Interview with Ralph Gomory by Irv Lustig, May 10, 2017

1. Introduction: Early Life

IRV LUSTIG: Hello. It's my pleasure today to be with Ralph Gomory, the former director of IBM Research, past president of the Sloan Foundation, and a research professor at New York University.

My name's Irv Lustig from Princeton Consultants, and we're here to learn today about Ralph's storied career that ranges from contributions to integer programming, to his work at leading IBM Research, to his work at the Sloan Foundation, and finally his research career at New York University.

So Ralph, I want to thank you for coming and arranging for this interview today.

RALPH GOMORY: Well, thank you for being here and doing it.

IRV LUSTIG: All, right so let's start off with your early life. Can you tell us where and when you were born?

RALPH GOMORY: Yes. I was born in Long Island College Hospital, which is in Brooklyn, New York, right adjacent to Brooklyn Heights. And my mother and father lived there. My dad was a banker. He was born in Hungary, and came over here for his first job and never went back. And my mother came from a Jewish family that was well-established. Came here, I think, around 1848.

IRV LUSTIG: And so did you grow up, then, in Brooklyn?

RALPH GOMORY: Yes, I did. Yes.

IRV LUSTIG: And so tell us, did you have any siblings?

RALPH GOMORY: I had an older brother, yes.

IRV LUSTIG: And did he end up doing anything related to what you did?

RALPH GOMORY: No, completely unrelated.

IRV LUSTIG: Completely unrelated.

RALPH GOMORY: Yes, yes.

IRV LUSTIG: And you mentioned your father was a banker. Did your mother have a profession?

RALPH GOMORY: Oh, in those days-- first of all, you have to realize that my growing up was in the 1930s. And in those days middle-class women did not work, except possibly as teachers. But usually if they were married, they didn't work.

IRV LUSTIG: And so tell us about your early education in Brooklyn.

RALPH GOMORY: Yes. Well, my early education, I think, was absolutely different and decisive. And really, I doubt whether I would have amounted to anything without it. I was extremely lucky that I went to an unusual school. It was called the Woodward School, and it was founded by Miss Woodward.

And they gave us a lot of freedom. I mean, we learned what we had to learn. On the rare days when we did standardized tests and stuff, we all did well, very well. But they managed to make it fun. We did projects a lot of the time.

And I got it into my head that learning stuff and understanding stuff was fun. Not the usual, oh, I've got to get this. And we did some pretty ambitious projects. One of them is worth really mentioning, that we wrote a book. Three of us.

IRV LUSTIG: A novel?

RALPH GOMORY: A novel. Right.

IRV LUSTIG: Do you recall what it was about?

RALPH GOMORY: More than recall, all right? Because as you will see, we're working on it right now.

It was about three children who, by mistake, stowed away on a sailing ship, a clipper ship. 1848, about that period. And unexpectedly, it went to China with them on board, and their adventures with pirates, everything, OK? And it was 120 pages. Three authors, one of whom died. And we wanted to get it published, and some publishers actually considered it.

So it was stowed away in an envelope with a skull and crossbones on it, saying, you know, whoever touches this will be cursed forever. Or words to that effect. And to my amazement, the other surviving person had it. We opened it up and inside were several copies of the book on onionskin, if you--

IRV LUSTIG: Oh, yes.

RALPH GOMORY: OK, if you know what onionskin. You couldn't scan it, it was too difficult. We had it typed. And we're just going through it now, writing an introduction. And it's in Word, and we're going to send it to all the members of our families and whoever else is interested. And amazingly, it's interesting.

IRV LUSTIG: And how old were you when this project occurred?

RALPH GOMORY: Yeah. We were, I think, in the sort of 10 to 12 range.

IRV LUSTIG: Wow. That's very interesting. And it's really nice that you've been able to keep in touch with your childhood friend.

RALPH GOMORY: Well, we were apart most of the time. We came together when one of us was dying, and I read her from some of our childhood books that we'd shared. But I had no idea that that thing was there.

IRV LUSTIG: So it probably brought back some good memories.

RALPH GOMORY: What?

IRV LUSTIG: It probably brought back some good memories.

RALPH GOMORY: Yeah. There are even some photographs with it, of us when we were children.

IRV LUSTIG: So the school that you went to--

RALPH GOMORY: Yes, Woodward.

IRV LUSTIG: Were you there, was that like a first grade through 12th grade experience?

RALPH GOMORY: No, it was third through eighth. And I can only say I really enjoyed that school and it spoiled me for every school I ever went to subsequently, because they didn't live up to-- it wasn't exciting and fun. It was uh, uh.

2. High School and College

IRV LUSTIG: So I guess your high school experience in ninth through 12th grade was more of the uh, uh?

RALPH GOMORY: It was the uh, uh type,

IRV LUSTIG: And where was that?

RALPH GOMORY: Well, I went briefly to something called Poly Prep in Brooklyn, and then to a boarding school in Pennsylvania called George School. It was a Quaker school. Quaker school, And that was an interesting place.

And it was a co-ed boarding school, which, you know, in the 1930s, right? And I got a lot out of that, too, but it wasn't like Woodward.

IRV LUSTIG: So what subjects were you interested in and good at while you were in school?

RALPH GOMORY: Well, I seemed to be naturally good at physics. The teacher got tired of having me in the room and said I didn't have to come anymore. And on the other hand, I was terrible at math because I didn't understand it.

And one of the things-- I am never comfortable with just remembering things. I really want to understand them. And the way math was taught, it was like, you do this, you do this, and you do this, and then the answer comes out. I didn't understand why I was doing this and doing this, and I wasn't good at remembering it. So I didn't score well on math aptitudes and things like that.

And in fact, when I was going off to college my advisor asked me what I thought I would study, and I said I wanted to study physics. And by the way, the reason I wanted to study physics was because it explains so much. You know, it explained why you could fall down stairs, what happens when it's raining. I mean, it explained the world around me. And that's what I like doing, is understanding the world around me.

And he said, you can't do that, probably, because you're so poor at mathematics. But fortunately, one day I caught on.

IRV LUSTIG: And that one day was when you got to college or later on?

RALPH GOMORY: No, it was the summer, I think, before I went to college. You see, I was a very enthusiastic small boat sailor. And if you know anything about sailboats, you know that when they're progressing against the wind, they zigzag. They can't go straight into the wind, OK?

And so I became curious about, how much extra distance do I have to go through the water when I'm going against the wind? And all of a sudden, it turned out, well, the answer involved sines and cosines. So all of a sudden, oh, that's what those things are for! And that's why you have to use these things. And so I caught on.

IRV LUSTIG: I see. And did you think that, in terms of your trying to understand the physical world, that there were things that ended up serving as a foundation for any of the later work you did in optimization?

RALPH GOMORY: No, I don't think so. What actually happened is that when I got to college-- and I went to Williams College-- I studied physics and I was a physics major. And I did well at it, but I lost interest in it.

And the reason why I lost interest in it was because physics stopped explaining the world around me. You get into quantum mechanics and stuff, or the forces inside the atom. Well, that doesn't tell you anything, OK?

IRV LUSTIG: You can't see an atom.

RALPH GOMORY: You can't see an atom, all right? And you can't-- it doesn't do anything that you can see and that changes the world around you, and that was why I got into physics. And so I thought, well, this is not good. OK?

And I wanted to switch to economics, because it seemed that economics was busy understanding the world around. But it was too late, I couldn't major in economics. And so I decided to major in mathematics, because it turned out that I'd taken enough math in connection with the physics that I could become a math major.

IRV LUSTIG: You mentioned that this was at Williams College.

RALPH GOMORY: Yes.

IRV LUSTIG: What made you choose to go to Williams?

RALPH GOMORY: A very good reason, all right? I visited the campus and it looked beautiful.

IRV LUSTIG: And that was it?

RALPH GOMORY: Well there was a group. Oddly enough, there was a group of us that thought we would go to that school. All of us had sort of the same reaction. We said, why don't we all apply? One of them was Steve Sondheim, the--

IRV LUSTIG: Oh, right, yes.

RALPH GOMORY: And we were all admitted and we all went. But you see, we didn't understand, nor did our parents, that there's a difference between a college and university, for example. And I should have gone to a university, probably. And so anyway, I ended up being a math major.

And it was the same story. I did it, I could do it, but what I really enjoyed was project, right? And so I wrote a senior thesis.

IRV LUSTIG: And the topic was?

RALPH GOMORY: Boundaries for the limit cycle of Van der Pol's equation. Catchy?

IRV LUSTIG: Sounds like a math thesis.

RALPH GOMORY: [LAUGHS] It was. But it was pretty good, and in fact, it ended up being published.

IRV LUSTIG: In an academic journal?

RALPH GOMORY: Yeah. I stayed on that summer. My math teacher, who saw, apparently, a lot of promise in me, invited me to stay that summer. And we fixed this thing up and published it as a joint paper in, I don't know what, SIAM or something. I mean, a real journal.

IRV LUSTIG: Really? That's pretty good, for an undergraduate student in mathematics to get a publication.

RALPH GOMORY: Right. It really was.

IRV LUSTIG: So you mentioned earlier how, when you were at the Woodward School, about how you had your projects.

RALPH GOMORY: Yeah.

IRV LUSTIG: And then you alluded to that there seemed to be-- were there projects that you also did while at Williams?

RALPH GOMORY: This was the first chance I had to do a project, the senior thesis. I was so happy to be able to do what I wanted rather than what was due the next day.

IRV LUSTIG: I see.

3. After College to Graduate School

RALPH GOMORY: And so then I went for a year to Cambridge, England. Which turned out to be very fortunate, because I wasn't ready for graduate school. Because what they taught in Williams and what was expected of a graduate student, there was a huge gap.

IRV LUSTIG: Can you describe what that gap was at the time?

RALPH GOMORY: Well, we never heard of epsilon and delta. No rigorous anythings. I think we had advanced calculus for engineers as a senior-- I mean, we were way out of it.

But fortunately, I spent a year at Cambridge, England, for no very good reason except that my dad always wanted us to see other countries. Because he came from Hungary, and it'd been a great advantage to him-- and he was educated in Germany-- to know different countries. And he knew the head of one of the Cambridge Colleges, and I went there.

IRV LUSTIG: So what year was this?

RALPH GOMORY: That would be 1945. The year '45-'46.

IRV LUSTIG: Right, so this is just after World War II.

RALPH GOMORY: Yes.

IRV LUSTIG: So what did you do while you were in Cambridge?

RALPH GOMORY: Well, I'll tell you, but actually, we sort of skipped over one thing when you mentioned the war. Because something happened that was very, very important to me and affected things that I did later in my life.

I was too young to be in the army, but there was a great shortage of labor. And so they organized kids my age to go and work on the farms in place of the men. And so I spent a summer working on the farm, hoeing corn, stuff like that.

IRV LUSTIG: This was your summers while you were in college?

RALPH GOMORY: No. This was before college.

IRV LUSTIG: Before college, I'm sorry.

RALPH GOMORY: And it made a huge impression on me. I was so impressed with the farmer. The farmer could go down a row of corn twice as fast as any of us, or maybe three times. It wasn't because he was stronger. We had some pretty big boys. His skill.

He could do all kinds of things. He could do a horse-drawn cultivator. Can you imagine? A horse-drawn cultivator. And I was really impressed how much he knew how to do, and how skillful and thoughtful he was. A person who I doubt had ever gone through high school.

And it made a permanent impression on me. Although I'd go to college and you're surrounded by college-educated people, that there's another world of people and that you should not look down on them. They are different, but they are remarkable, OK? And that was a very important influence in my life.

OK, returning to Cambridge. I won't go into various details, but basically I managed to fill in some of the gaps in my education.

IRV LUSTIG: So it wasn't a degree program, it was just an opportunity to take some courses?

RALPH GOMORY: Well, when I arrived there I thought maybe I would stay for a degree, but the way they did math didn't appeal to me at all.

IRV LUSTIG: But it filled those gaps that were important.

RALPH GOMORY: I managed to fill the gaps.

IRV LUSTIG: So after a year in Cambridge, what happened next?

RALPH GOMORY: Well, I thought I would apply to MIT, because I really like applied things. I mean, I like understanding the world around me. But then I got an invitation, a surprising one, from the head of the Princeton math department to come to Princeton.

IRV LUSTIG: And how did he know of your work?

RALPH GOMORY: He had run into my professor, Don Richmond. And Don Richmond had told them, you ought to get this guy.

IRV LUSTIG: And Don Richmond was at Williams?

RALPH GOMORY: He was my professor, math professor.

IRV LUSTIG: At Williams.

RALPH GOMORY: I should have mentioned his name earlier. He was a terrific person. And so, well, they seemed to want me at Princeton. What the hell, I'll go. OK? And so I went to Princeton.

Oh, and also, I forgot to say this Princeton person, Solomon Lefschetz, very interesting and good person. He was interested in differential equations, which was the subject on which my thesis, my undergraduate thesis, had been. So that was a connection, too.

And so Princeton wasn't so bad, because they only had a few graduate students, and they were a pretty select group. And so you didn't have to go to classes at all.

IRV LUSTIG: There was no class requirements for--

RALPH GOMORY: They gave courses, but if you attended it, fine. If you didn't attend it, fine. What you had to do was pass an exam called the general exam.

IRV LUSTIG: Sort of like the qualifying exams in other universities.

RALPH GOMORY: Yeah. Except that it was even more minimal. You went into a room with three professors and they asked you a lot of questions.

IRV LUSTIG: I think I remember reading a story where you were saying that the questions were, you were expecting them to be far more difficult.

RALPH GOMORY: Than they were, yeah. I was terrified, yeah. The downside of not getting grades or attending courses or anything is you don't know whether you're doing well or badly, OK? Anyway, I did fine.

IRV LUSTIG: Now what time period were you at Princeton?

RALPH GOMORY: Well, I guess I arrived there in '51 or '52.

IRV LUSTIG: OK. So you mentioned that you, if I remember correctly, you said you finished college in '45. So you had a year in Cambridge, so there were some stuff in between there.

RALPH GOMORY: Well, I was in class of 1950 at Williams.

IRV LUSTIG: Oh, so you started at Williams in 1945. Got it, OK.

RALPH GOMORY: Yeah. Right. So it was interesting, because I was so happy to have the generals behind me and be able to do research. And it was very different, because most of my classmates were very good at classes, but they'd never done any research. And so it was their turn to be terrified.

And so I very quickly got a thesis. I thought up things. I wrote a couple of papers that were published. One of them was my thesis.

IRV LUSTIG: And what were the areas of mathematics they were in?

RALPH GOMORY: They were in nonlinear differential equations. So I was being successful, but I just didn't want that to be my life.

IRV LUSTIG: Now, Lefschetz was your thesis advisor, as well.

RALPH GOMORY: Very good guy, yeah. He was terrific.

IRV LUSTIG: Now, you were also there around the time where there was a lot of math programming activity. A lot of math programming activity at Princeton.

RALPH GOMORY: I'm not catching the words.

IRV LUSTIG: Math programming.

RALPH GOMORY: Oh, math programming.

IRV LUSTIG: At Princeton. So you know, Al Tucker, Harold Kuhn was there around there. Nash, Shapley.

RALPH GOMORY: Well, Shapley. I don't think they were. I think that was just a couple of years later, or at least I was not conscious of them. Although, as you'll see, I come back and meet them all. I just didn't want to spend the rest of my life writing these papers, and I figured there maybe were 14 people in the world who could read them.

IRV LUSTIG: Did you have any interactions with von Neumann?

RALPH GOMORY: No. Not at that time.

IRV LUSTIG: Not at that time.

RALPH GOMORY: Yeah. I was just doing research on nonlinear differential equations. And so I thought it was time for me to go and get a tenured position somewhere. I didn't want to do it.

And so I joined the Navy. Naturally. [LAUGHS] You see, it's a little complicated. At that time there was a draft, OK? But no one I was in graduate school with really ever served, because they were deferred as graduate students and then they became teachers who were deferred.

But since I wasn't going to be a teacher, I was no longer deferred. And so I had to choose between two years in the Army or Navy, or I could go to Officer Candidate School in the Navy for three. And I signed up for three years.

IRV LUSTIG: And so you finished your PhD in what year?

RALPH GOMORY: '54.

IRV LUSTIG: 1954.

RALPH GOMORY: Yeah.

4. Introduction to Operations Research

IRV LUSTIG: So you sign up for the Navy.

RALPH GOMORY: Yeah, OCS.

IRV LUSTIG: And what happens there?

RALPH GOMORY: Well, I went to Officer Candidate School and learned a hell of a lot. Believe me, the Army and the Navy-- and I guess the Air Force, too-- they don't call it education, they call it training, but boy, they know how to do it. I mean, you get trained, OK? And you know what your job is. It's to take care of your men and obey orders.

IRV LUSTIG: So was there anything related to your mathematical training that you were doing at the Navy?

RALPH GOMORY: Nothing. Nothing at all at that point. And I joined the Navy because I was a small boat sailor. The Navy looked at that and they said-- when I came out of OCS-- hey, we've got a lot of small boat sailors. We've got practically no PhD mathematicians. They sent me to Washington. I never got on a ship.

IRV LUSTIG: Is that something that you at the time felt-- "wait a minute, I joined the Navy to be a sailor?"

RALPH GOMORY: I applied for minesweepers. The smallest boat I could find. Never made it.

IRV LUSTIG: So what happened when you were sent down to Washington?

RALPH GOMORY: I learned a lot. I was in the Office of Naval Research. And I learned a lot of things. I can give you a couple of examples.

IRV LUSTIG: Please.

RALPH GOMORY: I was there when Sputnik went up. I heard President Eisenhower, he got on the radio to reassure the nation. People were very shook up. The Russians are ahead of us, OK? And he said-- I'll never forget-- he said, we have, in both oceans, submarines that could rise to the surface and fire missiles into the Soviet Union.

And what he said was literally true, because I knew what we had. That was the sort of thing that I knew at that point. We had, in each ocean, one submarine that was capable of rising to the surface and firing something called the Regulus missile. Which was totally useless.

It was a subsonic aircraft, winged aircraft. So subsonic is slow. It had been used as a target drone for training. It would never have gotten anywhere. I mean, it'd be shot down in-- you had to control it by radio. It was useless.

So that was a tremendous lesson to me. And Eisenhower was a very straight-arrow guy, that these people do what they feel they have to. And that was important later in my life.

And another thing. I was in the physics branch, but down the hall there was the operations research group. And so I discovered operations research. I had never heard of it before. And I could do what I had to do and have time left over in the physics branch, and they were willing to let me go down the hall and help out the OR people.

And so I realized, oh, O.R., operations research. This is understanding everything. OK? This is for me. So I decided I would become an OR person.

IRV LUSTIG: So were there particular people there at the Navy in OR that were influential?

RALPH GOMORY: No, not so much, but another weapons system they asked me to look at, it was a McDonnell Douglas thing. And it was to send something over to the Soviet Union. And that something, an aircraft, had to be able to see the ground occasionally, to know where it was. And they had a computation which showed that they'd see the ground often enough. And I looked at that and it just didn't look right.

So I went down one Sunday to the Library of Congress, and it turns out they have big green books giving the cloud cover everywhere on Earth. And no one believed that the Soviets were giving that stuff out. But I looked, and there it was. Kiev, everybody. Cloud cover every day.

And you could see that the clouds came in together, all right? So you had three days of solid cloud. Couldn't see the ground. The average was fine, but then they had used the average, and they didn't think the green books were there. That ended that whole program.

So I learned something else, which is, hey, all these things that people do and spend a lot of-- it was going to be a few hundred million-- money on and so forth, you've got to look hard. Maybe it's not right. OK? So I sort of got educated that all these important companies and people and everything-- not necessarily. OK?

IRV LUSTIG: So having been exposed to OR at the Navy, you have now your three-year term there with Officers Candidate School. And you know OR is for you. What happens next?

RALPH GOMORY: What happens next is that Professor Lefschetz writes to me and says, do you want to come? We'll make you Higgins Lecturer at Princeton. It's a prestigious lectureship. It's not a tenure thing.

But I thought, OK. I'll go back, learn OR. I'd taken a night course down in Washington taught by Alan Goldman, and I learned linear programming. I was quite impressed with it.

IRV LUSTIG: And Alan, I know later he was at Johns Hopkins. Where was he affiliated with at that time?

RALPH GOMORY: I think it was-- it was not Johns Hopkins. Maybe American University or something. And we did night courses. And so I thought, well, look, I'll go to Princeton for a year. It'll look good on my resume, and I'll really learn this stuff, because Princeton is doing it then.

So I go there, and all the people you named were there. And they may have been there before, but I couldn't see them.

IRV LUSTIG: I see.

RALPH GOMORY: But I don't think so. Game theory and everything had taken off during those three years. And so I stayed there a year.

5. Discovering Integer Programming

But the Navy guys, the OR guys, kept me as a consultant. So I went down. And they were using linear programming to design a Navy task force. When you have an aircraft carrier, you've got to have some destroyers with it, and so forth. So you need to figure out the number of ships and things like that, and how far they can go-- and do they need tankers.

And they use linear programming to minimize the cost of the task force, how it was composed. But the trouble was that the answers came out things like 2 and a quarter aircraft carriers. They weren't whole numbers. And it wasn't clear what you did with 2 and a quarter aircraft carriers. You could fiddle around with it and decide, did they mean 2, or did they mean 3?

And they said, hey, it'd be really good if we could do linear programming and get whole-number answers. So I listened to that, and I thought, yeah. That's right. And it should be doable. I didn't realize that people had thought about this and thought it was not doable.

Because in ordinary linear equations, there are ways to solve for integer solutions. It's called Diophantine equations. I knew about that. I said, there ought to be the equivalent thing in linear programming. And so I went back to Princeton, and sat around for about a week trying to convert the methods of Diophantine equations into a way to get whole-number answers in linear programming. And I couldn't do it.

So then I said, look. What would you do if you really had to get an answer? And so I said to myself, I would solve it with linear programming and then I would-- oh, something hit me. Supposing the answer came out-- you had an objective function, which was also supposed to be integers and which had certain weights in it, I won't explain. But they were integer weights.

Supposing the answer came out to be 7 and 3/4 of the objective function. That meant, because the restriction to integers made it harder, it couldn't be more than 7. If it was over 7, the integer answer had to be less. And I said, how did I figure that out? It was just obvious.

And I realized that anything that was maximal at that vertex and was non-integer could be pushed in to be integer, not just the objective function. And that led to the development of the cutting planes. So anything that was optimal there could be pushed in if it didn't come out to be an integer. And the Gomory fractional cuts were-- and then I spent a month showing the thing converged.

IRV LUSTIG: Right. Back then, the idea was that you would keep applying the cuts until you found the solution.

RALPH GOMORY: You had to show that you would eventually.

IRV LUSTIG: Right.

RALPH GOMORY: Yes. And that was non-trivial. And afterward, other people developed cuts and they didn't converge, and so forth. So anyway, that's how that started.

IRV LUSTIG: Did you have any discussions with some of the other folks that we mentioned earlier while you were developing this?

RALPH GOMORY: No, I just sat there.

IRV LUSTIG: And this is that one year that you were at Princeton?

RALPH GOMORY: Yeah, that's right.

IRV LUSTIG: At the same time, I guess, as a lecturer you were teaching some courses?

RALPH GOMORY: Yeah.

IRV LUSTIG: And was the coursework that you were teaching back in your old area of nonlinear differential equations?

RALPH GOMORY: No, I think I was teaching undergraduates' calculus or something.

IRV LUSTIG: OK. So this work occurs in that year. You come up with this--

RALPH GOMORY: It may have been two years. I think I stayed a second year and I was promoted to assistant professor because of this integer stuff.

IRV LUSTIG: So this becomes a pretty fundamental contribution to integer programming. Well, really starts integer programming.

RALPH GOMORY: Well, it really started. I can remember meeting Martin Beale in the hall. He was a very good man. He died young, unfortunately.

And he said, I see you're down to give the seminar next week. What are you going to talk about? I said, how to solve linear programs in integers. And he looked at me. He said, that can't be done. That made me feel good.

IRV LUSTIG: And here yet you had your convergence proofs to show that it could be done.

RALPH GOMORY: Yeah, showing it could be done.

IRV LUSTIG: So after this year--

RALPH GOMORY: Yeah, two years.

IRV LUSTIG: OK, about two years at Princeton. You've got this great contribution.

RALPH GOMORY: Yeah. And that summer I was invited out to Rand, because they had a computer, a big computer. And I met Phil Wolfe. And Phil and I became friends, and we remained friends till he died.

IRV LUSTIG: Now, you mentioned that the Navy was solving these problems-- this is the mid-'50s or so-- as linear programs. What was their computational vehicles?

RALPH GOMORY: What?

IRV LUSTIG: How did they compute solutions?

RALPH GOMORY: Well, they didn't have to compute, they just had to get an answer. I mean, they'd get an LP-- linear programming-- answer and decided, well, let's try--

IRV LUSTIG: Well, yeah, but how did they get the linear programming answers? Did they have some computational computers that would solve?

RALPH GOMORY: Yes. Oh, they filled a room or two. That's right. That's a very good point. They had them, Rand had them, but each one of them was a named object, right? You know?

IRV LUSTIG: Right. And at Rand, I know there was some computational work being done there at the time.

RALPH GOMORY: Yes.

IRV LUSTIG: I think, if I remember, is that when Orchard-Hayes was there, maybe? Or he was somewhere else?

RALPH GOMORY: I don't know. Bellman was there.

IRV LUSTIG: Bellman was there, OK.

RALPH GOMORY: Yeah.

IRV LUSTIG: I know Dantzig spent some time there, too.

RALPH GOMORY: I think George was there, or he may have moved on to Stanford. But it was the center at that time. And Phil was enormously helpful to me, because he was allowed to put stuff on the computer. I wasn't. And he put my stuff on for me.

IRV LUSTIG: Oh, I see.

RALPH GOMORY: So he was just great.

IRV LUSTIG: So he was really probably your earliest collaborator in the area.

RALPH GOMORY: Absolutely. No question about it.

IRV LUSTIG: That's really nice. Well, my next question was, what do we view as your main contribution to the area of operations research? And certainly the Gomory cutting planes are a major one.

RALPH GOMORY: I think starting integer programming.

IRV LUSTIG: Starting integer programming, for sure.

RALPH GOMORY: Yes, although I've got lots of other things I could mention. [LAUGHS]

6. Moving to IBM Research and Column Generation

IRV LUSTIG: So you had a couple of years at Princeton. What happens next?

RALPH GOMORY: Then IBM Research was just starting up. And you see, that was really where I wanted to be. Now, let me explain why. When I was a kid, I went to camp in the summer. And I enjoyed it, OK?

And I read a story by H.G. Wells about the future. And in this future, people didn't have to work because they had intelligent machines that did everything. And I thought, wow, what a great

thing. Because then all year round it could be like summer camp, where we just did things that were fun.

And I thought, well, why do we have to wait for the future? Because I'd seen newsreels and stuff, of very complicated machines and factories doing this, that, and the other thing. We can do that, we have complicated things now.

And so I thought about it, and after a while I realized that although those things were complicated, they were repetitious. And that we had the ability to make robot-like things, but we lacked anything to make them adapt and learn. That was missing, OK?

Now, the first time I saw a computer, in the Navy, and realized how it was-- I said, "Ah! The intelligence has arrived. I want to be where that is." OK? And that was IBM.

So I thought, this is the future. I'm joining IBM. And they were just setting up research labs and a research division at that time, so I joined.

IRV LUSTIG: Now you joined in what role?

RALPH GOMORY: They made me the head of a group of five people.

IRV LUSTIG: Now, I think some of those people are names that others would know, right? That are well-known mathematicians?

RALPH GOMORY: I think they all are. Well, not all. But the thing was being set up by Manny Piore. Emanuel R. Piore, who had been the head of the Office of Naval Research. So there was sort of a faint connection there, too.

But there I was in my little group, which consisted of Benoit Mandelbrot, Paul Gilmore, T.C. Hu, and I can't remember the name of the other person, I think. But I will eventually. And later on, I persuaded Phil Wolfe to come and join us.

IRV LUSTIG: So you were hired out of Princeton into a role where you were actually leading this group of other mathematicians?

RALPH GOMORY: Yes. Don't forget, I was a trained officer.

IRV LUSTIG: Ah, yes, that's where it comes from. OK. I was trying to make that connection. Yes. OK.

RALPH GOMORY: But of course, it's a little different. Anyway. But to my great disappointment, you see, there was no connection with anything. We were just there, in buildings, free to do things.

IRV LUSTIG: To do research.

RALPH GOMORY: Yeah. To do research. Because one of the great delusions of the time was that if you just left people alone to do research, something great came out of it. Radar, the atom bomb, stuff like that. And that isn't right. You need problems.

But that was another giant misunderstanding. All of the-- GE, everybody set up research labs at the same time.

IRV LUSTIG: And when you're saying misunderstanding, it was a misunderstanding of the philosophy of setting up the lab?

RALPH GOMORY: They thought something would happen that wasn't going to happen, in my opinion.

IRV LUSTIG: They were looking for that next great discovery.

RALPH GOMORY: Yeah. Well, those are very rare. They do happen, and they're terribly important, but most progress is much more incremental. And in order to be incremental, you have to know what's there so you can increment it.

Anyway, so we struggled to get in touch. And Paul Gilmore and I learned, after much trial and error, that there was a problem in paper mills that looked like a linear programming problem. They made these huge rolls of paper, but then they had to cut them up into sizes that people could use. And there was waste.

And you could formulate it as a linear programming problem, but the only problem was that there were a few hundred million different ways you could cut these things, right? And so that the linear programming formulation involved hundreds of millions of columns and you couldn't write them down, much less run them on a computer. And so we developed something called column generation, which was also very important.

And that worked, and we went out and we sold them computers. To do this.

IRV LUSTIG: To solve these?

RALPH GOMORY: It was real.

IRV LUSTIG: So these algorithms that you developed, and then implemented on a computer, was used by multiple paper mills at the time?

RALPH GOMORY: That's right. The IBM salesmen who took us there were really happy to have something to give them aside from time clocks and stuff. And we had to prove we could get them better results than they were getting. And we mostly showed that. It wasn't a big difference, but it was enough to pay for it.

IRV LUSTIG: To justify the expense of purchasing an IBM computer?

RALPH GOMORY: Yes, or leasing one.

IRV LUSTIG: Right, I see.

RALPH GOMORY: So that led to a whole lot of other things. And eventually that led to us looking at, Paul Gilmore and I, we looked at a lot of data. And we saw some very strange things. And I don't want to go into too much mathematical detail.

But we unexpectedly saw in the data that once the roll got to a certain width, everything got simpler. It repeated in a certain way, and it could be interpreted in terms of group theory. It led to a whole theory of corner polyhedra. And the paper, which I think is the best paper I ever wrote, is called "Some Polyhedra Related to Combinatorial Problems."

IRV LUSTIG: And so this is while you were at IBM, and essentially a derivative of the work with the paper mills?

RALPH GOMORY: Yeah. You see, I really believe that practical problems can lead to theory, and I showed that.

IRV LUSTIG: And so were there other practical problems that you were exposed to during that time at IBM?

RALPH GOMORY: Yes, but this is the one that really had legs. I mean, T.C. Hu and I wrote a paper entitled "Multi-terminal Network Flows" so that you could calculate the flows in a network. And that's been quite well-known.

IRV LUSTIG: And that, I imagine, was derived from some practical problem that you were seeing at the time?

RALPH GOMORY: That one less so, I think. I mean, simultaneously we were pushing forward in the usual way.

IRV LUSTIG: So at that time, the IBM math department is just starting, with you and your colleagues there.

RALPH GOMORY: Well, no, we were just one small group within it.

IRV LUSTIG: Within it.

RALPH GOMORY: Yeah, it was a whole department, headed by Herman Goldstine, who had been von Neumann's collaborator.

IRV LUSTIG: I see. And did they give, like, a title to your group?

RALPH GOMORY: They seem like what?

IRV LUSTIG: Did they give a title to your group?

RALPH GOMORY: I forget what we were called. But I think it was probably something like Optimization.

IRV LUSTIG: Really? OK.

RALPH GOMORY: Yeah.

IRV LUSTIG: And at that time-- and this may be hard to answer, given your role at IBM as it evolved-- what do you think was the balance of doing theoretical math versus practical math within the IBM math department?

RALPH GOMORY: It was mostly theoretical, because it wasn't set up to be practical. I mean, we struggled to find out about the paper mill problem.

IRV LUSTIG: I see.

RALPH GOMORY: We weren't connected to other parts of IBM. It wasn't that people were scorning it, it wasn't there.

7. Leading IBM Research

IRV LUSTIG: Right. So now, while at IBM, your career then developed. You went from managing this small group of optimizers, we can call them, and you went on to lead the math department for a few years.

RALPH GOMORY: Yeah, that's true.

IRV LUSTIG: And so how did you make the transition from being part of a small group to leading the math department, and then eventually become director of research?

RALPH GOMORY: Well, I think it was just, I don't have a problem being a manager. I think I do that naturally. So I didn't have a problem being the head of the math department, and then when after a few years they needed a new director of research, they picked me. But that was going to be different, because now 10 years had elapsed.

And I went to see my new boss, Frank Cary. There's one year when he wasn't the head of IBM. But he was my boss, and then he became the head, the CEO. And I said, Frank, what do you want from the research division? And he thought a little bit, and he said, I don't want to be surprised by new technology. Because the technologies were changing very rapidly at that time.

And I listened very carefully, and I thought, well, I could do that with a staff of maybe 20, 30 people. I have 1,200 or so. And I think this whole model isn't going to work, OK? We've got to do something for IBM that counts, and that helps the company.

And all my previous exposure, to McDonnell Douglas and things, I could believe that we could all be on the wrong track, all these companies. And so I started working on how do we connect to IBM? And that was a tough, slow thing. We tried-- well, how much do you want to hear about that?

IRV LUSTIG: Well, I want to come back to that. Because I did have a question, because you were mentioning that you always felt kind of natural in management. But I know I've spoken to many of my colleagues who have had research careers or been involved as doing the work, right? Proving the theorems, writing the code, whatever it may be.

And then you make a transition to management, where you, frankly, don't have the time to do the things that you started off on. How did you manage that transition from solving interesting problems to becoming more of a manager?

RALPH GOMORY: You see, for me, they aren't different. I'm not a mathematician. I'm not a physicist. I just like thinking. And believe me, if you have 1,200 people and you want to make them useful, you have to think. And invent. For me, it's the same process.

And I'm glad you brought that up, because I've always been that way. So the reason I didn't feel it was much of a transition is just, I was changing subject matter.

IRV LUSTIG: It was a new, challenging problem.

RALPH GOMORY: A new, challenging problem. And it had to be invented, it wasn't lying there.

IRV LUSTIG: Right. So that then leads into what we were just talking about, is you had to change this IBM culture where now the research was going to be more beneficial to the company.

RALPH GOMORY: Yes.

IRV LUSTIG: So can you give some examples of how that occurred?

RALPH GOMORY: Well, the first thing I tried was I got all my direct reports, the people who reported to me, and we toured the development divisions. The divisions where they design the product before it goes into manufacturing, that's called development.

IRV LUSTIG: And the products then were computers? I guess typewriters were big then.

RALPH GOMORY: But of course, the development divisions, some of them, would be a component. A semiconductor. A disk drive. More like that. And wow. First of all, they had no clue as to what we could do or not do. Secondly, if it was important to them, they wanted to do it themselves. OK?

So it was a little bit like, we're going in there and saying, how can we help you? And they're saying, invent anti-gravity. That would be really good. You know? They didn't know what we could or couldn't do. So what I mainly got out of that was an appreciation of how difficult the problem was.

But over time we learned much more. And a very significant innovation was that I said, look, we are going to be responsible for transferring our technology into development. We would try, if people had ideas about a better printer, or better something. And they'd go to the development people, and the development people would say, well, we can't take that. Blah, blah, blah.

Sometimes they had good reasons, because they were on a schedule. They had to have their design complete. And now you're showing up in the middle of that schedule with something better? That's great, go away. All right? And so I learned that what we were doing didn't make sense, necessarily.

But so I said, we're going to be responsible for transferring our technology. And, you can't, without my approval or the approval of one of --, you can't turn off the attempt. And if you think you're right and they're wrong, we will appeal that to the top management of the company. That made people realistic, OK?

And so they started to learn what was really needed and when it was really needed. And both sides got confidence and knowledge of each other. And finally we ended up with something called joint programs. And I would credit Jim McGroddy, who eventually became the second director of research after me, with coming up with this notion.

Which, by the way, we went to Japan in the days when Japan was really learning how to do everything. Because there were patent exchanges and stuff. And we saw how the Japanese did things. And it was with government aid. They were getting into subjects they had never been in before. It was very impressive. I'm bringing this in because it comes up later.

So we saw that they took all these things. We learned something from them. And we came up with the concept of joint programs, which meant that the most advanced part of the development and research formed a single unit, say for the next generation of semiconductors, or two generations. And the semiconductor division was happy with that, because they didn't quite know what to do with their most advanced group. And we were happy, because we tied the two together.

And no one put up any money, you see, and both sides felt they gained. The semiconductor division said, oh, at last we got something rational happening in this thing which isn't our main problem, anyway, so we'll get back to work. And then by the time I retired from IBM, I think we had 18 joint programs. And they worked like a charm. They really worked well.

8. IBM Research Accomplishments Under Gomory's Leadership

IRV LUSTIG: So while you were director of research at IBM, you were overseeing 1,200 people. I imagine it grew during your tenure?

RALPH GOMORY: It grew, yes.

IRV LUSTIG: How large was it when you left?

RALPH GOMORY: Oh, I think it was around 1,500 or something. And we were getting good people, too.

IRV LUSTIG: And it wasn't just the activity here in New York.

RALPH GOMORY: No. Right.

IRV LUSTIG: The other labs were starting to grow under your leadership as well.

RALPH GOMORY: Yeah.

IRV LUSTIG: Did you start any of the other labs?

RALPH GOMORY: No. I think we had a lab in San Jose, which became the Almaden lab. I think I was the director when it grew into the new-- but they were there. They were there.

IRV LUSTIG: And then I think the others were Zurich.

RALPH GOMORY: Zurich, that's it.

IRV LUSTIG: And that was also there when you would--

RALPH GOMORY: Absolutely. And they had the world's most underrated lab manager. Karsten Drangeid, a Norwegian.

IRV LUSTIG: Underrated in what way?

RALPH GOMORY: He never got credit for anything. His lab produced two Nobel prizes.

IRV LUSTIG: But he didn't get the--

RALPH GOMORY: No one ever mentions Karsten Drangeid.

IRV LUSTIG: You were director of IBM Research for 18 years, was it?

RALPH GOMORY: Something like that.

IRV LUSTIG: And leading this large organization. What do you view as the most significant accomplishments of IBM Research during your tenure?

RALPH GOMORY: Well, probably we invented relational database, which all of you use. You may not know it. That kind of, that changes everything. That's a tremendous thing. We also invented what's called the RISC computer, which runs faster with the same amount of everything. And that's a very big thing.

But we also did, and much less obvious, a lot of little things. Because when there were real manufacturing problems-- you see, we had knowledge that others did not have. You take a wire and, say, it's connecting one circuit to another or one semiconductor chip to another. And you run current through it.

OK, current runs through wires, the laws are known. But when the wires get really thin, the current starts to carry away atoms. This was called the crack strike problem. So just running it destroyed it. OK?

Now your engineers don't know about that material problem. But our physicists can understand it. And they realized that by putting in certain other atoms in with the, whatever the conductor was. Let's say they could stop this process. OK?

So that kind of knowledge. Uh-oh, here we go. All right? We can't make this stuff work, because when we run it, it cracks. That kind of knowledge. If you're coming from a trusted source, and we were pretty much together in those days, can make all the difference. So we had a role in fixing things.

That particular example is a big one, but there were a lot of little ones. So we had knowledge that they didn't have. They knew all sorts of stuff that we didn't know. And so we worked out a role for ourselves. So much of the division's contribution was things like that.

IRV LUSTIG: I see.

RALPH GOMORY: And software, too.

IRV LUSTIG: And you mentioned earlier that there were two Nobel prizes that were awarded to members of IBM Research while you were in the lead.

RALPH GOMORY: Yeah.

IRV LUSTIG: So can you say a little bit about those, and if you had an interesting story to tell about how they were publicized.

RALPH GOMORY: They were both done at the Zurich lab, which was Karsten Drangeid's place, OK? He gets no credit.

The chaps who invented the scanning tunneling microscope, they didn't have any technician. And I was visiting. I said, we've got to get a technician. We have to move one out of the physical sciences thing. And the head of physical sciences objected to that.

And I said, well-- and I very rarely did this kind of thing-- we have to do this. He quit the next week. And went on to win the next Nobel Prize by inventing high-temperature superconductivity. He was a much better researcher than a manager.

So I really very seldom gave that kind of command. But it produced two Nobel prizes.

IRV LUSTIG: Now, I think we were talking earlier about--

RALPH GOMORY: But if we're talking about the contributions, this is not our contribution to IBM, but to the world. Benoit Mandelbrot, his invention of fractals.

IRV LUSTIG: Right.

RALPH GOMORY: All right? That's just a world-changing thing.

IRV LUSTIG: Yeah. We see them in animation every day.

RALPH GOMORY: Yes. Right. So that's a tremendous contribution. And I'll claim credit, because when I met Benoit, I said, this guy's different. And I really struggled to give him help. And he appreciated it, and he thanks me in his book.

IRV LUSTIG: So you were mentioning earlier when we were talking about the Nobel prizes, that IBM was a bit reluctant to publicize it. Do you mind telling that story?

RALPH GOMORY: We thought we were candidates with the scanning tunneling microscope, I think it was. By that time John Akers was the CEO. And I went to see him. We didn't get along that well. You know, we were very different. And I said, I think we might win this thing. And he said, uh-huh. And I said, we'll probably get a phone call in the morning. Do you want me to call you and wake you up? He said, no.

[BOTH LAUGHING]

And then we did win it, and I said, oh, great. Let's advertise that we won this thing. You know, Bell Labs is always rubbing it into us that they win a Nobel Prize and we don't. It will be good for hiring people, good for the reputation of IBM. And he wouldn't do it. At that time, I didn't understand why. Now I do. He had a good reason.

IRV LUSTIG: And that reason was?

RALPH GOMORY: And the reason was that the world had started to change. And the influence of the shareholders, which were all financial. The big ones, financial firms. Their influence was, you've got to get results now, next quarter or at the end of the year. And research, they viewed as an expense that might produce something in the future.

So basically, the shareholders, who are represented by the financial firms, were against firms that invested in research. And John, I think correctly-- and I'm just attributing this reason to him in

retrospect, but very likely-- was saying, I'm not going to advertise the fact that we've won a Nobel Prize. Because that's like saying you're doing basic research. It wasn't. It was very applied research. Didn't matter. Nobel Prize means--

IRV LUSTIG: Basic research.

RALPH GOMORY: Yeah. So I never could get him to do it. And I didn't understand that at the time. But I saw that over and over again in every company.

IRV LUSTIG: Right. And I think later on, I think you've talked about the role and written about-- and I think we'll get to your work at the Sloan Foundation-- about the impact of research and the interactions between science and technology in the firm.

RALPH GOMORY: Yes.

IRV LUSTIG: So we'll table that thought for the moment. I wanted to finish up the discussion about your leadership at IBM Research. Are you able to contrast today's IBM Research environment with the one that you left behind?

RALPH GOMORY: Well, I can't contrast the environment. I have not kept in touch with IBM Research. That's a quarter of a century since I left, OK? And when I leave, I say--

IRV LUSTIG: Goodbye.

RALPH GOMORY: God bless you. But I can say the environment, meaning the environment around IBM as far as research is concerned, and any other company, is a very poor one.

IRV LUSTIG: In what way?

RALPH GOMORY: Pretty much what I was trying to explain. That the shareholders are on a very short fuse. They don't know much about the company. They buy and sell. The average share of stock is held only for less than a year. And long-range investment is frowned on.

IRV LUSTIG: And so I imagine, then, you would say that if you look at today-- I know years ago in the time when IBM Research, when you were there, you had companies like GE and AT&T, et cetera, that were investing in basic research.

RALPH GOMORY: Yes.

IRV LUSTIG: And that generally has disappeared. IBM is one of the few companies that's left with the basic research.

RALPH GOMORY: And that's because-- I thought it was going to happen. And I spent 18 years figuring out ways to make them directly useful. I mean, that was solving that problem for me.

IRV LUSTIG: Right.

RALPH GOMORY: Yeah.

9. The Sloan Foundation

IRV LUSTIG: So after years of leading IBM Research, you left IBM to join the Sloan Foundation.

RALPH GOMORY: Yes.

IRV LUSTIG: What were the factors that led you to make that change?

RALPH GOMORY: Well, there was one big factor. I would have stayed on, except I reached the magic age of 60. And at that time, officers of the company-- and I was at that time a senior vice president-- had to retire at 60.

IRV LUSTIG: So how did you end up at Sloan?

RALPH GOMORY: Oh, well, that was quite natural. They needed a new president. Their president was retiring. And I knew the people on the board, they knew me. The world of technology and science, the leaders know each other.

IRV LUSTIG: I see.

RALPH GOMORY: OK? So they talked to me and I said, look, I have some things on my mind that I want to do, that I couldn't do at IBM. And I told them about some of them. And I said, if you want me, I want to be able to do these things. And they said, sure. They didn't have search firms and all that stuff.

IRV LUSTIG: So I know during your time at Sloan, you wrote articles about the often-misunderstood relationships between science, technology, productivity, and a successful economy, which was influenced by your time at IBM.

RALPH GOMORY: Very much so, yeah.

IRV LUSTIG: So you had really two roles. You were writing, doing your own authoring things. You were also leading the organization. So let's first talk about your own personal contributions while at Sloan. What would you view, from that time, as some of your key contributions and writings from that time?

RALPH GOMORY: In my own research?

IRV LUSTIG: In your own work. Yes.

RALPH GOMORY: I think, very clearly, it was a fundamental contribution to the theory of trade. You see, I had been exposed to the Japanese thing, and so I thought, there's something

wrong with this notion that if you just leave everything alone, everything is good for everybody in trade. First of all, the Japanese weren't leaving things alone.

And secondly, they were growing. They were getting into the industries that we had and taking part of it. Their economy was not static. You see, generally, the economists had looked at-- and there were exceptions to this-- a static model. Say, OK, you've got these capabilities, I've got these capabilities. We trade, we're better off.

And that's right, by the way. But the difference is, hey, capabilities can be acquired. See, it was hard to grow grapes in England and acquire what Portugal was good at and all that stuff. But so the question is, what happens when your trading partner is getting good at different things? All right?

And I teamed up with Will Baumol, the very well-known economist, and wrote a book on that subject. And I was helped enormously by a former classmate who had become a professor of economics at Yale, Herbert Scarf. Herb taught me what the relevant equations were, and I could really solve them, right? Most economists couldn't do that.

IRV LUSTIG: So you were able to sort of bring back your old mathematical talent into this work?

RALPH GOMORY: Absolutely. It was crucial. Both linear and integer programming enabled me to show, and Will helped me, the former head of the-- anyway, a very well-known economist. He just died, unfortunately. And I wrote an article taking a standard model and introducing economies of scale. That's where the integers come in.

IRV LUSTIG: I see.

RALPH GOMORY: And then he and I wrote a book together, which was endorsed on the back by a Nobel Prize winner and the leading person in international trade. So it had high-level acceptance, but it was not what anyone wanted to hear. Because the title of the book was Global Trade and Conflicting National Interests.

Because what we showed in the book was, what's good for one country, if it's growing, can very easily be bad for the other. There's a fundamental conflict. There's a place in the middle that's good, but it's unstable. Both of them can gain if they can push the other one away. Right?

So that's not a picture that anyone wanted. And so our corporations have gone cheerfully on moving the jobs overseas and everything, and doing things that are harmful to the country, and saying, well, this is just free trade. But it isn't. It's more than that. It's changing our capabilities and theirs. And that can be damaging, and has been damaging.

IRV LUSTIG: Right. So I asked the question about your individual contributions, but then you were also leading this foundation that was leading a number of different key initiatives. So which ones of those initiatives that you were overseeing, maybe not directly involved in, were you most proud of while you were at Sloan?

RALPH GOMORY: I think the one I'm certainly most proud of was one that we could never have done without the support of the foundation board and money. Which is we took the idea of online learning, which shouldn't exist, really. I was able to persuade Frank Mayadas, who had run the Almaden lab for me, to come with me to Sloan because things were getting tough in IBM and he saw, hey. We can do something at this other place.

And so we took seriously, and most people didn't at that time, the notion that you could-- you'd call it today online learning. But you couldn't call it that then, because there was no internet.

IRV LUSTIG: Yeah. There was no "line" to be "on."

RALPH GOMORY: There was nothing to be online. OK? Companies would have their own thing.

IRV LUSTIG: Internal networks.

RALPH GOMORY: Internal networks. And there were some proprietary systems they could buy, but it would just be-- all right? But there were a few people who thought you could learn that way. And different ideas.

And so Frank and I said, we're going to make this thing happen. And we developed a certain style of learning called ALN, which stood for-- very catchy-- asynchronous learning network. OK? So you have a professor, a regular professor, and he puts up his lectures, let's say, as text. By the way, all this is on phone lines. No broadband.

IRV LUSTIG: That's right. No video.

RALPH GOMORY: But anyway, phone lines can carry text. So he's got his lecture up there, and examples, and homework and stuff. And you read it and you react to it, and you send in your stuff. Your homework or whatever. And it was asynchronous because not only did you not have to be there for the lecture, but you could do your work at any time. You could read this when you had time to read it.

IRV LUSTIG: Right. Which is exactly how the online learning is working today.

RALPH GOMORY: Of course. That, of course, no one thought that-- anyway, we could find people who were willing to try it, and we even found a few people who had taught a course not quite exactly like that, but OK. But we started to do it. And we were lucky.

And we had got everyone in the US who was interested at one table. So about 20, 25 people. And we said, we'll fund this kind of stuff. Try it. And some of them wanted to. And there were a lot of very good guys.

And it started, and it seemed to work. They did all the different things, but we stuck to the asynchronous model throughout. And it was working. And one very smart thing we did was we refused-- places like MIT wouldn't touch it, or Harvard, OK? They wouldn't use it.

They said, well, if you want to, we'll do an experiment for you. We'll test your thing against a normal classroom. And one thing we were smart about was, we wouldn't touch it. A normal classroom-- and this background helps-- is highly developed. It's been around for many years. They do a lot of little things right. This thing? It's the first.

IRV LUSTIG: It's all new.

RALPH GOMORY: It's all new. It's all clumsy. I don't care how-- all right, I don't want the bad news. I know it'll be bad. So we wouldn't touch anybody who wanted to test. We just funded people who wanted to do it for whatever crazy reason. And it started, and it seemed to be working. And they just started getting better at it.

And then we were lucky. The internet appeared. So that took a lot of the burden of learning away, OK? And then it really took off. Each year we had an annual meeting and-- bigger. I don't know how big.

It was a few million people coupled by the year 2000 or 2001, and I think by 2004 there were four or five or six million people taking courses for credit at established schools and paying for it. But see, they could pay for it because they could keep working. That was the-- we wanted to do something for people who couldn't afford to take the time off to go to college. Reference my farmer.

IRV LUSTIG: Right.

RALPH GOMORY: OK? I believed in those people.

IRV LUSTIG: That's right. That's right. So that would give those people opportunities, give working people opportunities to learn.

RALPH GOMORY: Because you couldn't make a living farming anymore, really. It turned into something else. And so it became a huge success.

And most people don't know about it, because after we'd done this and had all these millions of people, finally the Harvards and MITs and so forth said, oh, well. Or Stanford. Started putting courses online. With no support, no credit, and no charge. They were just giving it away.

And everybody, oh, my god, these MOOCs, they called them. They've just invented online learning!

IRV LUSTIG: Without knowing that there was some foundational work done by Sloan Foundation.

RALPH GOMORY: Well, no, that we had a working thing. That people got credit and paid for it, and no one got credit for these things, and most people dropped right out of it.

IRV LUSTIG: Well, and the other part, as you were saying, is, now it's online learning in 2017. It's very common, everybody knows you can get degrees 100% online from universities.

RALPH GOMORY: Yeah.

IRV LUSTIG: We're rewinding the clock now 20 or so years, to when you were experimenting and developing the concept.

RALPH GOMORY: Well, the things that the MITs and Harvards did were not what we proposed. We proposed a professor and interaction with them, OK? The MOOCs, the massive online courses, had none of those things. They just put up the course.

IRV LUSTIG: They put up the material and you do with it what you want.

RALPH GOMORY: Good luck.

IRV LUSTIG: Right.

RALPH GOMORY: Right. And that doesn't work for most people. It works for some people. And even if it worked for them, they had gotten no credit. So they've gradually modified. But mostly the schools-- I mean, you've got to give people support.

So anyway, that was a huge success, it really was. And I like having the chance to talk about it, because most people don't know it ever happened.

IRV LUSTIG: Well, no. And it is a great story. It's absolutely a great story. All right, so besides the project about online learning at Sloan, were there other projects that you were involved in leading at Sloan that you're proud of?

RALPH GOMORY: Yes. There really are. There are many, and I can't name them all in this.

IRV LUSTIG: So maybe pick your top three.

RALPH GOMORY: One of them, with the online learning, that was partly my idea. But with the things I'm going to describe now, my only role was being able to recognize and help people.

The Census of Marine Life was just a wonderful thing. Jesse Ausubel really thought it up, a very independent-minded person, and made it happen. And he was able to galvanize a worldwide program. We supplied the money, he supplied the-- and the first attempt to see what life is in the oceans. What's there and not there, and what is the life of the animals? For instance, where do the whales go? OK?

And you see, with satellites and things, you can actually follow some of the marine animals and find out where do they go at what season, they cross the oceans, they meet over here, they breed, they scatter. What that whole pattern is, for example, for whales. And you can tag animals and then listen to what they do.

So we shed an enormous amount of light, for the first time, on what's in the ocean. So we called it the Census of Marine Life. And it was a really wonderful idea of his, and it was a good way to use the foundation's money.

IRV LUSTIG: That does sound like a great project.

RALPH GOMORY: And a similar thing was the Sloan Sky Survey, in which we put up the money to build a new kind of telescope, which was called the Sloan. And it's still called the Sloan. And it was totally automated, and all the results from-- it was built to count the stars and how much they are deviated,

I mean, it could take in enormous masses of data. It wasn't limited to a person, all right? And all of that flowed into a databank which everybody could use, so it was a new kind of open astronomy in addition. And it has shed an enormous-- you can look it up in Wikipedia or anything-- light on the distribution of dark matter. It turns out that most of the universe is made up of dark matter. Things like that. So it really has added to our understanding of the universe.

IRV LUSTIG: That's very cool.

RALPH GOMORY: So it was a very, very good program. And I'll just say that we also continued to study industries, and later this week I'm going to a meeting of the Industry Studies Association, which Sloan founded. And it's still going and studying different industries, say, the financial measures are not enough, all right? You have to understand how it works. And these people study that.

So those are more. There are tons more.

10. Research Professor at New York University

IRV LUSTIG: I'm sure. Well, let's move on now. About 10 years ago, you left to join NYU. I think you're a research professor in the Business School.

RALPH GOMORY: That's correct.

IRV LUSTIG: And from your bibliography, it seems you came back to doing some work in integer programming. I remember seeing you within the past 10 years speak at a conference about some of your more recent things. How did you make that transition from having not really worked deeply in the field since the Gomory cut days?

RALPH GOMORY: Oh, please. Not since then? I did an awful lot after that! No, it was more, I didn't do that much work. Mostly down at NYU I collaborated with Will Baumol on more economics, often using linear and integer programming. And also with Richard Sylla, a well-known historian of economics, on how the change came about in the American corporations.

So I really spent most of my time on pursuing some of my other directions. Understanding the corporation, the motivations of them and so forth, and collaborating with people in those areas.

Yes, I did do some work, but it was mostly tied to not cutting planes. Please. That was so long ago. It was all the things that had come out of that, like the study of corner polyhedra and so forth.

IRV LUSTIG: Right.

RALPH GOMORY: And it was mostly retrospective.

IRV LUSTIG: I see. OK. So you've written, while at NYU, about issues related to your interests in economics.

RALPH GOMORY: Yes.

IRV LUSTIG: I think you mentioned earlier, during your schooling days, while you were in college, you said, getting into the physics of the atom, you said, well, maybe this economics stuff is more interesting.

RALPH GOMORY: Yes.

IRV LUSTIG: Can you talk about how that evolved from your early exposure in college, through your time at IBM and at the Sloan Foundation, how your interest in economics, including the roles of the corporation and free trade, has evolved and how it connects between those experiences?

RALPH GOMORY: Well, I think actually it started while I was still at the two-year stint at Princeton. There was a young-- I was assistant professor by then. Will Baumol was an assistant professor. And we'd wrote a paper together in which we tried to interpret the economic meaning of cutting planes. So that's how we got together, so that was 1958 or '59.

IRV LUSTIG: Yeah, like 60 years ago.

RALPH GOMORY: Yeah. Right. And so when I had time and motivation to pursue what I thought were problems in trade with Japan, and all that kind of stuff, it was natural for me to look up Will. And Will was a professor in the Business School.

IRV LUSTIG: Here at NYU?

RALPH GOMORY: Yeah, at NYU. So it wasn't that much transition, it was more like we were just resuming. Well, as I say, we'd already gotten together when we wrote the book. So really NYU has been a continuation of all the things that I have thought about.

IRV LUSTIG: Right.

RALPH GOMORY: Yeah.

IRV LUSTIG: Right, and you continue to be productive today in terms of writing and thinking about different things.

RALPH GOMORY: Oh, I even write things aimed at Capitol Hill and published in The Hill magazine.

11. Operations Research Today

IRV LUSTIG: So we took a break, and I know during the break you talked about how there seems to be a common theme coming out as you look at your long career. And even going back, I think, to your time at the school, when you were a young man.

RALPH GOMORY: Yes, it all comes back to the school, I think.

IRV LUSTIG: About understanding how things work and why things work.

RALPH GOMORY: Yeah. Yeah.

IRV LUSTIG: It seems you're still looking at that today.

RALPH GOMORY: I am still interested. And I'm still learning stuff, too.

IRV LUSTIG: So I'd like to turn us a little bit back onto operations research and optimization.

RALPH GOMORY: Yes.

IRV LUSTIG: From your perspective, do you have opinions on how you feel the field of operations research has developed over time, from when you were first introduced to it and to where it is today?

RALPH GOMORY: I think there's been tremendous progress. You see, the surroundings for companies, I think, have become difficult. The surroundings for analyzing and using OR, and the methodology, have become much better, OK? Like, 10 times better every 10 years. All right?

Which means that since I was at Princeton, a million times, at least, better, right? Because instead of having a room that only a few people could put in a program, I have in my jacket pocket here something much more powerful and easy to use. So the sheer overwhelming ability to use this just has helped make it possible to analyze things and data to an extent that I don't see how OR can miss.

I mean, we may not even call it OR. We might call it "what we always do." This is what we just normally do.

IRV LUSTIG: Well, we have these debates now about, should we keep calling it operations research? Or management science? Or should we call it advanced analytics? Data science is the buzzword of the day.

RALPH GOMORY: The advanced analytics is very hard to separate from artificial intelligence.

IRV LUSTIG: Right.

RALPH GOMORY: And so we're in a benign situation for doing the kinds of things that we used to call operations research.

IRV LUSTIG: Right. That's right. So are you able to take the perspective and realize now much of your work is more in the economics and that's where your thinking has been? Do you have a perspective as to how you see that the field is going? I mean, maybe we've kind of answered that.

RALPH GOMORY: I think I've done my best.

IRV LUSTIG: So I want to end with this following question, which I know you said would be a difficult one to answer, but you know I'm going to ask it anyway. So you've had a long and illustrious career. You know I've done a number of these interviews with a number of the founding people in math programming, and your career has certainly had a lot of diversity to it. The OR community certainly knows about your fundamental contributions in discovering integer programming. Beyond that, how would you like to be remembered?

RALPH GOMORY: I think I would like to be remembered as someone who had a lot of ability to invent and solve problems, and tried to use them in good ways.

IRV LUSTIG: So the good ways, as an example, like the online learning?

RALPH GOMORY: Like online learning, or getting to the roots of why trade is having a negative impact on the country, in the hope of changing that. That sort of thing.

IRV LUSTIG: That's really great. Hopefully this video will help preserve some of that.

RALPH GOMORY: Thank you.

IRV LUSTIG: I want to thank you for your time today. It's been a real pleasure having this conversation with you.

RALPH GOMORY: Well, it's been a real pleasure for me to be able to talk about these things. So I want to thank you. You made it very easy and you are very helpful.

IRV LUSTIG: All right. Thank you, Ralph.

RALPH GOMORY: Thank you.