereafter she opened a studio. My first memories of her studio date to the mid 1940s, when her studio was on the other side of the wall from our apartment. My father had rented a loft on the third floor of a building at 142 West 54th Street in Manhattan, and with the help of a friend of his, a painter names Hans Hoffman, he had the loft converted into a small apartment and my mother's studio. Amusingly, there was only one bathroom for the whole loft, which abutted the girls' dressing room. One could enter the bathroom from either the studio or by passing through the dressing room. I remember that when my mother wanted to bathe me in the evening, while the studio was being used by other ballet teachers, she would poke her head into the dressing room and ask "Girls are you decent," and once she got a positive response, she would trot me through for my bath.

Artsvi Bakhchinyan: She was the ballet teacher of Hollywood legend Audrey Hepburn. Has she ever told something particular about her?

Alexis Bell: No, I do not recall mother talking about Audrey Hepburn, but I do recall another one of her famous students, Maria Tallchief, one of a few Native American ballet dancers. On a few occasions when my parents wanted to go out and needed a babysitter, they asked Maria to do so.

Artsvi Bakhchinyan: You remind me of your uncle very much. How were your relations? Do you have a special memory about him? Were you communicating in Russian?

Alexis Bell: I have many fond memories of my uncle, Henri. In my younger days when the whole family would spend a summer month together, he tried to join us for at least a part of the time. He spoke Russian fluently, as well as French. As a teenager, I visited him both his apartment in Paris and his summer home in Peymenade, near Grace. While I did not have a lot of private time with him, I did enjoy speaking about his writing, and he was always interested in what I was doing in my professional life. He also told me that he hated public speaking and tried to do as little as possible. He also told me that when was invited to meet Gorbachev at the Élysée, he at first declined the invitation because he was not sure what he might have to talk about; however, he was finally convinced to attend by his wife.

Artsvi Bakhchinyan: Henri Troyat was born in Russia, but never visited Russia so as not to destroy the image of the country he had in his mind. You, born in the US, have visited not only Russia, but also Armenia. Why?

Alexis Bell: My interest in Russia was formed at an early age, fostered by listening to stories my mother told me about her childhood in Armavir and Moscow, many, many dinner conversation among my parents' Russian friends, and most notably the children of Feodor Chaliapin – Boris, Tatyana, Feodor, and Lydia. This group loved to reminisce about their childhood and youth in Russia, sing Russian songs, and enjoy Russian food, usually prepared by my father, who was a very accomplished cook. I also have fond memories of spending Russian Easter at Boris Chaliapin's home in Easton, Conn. These events involved decorating Easter eggs with gold and silver paints, preparing an elaborate Easter dinner, which has done by Boris's wife, Helcia, and my father, Vladimir, both of whom were Jews. When all was ready, we would pile into several cars and drive to a small Russian Orthodox church to hear the Easter service, and after that return to Boris' home for an Easter feast.

As I may have told you, my love of the Russian language led me to join a Russian-speaking dormitory in my freshman year at MIT. This group comprised 15 freshman students and a Russian-speaking tutor, David Perlmutter, who had been a translator at the first Soviet-American trade show in Moscow in the late 1950s. At the time that I met him, he was a graduate student in linguistics at Harvard and also an instructor in Russian language at MIT. David and I were the only members of the dorm who spoke Russian fluently, so it was our task to help the other students develop their Russian language skills. In the second year of the dorm, the Slavic Languages department declared that it had run out of funds to support Perlmutter. Since the students in the dorm were very fond of him, we decided to take matters into our own hands and find funds for his salary. At my initiative, we decided to run a Russian film festival on campus. Every week during the school year, I would order Soviet films — mainly classic Eisenstein films — from Brandon films in New York City, show them on Saturday and Sunday nights, and then return them by mail on Monday. This way we earned $5,000, which was enough to pay Perlmutter's salary.

Artsvi Bakhchinyan: You are in Armenia for the second time. Do you feel already some attachment to this country? Do you have already some places you prefer?

Alexis Bell: My knowledge of Armenia and Armenian culture developed relatively recently, thanks mostly to the efforts of Gregorii Karapetyan, an Armenian community activist from Armavir, who invited us to Armavir in 2014 to celebrate the 175th anniversary of the city's founding. Gregorii also helped organize our first trip to Georgia and Armenia in 2015, as well as our trip this year. These trips, including visits to the national historical museum, the art museum, the Paradjanov museum, as well as visits to Echmiadzin and Lake Sevan have given me a growing appreciation of Armenia and its people. What both Tatiana and I have found is that Armenians are warm and very hospitable people, who are very proud of their heritage and also quite aware of the hardships that their people have endured over the centuries. I have commented that Armenia is much like Israel, a small nations of very bright and industrious people, surround by nations who are not friendly. All of this has given me tremendous respect for Armenians.

Discover more cities: Armenia USA

Related Articles | **More from Author**

Composing after Komitas

JANUARY 16, 2020 •
4 min read

- *by* Muriel Mirak-Weissbach

ART BOOKS COSTUMES HISTORY PAINTING

Gourgen Manoukian Preserves Armenian Traditional Costumes and Creates New Art

JANUARY 16, 2020 •
3 min read

- *by* Aram Arkun

HISTORY MUSIC OPERA

Operatic Roadblocks Threaten Tchouhadjian's Legacy

JANUARY 16, 2020 •
12 min read

- *by* The Armenian Mirror-Spectator

Serbia to Open its Embassy in Armenia at End of February

JANUARY 16, 2020 •
1 min read

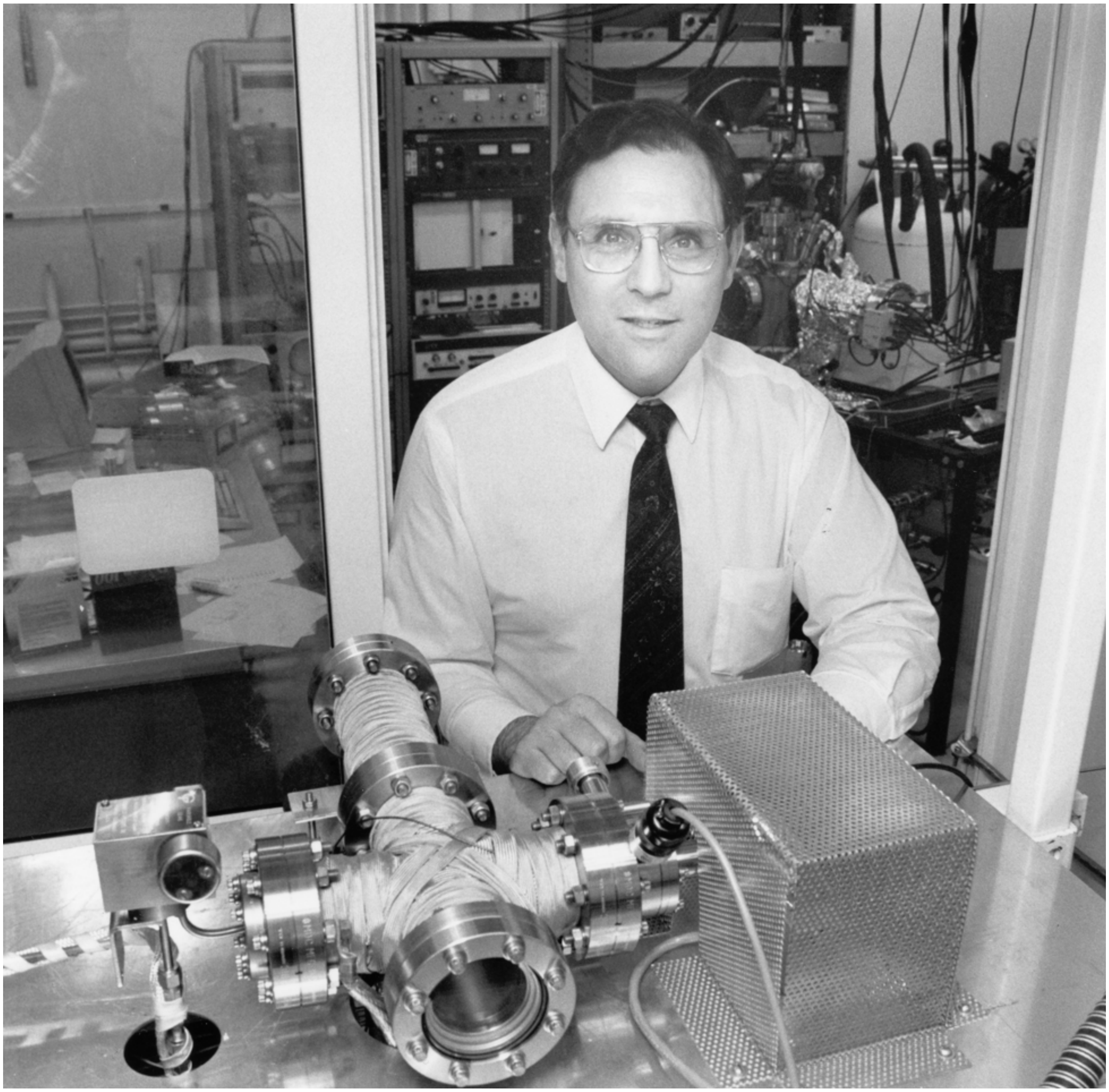
- *by* The Armenian Mirror-Spectator

Appendix B: Photographs courtesy of Alexis T. Bell

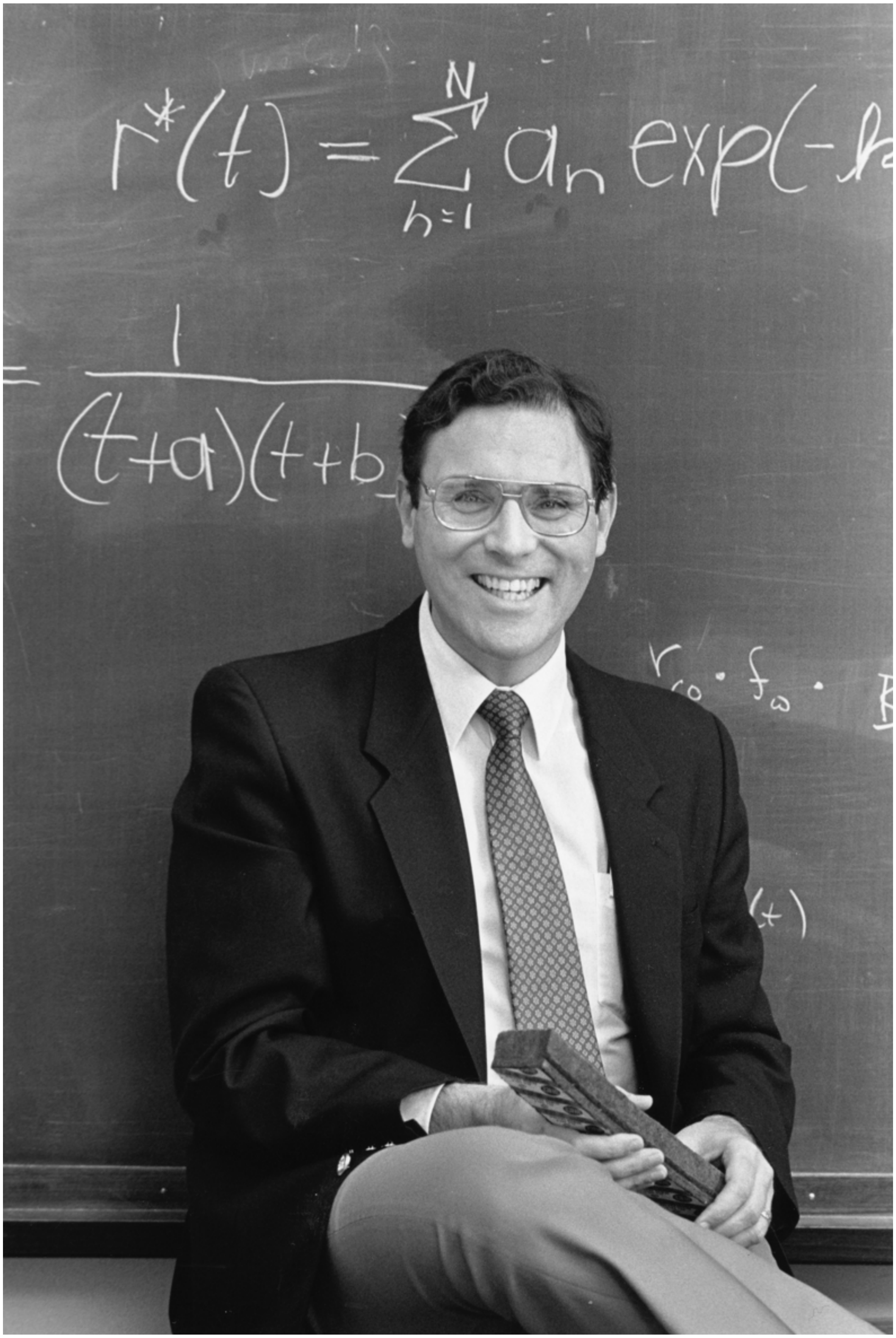
Grandfather Aslan Tarasoff and Alexis Bell in France, circa 1960.

Alexander Tarasoff (left), Aslan Tarasoff (center), and Leon Aslanovich Tarasoff (pen name Henri Troyat), uncles and grandfather of Alexis Bell in France, circa 1960.

Alexis Bell (left) with parents Olga Tarassova and Vladimir Bell at the annual Franco-American Soiree of the Cercle Artistique Français, which his mother choreographed, May 1958.



Alexis Bell in his UC Berkeley laboratory with a mass spectrometer he built for studying plasmas, circa 1980. Photo courtesy Denis Galloway.



Alexis Bell in UC Berkeley classroom, circa 1990.

Alexis Bell and his family at daughter Alisa's wedding, August 2000.
Left to right: Carmi, Alisa, Alexis Bell, Suzanne, Nehama.

Alexis Bell with family and grandchildren, circa 2002.
Back row: Anthony Dave. *Middle row*: Nehama, Alexis Bell, Alisa, Carmi.
Front row: granddaughters Raven and Aria.

Alexis Bell and his wife Tatiana Starostina Bell, photo taken in 2003
in celebration of Alex's 60th birthday on October 16, 2002.

Alexis Bell and wife Tatiana Starostina Bell at the International Conference on Catalysis, 2008.

Alexis Bell and wife Tatiana Starostina Bell at Squaw Valley Ski Resort
near Lake Tahoe, California, circa 2012.

Alexis Bell presenting in Dalian, China in July 2014 after earning a 2013 Einstein Professorship from the Chinese Academy of Sciences.

Alexis Bell and wife Tatiana Starostina Bell celebrating Christmas with Tatiana's daughters, Anna Starostina (left) and Vera Martynets (right), 2016.

Alexis T. Bell (center) with students from his laboratory at UC Berkeley, 2019.