Chapter 1: Beginnings of Linear Programming

IRV LUSTIG: So Professor Dantzig, we've had a lot of conversations in the past about the history of linear programming. And we all call you the father of linear programming. So can you tell the story of how things began?

GEORGE DANTZIG: Well, I can tell you how I became the father of linear programming. I was invited-- this was in the very early days-- I was invited to Japan. And I came off the plane.

And the people who were my hosts kept looking for me because they couldn't find me because they had the vision that the one who originated linear programming would be an old man. And in those days I was still very young. So that's the way I became the father of linear programming. They named me.

IRV LUSTIG: So how did the work in linear programming begin?

GEORGE DANTZIG: Well, it certainly didn't begin as linear programming. It was part of the aftermath of World War II. It was an effort on the part of my friends in the Pentagon to keep me there. I was looking for an academic job at the time.

And all during the war, I had been doing planning and things of this sort. And they tried to find some reason for my staying. These were two people. One was named Marshall Wood and the other was named-- it escaped me-- Al Hitchcock.

IRV LUSTIG: Is that the same Hitchcock as the Hitchcock--

GEORGE DANTZIG: Not that Hitchcock.

IRV LUSTIG: A different Hitchcock.

GEORGE DANTZIG: I don't think I quite know what you're talking about. Which Hitchcock?

IRV LUSTIG: The Hitchcock-Koopmans transportation problem.

GEORGE DANTZIG: No, not that one. That Hitchcock was a professor at MIT. And the time that he wrote that, it was towards the end of his life. And I think it was the only thing he did. And I never met him. But he did exist in my time.

IRV LUSTIG: So at the Pentagon, Marshall Wood and Al Hitchcock were trying to find a way to have you stay.

GEORGE DANTZIG: Yes. During the war, I was head of a group which was called Combat Analysis. And it's part of statistical control. And it was a big position. And Tex Thornton was the head of it. He later on became the head of Litton Industries.

I don't know if you can remember there's a new building here on campus. It was a legacy of Tex Thornton.

So during the war, I was in charge of a group which was called Combat Analysis. But I also did a lot of work in helping other groups within the Pentagon do planning.

Then the war ended. And I went out to Berkeley to finish my PhD. That was one semester.

And then I came back to the Pentagon because Berkeley made me an offer. But I didn't like it. It was too small.

Or to be more exact, my wife didn't like it. It was a grand salary of $1,400 a year. She didn't see how we could live on that and then have a child, too. So she said no.

So I went back to the Pentagon to look around for another job. I was actively looking. And this was June of 1946.

I was actively looking for a job at a university. And I had received a number of offers. And I had received a number of un-offers.

And they looked for something that I might do to keep me in interest. And the idea came up to mechanize the planning process.

Before that, the Pentagon was all done by hand.

IRV LUSTIG: What kinds of planning were they doing by hand at that time?

GEORGE DANTZIG: Well, if you want to know, the war effort was an enormous effort. And it took place in a period of about four years.

And by the end of the war, it was essentially doing the same thing-- planning a whole country on an enormous scale. And we developed all kinds of special techniques for doing it by hand.

IRV LUSTIG: So they were looking to plan the different operations, in terms of deployment of forces and logistics?

GEORGE DANTZIG: That's right. And it was complete from the logistics of nuts and bolts, to training and people, to the manufacturing of airplanes, manufacturing of everything that was going on.

And the scale of operations just blows your mind. There were hundreds of thousands of different kinds of material goods. And there were maybe 50,000 specialties of people.

My office was in charge of the actual combat itself, keeping track of number of sorties flown-- that sort of thing-- the casualties, the attrition rates. I was also sort of-- I'll say-- hired out. But that's of course not correct. Nobody paid me to work with various parts of the Air Force on their planning. So I became a skilled expert-- but doing it by hand. Essentially, the hand techniques.

IRV LUSTIG: At the time there was no-- they were just trying to plan how we're going to get this done, without worrying about trying to do it efficiently. Is that correct?

GEORGE DANTZIG: Of course, we always pretended we were doing it efficiently. And so we developed various techniques.

At the end of the war, everything began to dissolve and break up and people went their own ways. Their own ways meant getting out of the military work and going back to civilian life again.

So my process of looking for a job after I finished my PhD was to find an academic job. But I looked at other places as well.

IRV LUSTIG: Now at the Defense Department, you began to work on the planning problems that led to one of the first papers, which was Programming in a Linear Structure. Were there specific models that you had in mind at that time in the development of the new programming model?

GEORGE DANTZIG: They paralleled very closely with the military planning. We weren't trying to start a completely different planning process than what the Air Force was using. In fact, all we tried to do was speed it up and do it more quickly, and to organize it.

IRV LUSTIG: Now when the first development came, you came up with the linear programming model. And then there was the development of the simplex method.

GEORGE DANTZIG: That was the order in which things happened, yes.

IRV LUSTIG: And once the method was developed, was it then used by hand immediately to solve some of these planning problems?

GEORGE DANTZIG: You've got to remember there wasn't any computers.

IRV LUSTIG: Right.

GEORGE DANTZIG: I mean, it was a great idea. Everybody immediately saw that it had great potential. So we went through the game that we were going to do the whole planning process using computers. And in fact we were responsible for actually getting money from the Air Force and from the Military to the manufacturers to build computers and to do the research on them.

Chapter 2: Early Applications and The First Solved Linear Program

IRV LUSTIG: I've always tried to look for connections between the early development of computers, and the first UNIVACs that occurred at Pennsylvania, and the development of linear programming at the time. Can you describe some of those connections?

GEORGE DANTZIG: The idea of developing computers was people like the University of Pennsylvania--Eckert and John Mauchly. I think John was his first name.

IRV LUSTIG: Were some of the computers that were being built by the manufacturers then built really for the applications of linear programming?

GEORGE DANTZIG: Yes. Of course, there were other people that had different ideas.

IRV LUSTIG: So how early would you say was the military able to realize some of the benefits of the models and then the algorithm for solving these models?

GEORGE DANTZIG: I'd say a ten year period. In other words, 1945 saw the beginning of this field. And it wasn't until 1955 that any of the computers really worked.

IRV LUSTIG: Right. So prior to that, there were problems that you solved by hand.

GEORGE DANTZIG: All problems we solved by hand.

IRV LUSTIG: So can you tell us about the first applications of linear programming that you did solve by hand?

GEORGE DANTZIG: There was something called the Berlin Airlift. At the time, we were having a lot of trouble with the Russians and they had blockaded Berlin so that the American and Allied Forces-- other than Russia-- were like prisoners in the middle of Berlin.

And the only way that supplies were coming in to Berlin at all was via airplanes. And the United States and Britain had control of an airfield in the Berlin area. And we were flying in supplies.

And so there was one program that we invented called the Berlin Airlift, which set up the logistics of it. And we solved that problem. It was all pretend because there were no computers to solve that problem.

IRV LUSTIG: So by hand, essentially, you were-- at that time, it was the tableau method-- what we call today the tableau pivoting simplex method-- that you would be doing by hand.

GEORGE DANTZIG: No, it was more primitive than that. We just laid out a schedule like you would for doing it.

IRV LUSTIG: I see. Now, what would you say would be the first problems that were practically solved with the simplex method, by hand or by computer?

GEORGE DANTZIG: I'd say the diet problem.

IRV LUSTIG: And do you recall when that was done?

GEORGE DANTZIG: I think it was done early in the 1950's, when I was at RAND Corporation.

IRV LUSTIG: And would you say that when that particular problem was solved, was that also done by hand?

GEORGE DANTZIG: There was a man by the name of Stigler. And he wrote a paper called The Diet Problem. And he also outlined how he solved the problem. And he wrote it up.

And how he guessed the problem-- how he guessed the optimal solution. So one of the first things that we did is that I was looking around for a problem to illustrate how this simplex method worked.

And I got in touch with some friends that I had in the Bureau of Labor Statistics. One of them was Jerry Cornfield and another named Duane Evans.

And we all met and they suggested that we try it out on the diet problem. And I tried to get a hold of it. And Jerry Cornfield said that he had prepared the material, and that he would get it for me. So he got me part of the problem.

And I had to go to the Economics Unit of-- [LAUGHS] 50 years ago. I'm a little bit rusty on it.

So these, I guess, were before you were born!

IRV LUSTIG: That's right.

GEORGE DANTZIG: Anyway, I decided that would be a good show problem.

IRV LUSTIG: And then when you solved that problem, at that point, it was by hand-- pivoting?

GEORGE DANTZIG: Yes.

IRV LUSTIG: And so you had a bunch of people working together to do the arithmetic.

GEORGE DANTZIG: There's a fellow that worked for the Bureau of Standards. The Bureau of Standards had a computation group located in New York City. And so I arranged with a fellow by the name of Jack Laderman to have the computation done. And it was done by hand in New York City.

And what Jack Laderman did is he got-- let's say-- 30 different people working in it simultaneously. So we had a parallel operation going on.

And so the problem as a linear program had about 10 rows. And it had close to 100 different foods.

And the diet problem-- he worked for selecting the optimum diet. And so he parcelled it out to his various helpers. I'd say there were a whole bunch. I don't know how many.

But they each had a little piece of this tableau which they did the operations on. And they were all on individual little pieces of paper like this. But it was really one big tableau-- very, very long and not too deep.

And then he pasted it all together so it would look like one sheet. So this is the way the first one was solved.

IRV LUSTIG: I know you've told--

GEORGE DANTZIG: By the way, the answer that Stiglitz got was wrong. He did not find the optimum solution. Ours was $0.36 cents cheaper. And this was for a whole year.

IRV LUSTIG: There's actually a new paper Saul Gass did with-- I think we looked at the old problem in today's prices. And then did a more modern version-- like certain foods that we eat today that we wouldn't eat yesterday, and vice versa.

And we solved it. So I just skimmed it quickly. But that just appeared within the past month. So it's still an active problem of interest.

Chapter 3: Programming, Optimization and Objective Functions

I know we've talked about and seen in your book how Koopmans suggested taking the term programming in a linear structure and created the term linear programming. And later on, we have now mathematical programming, and the Mathematical Programming Society.

Today, as we're trying to market optimization, we're using optimization as a word to describe mathematical programming and other methods of optimization. Can you recall at all when optimization started to become used as a word in the field?

GEORGE DANTZIG: Well, the whole idea of objective functions-- which, of course, optimization implies-- was not known prior to linear programming. In other words, the idea of optimizing something was something that nobody could do. Nobody tried to optimize.

So while you are very happy with it and say it's a very familiar term, optimization just meant doing it better than somebody else. And the whole concept of getting the optimum solution just didn't exist. And so my introducing the whole idea of optimization in the early days was novel.

IRV LUSTIG: Well, it was with respect to introducing the objective function over the set of constraints.

GEORGE DANTZIG: That's right. If you talked to somebody, they acted like, well, yes, this is optimal. This is better. But it was only in the sense that it was really better. And the fact that you were talking about it in the mathematical sense of the optimum just was not part of the realistic vocabulary.

In fact, in your letter to me, stressing the idea that this optimization is a popular term these days was a surprise. Because I don't think of this as being a popular concept. And the usual meaning of that was not as precise as we do it in practice.

IRV LUSTIG: Well, it's interesting. Because if you go back 10 years, optimization as even the name of any of our journals was not used. The Mathematical Programming Society has the society in the journal.

And I recall a talk once by Margaret Wright that I heard about five, seven years ago, where she said one of the smartest things we ever did was start using the word optimization. Because now we can explain to other people what is that we do.

And so it's one of the reasons-- and I think as I've been talking more now to lay people and keying on this word, it's been helpful. Because if I went to them and said we do mathematical programming, they have no clue what we're talking about.

Going back to the time of the invention of the simplex method, what kinds of people were you working with, at that time?

GEORGE DANTZIG: Well, let me say a few words about the sort of mathematical programming. One of the people who was at the Pentagon, in those days, was a chap, an economist, well known-- Harvard professor, eventually. And that was Robert Dorfman, Bob Dorfman. And he was after me to use the term mathematical programming, and not linear programming.

And I felt that the whole way in which economists would set up their models was far, far more general than the linear program. Linear program was a special case. And that, in order for the field to progress, we should stick to the simpler term-- linear program. So he was after me, right from the very beginning, why not generalize it? Why not use a more general term? Mathematical program.

And I had the view that you had linear systems-- if you think of your mathematical background, you had linear systems of equations that you solved. And then you went through the calculus and the more general mathematical systems. So that I felt that linear programming was the foundation of the field. You had to be able to solve linear programs first, and then go generalize it.

But the economist had generalized it already-- made it so general that you couldn't get your hands on it, and use it for practical planning. Because practical planning, such as we were doing in the development of the military during World War II, was essentially linear programs, without the objective function. So that was the basis by which we went.

And then, as you put the objective function, how did they then solve these military systems? Well, they laid out the conditions of the logistical operations. The sorties that were being sought, and everything else. And these were all linear programs, but they didn't have anything that was driving them. And how did you then get something to drive?

Well, he got a military general to say, well, our objective is to do the following. So you had all kinds of special rules for achieving optimum solutions-- what they defined to be an optimum solution. And they kept thousands and thousands of special rules. And what makes me very nervous about what's going on at present time is that these computers are so powerful, that you can introduce all kinds of special cases and special conditions on the system.

And it's closer to the way old fashioned planning was done. You have to introduce many, many rules as part of the system. And then, I said to myself, but we can't work with all these rules, because what it meant is that you set up a plan, and then you'd have so many rules that you had to get resolution of these rules, and statements of what they were. And you'd have to be running to the general, and his assistants, and asking them all kinds of questions.

What you want to do? What is your purpose? And of course, the general question is, if you ask, what is your purpose? Well, you say, the purpose is to win the war. What do you mean by winning the war?

Well, it meant, if you were a Navy guy, it meant building battleships. So that became-- replaced the objective. You'd say, well, we're going to build the battleships. And then, the next question is, how do you build a battleship? And these guys will says, well, we've got to make them 3 inches thick. That became another objective.

And so on and on and on, there were these objectives added in. Because on top of the linear program, you had to try to drive the system by something. And these were ground rules. These were called ground rules.

IRV LUSTIG: Now what would you say brought the word programming into it? I mean, was that a word that was used a lot in the military?

GEORGE DANTZIG: Yes, it's just another word for-- programming was just another word for planning.

IRV LUSTIG: Right. It's interesting that--

GEORGE DANTZIG: This is the program. We're going to have-- the program was essentially a schedule.

IRV LUSTIG: And it's interesting today, because the proliferation of the computer, and computer programming, people then don't understand that we're talking about a different kind of programming when we speak of mathematical programming.

GEORGE DANTZIG: That's right. The word programming was used and linear programming was in vogue before programming of computer. Coding-- we'd call that coding. Coding for the computer.

IRV LUSTIG: So maybe we should get the computer programmers to call themselves computer coders.

GEORGE DANTZIG: Yeah, that's right.

IRV LUSTIG: What kinds of ideas would you say you worked on, lines of research didn't work?

GEORGE DANTZIG: Well, of course, my beef-- and I read your letter very carefully, but I didn't see it anywhere-- is there's nothing in there about the words uncertainty-- planning under uncertainty. This I feel is the real field, where we should be all working on.

IRV LUSTIG: Well, in fact, it was your interests, even at the beginning, was to work on those problems.

GEORGE DANTZIG: That's correct.

IRV LUSTIG: And I think we've made good progress, in that regard. But I think even today, our ability to compute on those problems is still a challenge.

GEORGE DANTZIG: Well, I don't think you've got to first base yet.

Chapter 4: Early Collaborations and Symposium Zero

IRV LUSTIG: Yeah. What people in the field have you admired, from really-- I would say, I know you've taught a lot of students, including myself. But you've also had the people that you worked with at the time, that you admired for the work that they were doing?

GEORGE DANTZIG: I certainly admire some of the pioneers of the field who early realized that it was a real good potential. So that would be Al Tucker, who you met. And that whole Princeton group, which consisted of David Gale, Harold Kuhn, and Lloyd Shapley. They were early pioneers in the field.

Then the economic group, which were headed up by Tjalling Koopmans. Tjalling was at the University of Chicago at the time. Then he moved to Yale.

This book was found in Germany. We couldn't find it anywhere around here, but, it was found in Germany by someone who is currently writing a PhD on this very subject.

This book is a remarkable book. It's called Activity Analysis of Production and Allocation. It's the proceedings of a conference that was held in 1949.

IRV LUSTIG: And this is now referred to as sort of symposium zero?

GEORGE DANTZIG: This is symposium zero. It was the proceedings of the conference two years after it started, since when it started was '47. So this would be '49. And if you can imagine it, it was a field that didn't exist in 1947, just started. And two years afterwards, you had a conference that produced these proceedings.

You can read this book today, and it's just as up to date. Because in those days, everybody who were involved in the war effort and were hungry to do something-- somebody realized this was a new field with great potential. And they began to write papers and do things on the subject.

IRV LUSTIG: Now how were-- I mean, today, with the internet and the worldwide web, and email, we're able to send papers across the world in a matter of minutes. But back then, there was no internet. There wasn't fax machines. How were people communicating among the various institutions about the work that was going on?

GEORGE DANTZIG: Not very quickly. Not very quickly.

IRV LUSTIG: But you would just have personal meetings, people going by train from institution to institution?

GEORGE DANTZIG: From time to time, we would have meetings. For example, this was in '49. But it was decided very early to have another meeting soon. And soon meant three years. Like for example, the one that you went into in--

IRV LUSTIG: Atlanta.

GEORGE DANTZIG: In-- where was it?

IRV LUSTIG: We were in Atlanta last August.

GEORGE DANTZIG: Louanne.

IRV LUSTIG: Lausanne.

GEORGE DANTZIG: Lausanne, that's right. One of the, I don't know, the thirteenth or fourteenth or fifteenth meeting. But that has been going all the way down from the first one, which was this one. And yet, in three years, from the beginning-- it was two years from the beginning-- people who were involved in the war effort and who had some kind of job, but not what they really wanted to do.

And so they were looking for a new outlet-- something different. So Koopmans, who was an economist, he was at the University of Chicago, Cowles Foundation. And he was very influential. And he introduced a lot of people to the whole field. For example, Ken Arrow which is one of the first people who got the Nobel Prize in Economics. Well, he was the second one to get it-- the second or third.

He was there at this conference. And just to read you some of the names of the people who were involved. Ken Arrow was there, George Dantzig was there, Robert Dorfman was there, David Gale was there. Just reading you the names of people I think you would know. Harold Kuhn was there, Oskar Morgenstern was there. Paul Samuelson was there. Herb Simon was there. Al Tucker was there, Marshall Wood was there. And this was the first group, got together, and it was almost exactly two years from the start of it.

IRV LUSTIG: So that must have been pretty exciting.

GEORGE DANTZIG: Well, we all knew that we were onto something.

IRV LUSTIG: I guess this was a pretty significant event, but if you look over the history, now, going back 54 years, say-- what project or event would you say has made you proud of what began back then?

GEORGE DANTZIG: Well, if you ask the question, did we visualize that it would evolve as it did-- we all saw that the computer was going to be something. And in our mind's eye, the computer was not much different than what's today. Seems hard to believe, but an enormous increase in speed took place. If you ask, well, did we visualize it would speed up like that, well, probably not.

IRV LUSTIG: But you knew that it had the power to eventually solve these kinds of problems?

GEORGE DANTZIG: Well, you might ask the question, why didn't linear programming start earlier? Because after all, the systems that we are solving are essentially linear systems. And yet, no-- there was very little interest in the whole field. But Theodore Motzkin, who wrote his thesis around 1936, wrote his PhD under Ostrowski, I think, in Switzerland. His PhD was on the inequality system.

And yet, there was no mention of any optimization. Not quite on the subject, but anyway.

Chapter 5: The Field of Optimization

IRV LUSTIG: Well I was going to say, I was guessing, what would you say has been the thing that you've seen, that makes you sort of proud of the field?

GEORGE DANTZIG: I guess I'm going to have to be a diplomat and say I'm proud of the field.

IRV LUSTIG: OK. If you could go back and start all over again, would you still think you would make the same choices, to work on the same problems?

GEORGE DANTZIG: I guess the answer is yes.

IRV LUSTIG: Are there are some lines of research that you've tried that you've regretted and said, oh, we spent too much time here. Wish I'd recognized that earlier. As a mathematician, I always found you try that proof, and you spent a few months, and you say, this isn't going to work. And then, all of a sudden, you have the insight of how to solve the problem. Do you recall things along those lines?

GEORGE DANTZIG: I made a mistake? I guess one moves along with one's successes, and quickly forgets when it's--

IRV LUSTIG: Failures.

GEORGE DANTZIG: Failures, yes.

IRV LUSTIG: What would you say is the-- you've talked about in the future, that you'd like to see more planning under uncertainty. Do you think that that's sort of the next big step for optimization to take?

GEORGE DANTZIG: I would like to see it that way, yes.

IRV LUSTIG: How do you explain optimization to people who haven't heard of it?

GEORGE DANTZIG: I would use the example of the gasoline that you put in your car. Or, use the diet problem.

IRV LUSTIG: What would you say is the most invalid criticism of optimization?

GEORGE DANTZIG: I would say that-- how do you know what the planning factors are? They would criticize the formulation.

IRV LUSTIG: OK. And turning that around, what would you say the most valid criticism of optimization is?

GEORGE DANTZIG: If it was really seriously developed, you could change the world.

IRV LUSTIG: What do you think has made optimization being held back from becoming more popular?

GEORGE DANTZIG: The thing that would hold it from being more popular-- I have a feeling that the person hearing it doesn't see what is in it for him or her.

IRV LUSTIG: I know you've answered this question for me in the past. But I think it would be useful for you to say is, what would you like to be remembered for?

GEORGE DANTZIG: You're talking about posterity.

IRV LUSTIG: Yes.

GEORGE DANTZIG: Well, it turns out that my father-- who was a mathematician, and who wrote popular books on mathematics-- was always interested in posterity. He was big on it. And I'm not big on it. I'm not big on it. I like to say it would be nice to think that I would be remembered for something, but I doubt it.

IRV LUSTIG: Well, I think the field does remember you for a lot of things. I recall a conversation I had with you a number of years back, that it wasn't the simplex method; but it was the creation of an objective, which we talked about earlier, that you felt was really the key contribution. I was just about to ask you. You had mentioned that you had some papers and things that you wanted to show.

GEORGE DANTZIG: Well, and this has to do with my-- if you could get that red book over there.

In the foreword, I have something here called a summary of my own early contributions. And the first thing is the recognition that most practical planning relations could be re-formulated as a system of linear inequalities. So most of what we do with planning, it could be restated as a set of linear inequalities.

Before that, people would say, what are the rules? What are the conditions? But not recognize that what they really were setting up was a system of linear inequalities. So the very fact that you could formulate it that way.

Another way of saying it is if you have columns, which are activities, and those are the inputs and outputs of various things that you put into the different things that you do. If you're talking about a food, you're talking about the vitamins, and minerals, and different quantities of things that go into it in fixed proportions.

And if you're talking about businesses, almost anything that you do there can be broken down into parts. And those parts are statements of inputs and outputs to various activities. And you have a certain quantity of it. So it's a statement of that kind.

So to affect that what we're talking about in our linear inequality systems, that was actually recognized by economists. But they went ahead and said, well, let's make it more general. And so they generalized the hell out of it.

And I went back to basics and said, essentially this is what you do. And this is what actually we did in planning during World War II. We did it with planning a whole thing that was comparable to running a whole country.

The second thing was replacing all those ground rules for selecting good plans by replacing it with an objective function. And then the third thing was the inventing of the simplex method, because it worked.

IRV LUSTIG: Right. And it still does.

GEORGE DANTZIG: Well, that's the great accident.

IRV LUSTIG: Now, why do you describe this as "the great accident"?

GEORGE DANTZIG: Well, I certainly, when I worked on it, didn't think that-- I thought the old-fashioned techniques for optimization, the whole concepts of it, that one of those would win out.

IRV LUSTIG: So what were some of those techniques?

GEORGE DANTZIG: Well, no. Once I realized that the simplex method was essentially going around the outside of a convex body to get to the optimum, it seemed to me that an interior method should work better.

IRV LUSTIG: And now today, actually, we find that it's about 50/50.

GEORGE DANTZIG: Yeah. So try to even understand why that is even so. It's quite a surprise to me still that's--

IRV LUSTIG: I think it's still an open question for people working in the field.

GEORGE DANTZIG: Well, you would just think an interior method would be better.

IRV LUSTIG: Right. I think some of the issues, a lot of it depends upon how we measure better. I mean, if we count our number of steps, interior methods are better. But computationally, those steps are very expensive to compute.

So it's like you can quickly move from one vertex to another. But to move from one interior point to another takes a lot of hard work. And if somebody's real smart, maybe they'll figure out a way to make it not so hard to move from one inside to another.

GEORGE DANTZIG: Well, the way I like to say it is our intuition in higher dimension is pretty poor.

Chapter 6: The Diet Problem and Anne Dantzig

IRV LUSTIG: Right. There were some other materials I know you had collected to show us.

GEORGE DANTZIG: I found this. This is by my friend Andrew Vazsonyi. And he's trying to explain how my wife upstaged me.

IRV LUSTIG: So I think I've heard the story. But would you mind retelling it?

GEORGE DANTZIG: If you look at this picture here, it's pretty crude. You see vinegar. You see molasses. You see bran.

And you see bouillon, meaning bouillon cubes. And you see the word "simplex" right there. And you see my wife's name, Anne Dantzig-- spelled wrong. She spells it with an E, like the French do.

And the story is that I went to the, I left the Pentagon in 1952. And when I was at RAND Corporation, I decided to use the simplex method and linear programming to solve the diet problem. But not just the diet problem that Stigler wrote up; but to apply to myself-- I was a little bit overweight.

And so I called up my wife one day and I said, we're going to solve the diet problem for me, George Dantzig. And I want you to be ready. I'm going to make you run it to cook supper and prepare it according to whatever the computer says.

So it was getting late in the day. And finally Anne calls me up and she says, what's for supper? What's for supper?

And I said, well, we ran the program, and it said-- I gave her the list of things. And among other things was the first one on this list, vinegar. And it was a couple gallons of vinegar and some other stuff was the optimal diet. And I says, well, you're just going to have to take vinegar out as a food. And it ended that day.

So the next day rolled around. I called her up and I gave her the list of stuff for supper. And among other things was bouillon cubes. Know what bouillon is?

IRV LUSTIG: Yeah.

GEORGE DANTZIG: Looks like a French name, French word. So anyway, bouillon cubes was on there. And it was something like a couple hundred bouillon cubes was part of the diet.

IRV LUSTIG: They were cheap but nutritious.

GEORGE DANTZIG: Cheap? Bouillon cubes are not cheap. I don't think they accuse them of being cheap. So I answered, well, I'll get you the bouillon cubes, but you be prepared to go to the hospital. So I put five. I said, well, if you were going to get a couple hundred bouillon cubes in me a day, we were going to start with five. So we put five of them in. Have you ever tasted five bouillon cubes?

IRV LUSTIG: If you don't dissolve them, it must be--

GEORGE DANTZIG: You put it in. You pour hot water on it, and it's pure salt. It's so salty you just wouldn't believe it. So I decided that maybe two bouillon cubes with a drop of lemon that you could use. So again, bouillon cubes got out of there and vinegar got out of there, and the next thing that came up was this one. Each one of these took a day.

IRV LUSTIG: Because you had to solve it by hand.

GEORGE DANTZIG: Well, we were solving it on RAND computers. It was just taking it out of the list and resolving. And the bran was about two pounds of bran a day. And the answer, if you take two pounds of bran a day, you'll be in the hospital. So we put an upper bound on it. That's what we did next.

And then when you took the bran out, the next thing we came up with was molasses, and that's blackstrap molasses. I think molasses is what's used to make sugar, isn't it?

IRV LUSTIG: Yeah.

GEORGE DANTZIG: It had a very strong flavor and it was just substitute pound for pound instead of bran, you had molasses. And by this time, Anne got tired of the whole business because each day, I was calling her up and telling her what was for supper. And she says, no, I'll put you on a diet. So she put me on a diet and that was the end of the story.

And then my friend Andy Vazsonyi, who is a Hungarian with a sense of humor, so he wrote up a little story about it. His story doesn't match my recollection.

IRV LUSTIG: But the story is always in the telling.

Chapter 7: My Parents

GEORGE DANTZIG: He knew my father, and his favorite book was my father's famous book called Number. And so he starts out with that.

IRV LUSTIG: You were saying about where your father and mother met.

GEORGE DANTZIG: Which is the Sorbonne in Paris. My father studied under Henri Poincare. I don't know if that means anything to you.

IRV LUSTIG: Yes.

GEORGE DANTZIG: She probably thinks of him as--

VIDEOGRAPHER: No.

GEORGE DANTZIG: He's a French--

VIDEOGRAPHER: You mean like the president Poincare?

GEORGE DANTZIG: Yeah. He was the brother of Henri Poincare, but the brother was more famous than the president.

VIDEOGRAPHER: So the baby is you?

GEORGE DANTZIG: That's supposedly me. I don't remember it, of course.

Chapter 8: Awards

IRV LUSTIG: How about some of the other things that you have here?

GEORGE DANTZIG: This is probably the most important thing. This is the National Medal of Science, and it was presented to me by the President of the United States. His name was Gerald Ford. And this is what I got it for. And you can see it's a long time ago.

IRV LUSTIG: 1975.

VIDEOGRAPHER: That's not too long.

IRV LUSTIG: And I think what's very interesting is that in the citation, it says "has led to wide scale scientific and technical applications to important problems in logistics, scheduling, and network optimization," and that's still true today. We're seeing the same growth in those same application areas.

GEORGE DANTZIG: I think actually, this citation was written by Pete Veinott

IRV LUSTIG: Oh really?

GEORGE DANTZIG: Yeah.

IRV LUSTIG: And let's see what else. I was noticing--

GEORGE DANTZIG: This medal, this picture here, this medal is this medal. It's the same. That's the medal and that's the picture of the medal. This particular one over here was given to me by the head of the War Department for my work during World War II.

IRV LUSTIG: So this was shortly after the war?

GEORGE DANTZIG: No. That was during the war.

IRV LUSTIG: During the war? OK.

GEORGE DANTZIG: Now, this medal here was given to me by the English.

VIDEOGRAPHER: This one?

GEORGE DANTZIG: Yeah, the English operations research. From, I think it was University of Maryland. I don't remember if it was Phi Beta Kappa. I don't remember.

IRV LUSTIG: It's Phi Kappa--

GEORGE DANTZIG: Phi Kappa Phi.

IRV LUSTIG: OK. I think the other one on the right is Phi Beta Kappa, if I'm reading that correctly. Then on the bottom is the Von Neumann Theory Prize. I think the first Von Neumann Prize was given to you, although I wouldn't know.

GEORGE DANTZIG: I wouldn't know either.

IRV LUSTIG: Now, is that an accurate likeness of Von Neumann?

GEORGE DANTZIG: Not bad. Not good, but not bad.

IRV LUSTIG: Now you also, I noticed, have your-- for your PhD.

GEORGE DANTZIG: Yes.

Chapter 9: Planning Under Uncertainty

IRV LUSTIG: You had mentioned earlier that planning under uncertainty has always been an interest of yours, even going back to when you were working on the foundations of linear programming.

GEORGE DANTZIG: Well, those of us who were doing the planning right from the very beginning understood that the real problem was being able to be able to do planning under uncertainty. Because the mathematical models that we put together act like we have precise knowledge about the various things that are happening, and we don't. So we need to have plans that actually hedge against these various uncertainties.

We put a little bit of that into the models, usually, by overstating things. So being on the safe side. That's the simplest thing that we can do. But overstating it is almost another way of saying we're going to make it inefficient.

IRV LUSTIG: I know there's been a lot of progress, especially over the past 10 years within the research community, on planning under uncertainty. What would you say are the areas for it to be more widely used in practice?

GEORGE DANTZIG: There's a tendency to do economic planning. For example, in this country we're no longer making steel in this country. We're importing almost everything which we have. This shirt comes from someplace, but not United States.

In other words, we don't really hedge. We don't really protect ourselves in case a major emergency. One day we are paying low rates for electricity. And the next thing you know it becomes short and my bill for utilities, which used to be around $200 or $300 is now $800. Overnight, it just goes through the sky.

A lot of things which they call globalization to me look very, very dangerous. From the point of view of just protecting the country. I see our country losing all kinds of skills. We're not hedging and protecting ourselves.