INTERVIEWER: Thank you for doing this.

GRAY: It's my pleasure.

INTERVIEWER: Let's just start at the beginning. When were you first aware of electricity as something you could control, something you could actually think about intervening in the flow of electricity to make certain things happen?

GRAY: About as early as I can remember. I have to back up and start with my father. He was born in 1900. He never finished high school. He went to work for a public utility as a technician. And he was smart. And he got promoted eventually to a job in which he had reasonable responsibilities, working for engineers. And I don't know whether it was his involvement with electricity that got me started or something in myself, but I can remember as early as first and second grade making things electrical, like electromagnets. Winding copper wire on a nail and being able to turn it on and off. And that just continued through as I say as far back as I can remember. I was involved in making gadgets around the house. If anything could be taken apart that was electric from clocks to radios or whatever. By the time I was 10 I was doing radio repair for the neighbors, vacuum tube radios at that point of course. As soon as the war ended I got myself licensed as an amateur radio operator and built all my equipment. So it goes way back.

INTERVIEWER: Do you remember asking your dad how come the filament lights up in the light bulb or why does this work or did he ever tell you a story about how something electrical works?

GRAY: Yes I mean we made things together. I did a lot all by myself but we made things. We made a large electromagnet that could be operated by plugging it into the line. By large I mean it had a four- inch by four- inch steel core, laminated core, about a foot long and a ton of wire. And with this you could levitate things through electromagnetic induction and you could show the way induced currents produced heat. We also made a Tesla coil with vacuum tubes, which produced probably 20 or 30 kilovolts. And you can do interesting things what that high voltage, essentially static electricity.

INTERVIEWER: Create the lightning effect.

GRAY: Right. Create a Jacob's Ladder, if you know what that is.

INTERVIEWER: The lightning that goes up the two poles.

GRAY: Put a propeller on the top and have it spin around, because of the discharge of the electricity.

INTERVIEWER: And you levitated what, like a toaster, your little brother?

GRAY: Levitated cake pans without the bottom. You know you get an open cake pan and put it an on this coil and plug it in and it would shoot up and hit the ceiling in the basement.

INTERVIEWER: And your mother thought this was just --

GRAY: She thought this was okay, I also messed around with chemistry in the basement and occasionally it would make a big stink and that was not so okay. But the electrical stuff was quiet and not smelly for the most part.

INTERVIEWER: That's great. Do you recall the first vacuum tube you understood exactly how it worked?

GRAY: Well it was somewhere around 10 years of age because I was then building radios with vacuum tubes, receivers. The war was on and I couldn't use a transmitter but I was building receivers from scratch with vacuum tubes. Started out with the crystal radio as everybody did in those days but quickly switched over to a regenerative receiver with an audio amplifier and a loud speaker.

INTERVIEWER: And what was it like to understand how you could intervene in the current with a grid and a vacuum and take that signal and turn it into voice or code or whatever it is you did?

GRAY: Well that was a very powerful idea. I was about to say it was my first experience with what the English would call a valve, a way of controlling electricity, the flow of electricity. But actually earlier experiences. I mean a switch is a valve if you will, it's a bipolar valve. But the idea of a vacuum tube where you control the plate current with the grid voltage was very powerful. And I didn't understand it in the level of detail that I came to understand it when I arrived here through my electrical engineering studies. But I understood that by making the grid negative you repel the electrons from the cathode and they didn't make it to the plate. But the whole idea of space charge and how you control space charge was beyond me at that point.

INTERVIEWER: But even on the non-atomic level, you understood that by messing around with the electricity on this pole of the vacuum tube you could control the flow of electricity from one end of the tube to the other.

GRAY: Yes

INTERVIEWER: And that that variance became the signal that was radio, audio, voice, whatever it is you wanted to mess around with.

GRAY: Right I think my introduction to it was with a simpler tube, namely a rectifier, a two element tube, a cathode, and a plate. Because the first thing I built not knowing I was going to be building a radio was a power supply, a 250 volt DC power supply. And again it's easier there because when the polarity of the AC is negative with respect to the cathode it repels the electrons and when it's positive it collects them, so it's an easy concept to get.

INTERVIEWER: It turns AC to DC right?

GRAY: Right. And when you put the grid in you have a more delicate and a more powerful control mechanism, one that doesn't expend power, or not very much power.

INTERVIEWER: So with all this gadget making and amateur radio operating and building, you arrived at high school with a decision to make, where to go to college. What were you looking at that point?

GRAY: I was thinking at that point exclusively of engineering. I wanted to understand more about the way things worked. I wanted to make things.

INTERVIEWER: What kind of things?

GRAY: Anything that had electricity involved with it. Most anything. This was before the semiconductors of course, it was all thought of in terms of what you could do with vacuum tubes. But I entered high school with the conviction I was going to study engineering. As I went through high school those four years. My town didn't have a high school in those days so I was bussed to a neighboring town. A class of about 250, of which maybe 30 of us were from the town I lived in. And in my senior year I applied to MIT, which my father's supervisors said, "This is the place you want to study engineering," and to Yale, which then had the Sheffield School of Engineering,

and to RPI. I was admitted to all three. But MIT was the only one that didn't offer me any money. The other two made it quite easy to go. And I was about to go to Yale, which it offered the most, when I had a conversation with really my first mentor besides my family. And that was my English teacher in high school: had her for four years. Emily Morford. M-O-R-F-O-R-D. And I told her-- she knew where I'd applied, she wrote a reference-- and I told her what my tentative decision was and she took me to the woodshed. And she said, "You can't do that. If you have a chance to go to MIT that's where you should go. It's the best place to study engineering."

INTERVIEWER: Now wait a minute, this is the English teacher telling you?

GRAY: The English teacher, English teacher. Who lived long enough to see me elected president here. What, 1950 to 1980, 30 years later. She couldn't come to the inauguration. She was in her 90s and lived in Florida, but she knew about it. She had been an important-- she was perhaps the teacher in high school that I remember the most. And that includes chemistry and physics and biology and mathematics. And it was her influence that pushed me the other way. I went back and the family said, "Well we can manage that. Do it." So that's how it happened.

INTERVIEWER: What does it say about your subsequent influence on this institution and your role in the scientific world that your key mentor as a young high school student was an English teacher and not some Mr. Wizard in the chemistry lab?

GRAY: What does it say? I don't know. I've always enjoyed writing and do a lot of it. And maybe that's part of it because she taught writing, she taught the English language, the way it should have been taught. You know we diagrammed sentences, we worked on paragraph structure, the whole nine yards. And I came out of high school I think being a pretty good writer. And it paid off in later years here, still pays off.

INTERVIEWER: Do you think many MIT students can diagram a sentence today?

GRAY: No, too many of them can't really create a sensible sentence, let alone a paragraph. It's astonishing to me. I mean MIT students come here with an average verbal school of something like 750. But still most of them are abominable writers. Not all-- I mean, some are very skillful. Some have learned the craft. But a great many of them come here needing a boost in their writing, which they get. So--

INTERVIEWER: What was the undergraduate experience like at MIT in those years?

GRAY: At that time MIT had a wholly scripted freshman year. No choice. You took five subjects, same five subjects. If you were American and male, you took ROTC. It was required for two years. And the whole freshman class had one adviser. There was a dean, Dean Pitre, and sometime in the summer you got a letter from the dean saying you were assigned to section 37. And you attended all your classes with that same section, which had a real value by the way. You got to know 30 students pretty well.

That doesn't happen anymore with a great variation in a freshman year. Freshman year went well, I loved it. I was invited in the second semester to take, to be in a special section of second semester math, which would be more theoretical in nature. And I did that for about a month and said, "No this is not for me. I'm interested in the applications of mathematics and not so much in the theory." And so I switched back to the normal, what was then called M12, second semester math.

But the undergraduate experience for me was fine. I enjoyed it. I could hardly wait to come back. And I did pretty well at it. During the summer, in those days, freshmen got visited by fraternity students because when you arrived here, you had to make a choice between whether you were going to live in a dormitory or live in a fraternity, pledge a fraternity. And I had a visit that summer from two students, both of them living in New Jersey, and I said, "No, I'm not going to rush week. I'm going to live in the dormitory." I all ready had an assignment in East campus which was then all single rooms. And I lived there through, about through Thanksgiving, but found it was intensely lonely, partly because all the folks around me in that dormitory were GIs who had come back from World War II. You know, the largest class ever to graduate from MIT was the class of 1950, because it swept up all the guys who had had their education interrupted in the early '40s. And the GIs who returned were very single-minded about their studies. They were not involved in any social life or other activities that eighteen-year-olds would be involved in. And I just felt isolated.

So as it happened, the two students who had visited me in the summer showed up again one evening and visited me at the dormitory and said, "Why don't you come over and have dinner?" Well I did. And that opened my eyes to a very different style of living at MIT. To live with 28 other people in a four-story house on Commonwealth Avenue. And so I moved into the house in December and lived there for the next three-plus years. Three-and-a-half-plus years. And that was also an important learning and living experience for me because I was an only child. I had only two cousins, one on each side of the family, saw them seldom and really had grown up without-- had neighborhood friends, to be sure, but their interests were different from mine-- had never had an association with other people my age whose interests overlapped with mine. And I had a role there eventually in governance of the place, as well as most people did, and it was a great experience.

INTERVIEWER: So for you, unlike a lot of young people who have the experience almost exclusively of leaving home to enter an undergraduate community, you certainly left home in New Jersey but you also found this as a homecoming?

GRAY: Yes, yes, very much so.

INTERVIEWER: You found a family here. Are you still in touch with those fraternity guys?

GRAY: Yes. Oh yes. The living members of my pledge class, of which there are about five or six, we get together every September for a clam bake at one or another's house. This year its at our place.

INTERVIEWER: You graduated, you say you did fine as an undergraduate, you were class of what?

GRAY: '54.

INTERVIEWER: When you were celebrated a few years ago by Charles Vest he noted that your class was illustrious. Class of '54. What's he talking about there?

GRAY: Well he was talking I think about the fact that there were three perhaps four members of my class who had been major donors to MIT. Major donors on the scale of tens of millions of dollars.

INTERVIEWER: Done good.

GRAY: Darn good. So it was partly connected to that, but they were all members of the Corporation as well. When I retired from the Corporation, just a year ago at this meeting, the meeting this Friday, there were two other members who were retiring. Not at the same meeting but who retired at the June meeting. So three of us, members of my class, who'd been life members of the Corporation, all retired that year, last year. And the other two were both in that category of more than 10 million dollar donors, steady, really important support to MIT. And I think when Chuck was saying this: the illustrious class of 1954 he had in mind, that there were some heavy hitters in it.

INTERVIEWER: Are you a heavy hitter?

GRAY: No, not in that sense. I worked for 50 years for a nonprofit institution.

INTERVIEWER: We wouldn't call that a business model would we? Well, your contributions are certainly priceless to this institution. So, upon graduation your ROTC experience figured fairly probably in what you would do next.

GRAY: Right. I was commissioned when I got my Bachelor's degree in 1954. I at that point had been dating a young woman from Wheaton College for three years. We intended to marry. She was a year behind me. She was glass of '55. So I asked the Army for a one-year leave during which I was going to pursue a Master's degree, also in electrical engineering. And in those days it was possible. I had an NSF fellowship for that year, and it was possible by working at it full-time to do it in a year. So in 1955, a year later, I got my Master's degree. She got her Bachelor's degree and graduated. The week after that we were married. I had a summer job in Princeton, New Jersey with the RCA laboratories, which I had intended to be a full-time job.

I have to tell you, when I left MIT in June of 1955, I told everybody who would listen that I'm never going to set foot in this place again. Because I had had it, right up to the nose. Five years of full-time, fairly high pressure education had left me worn out. And I said, "I'm going away and I'm going to be a captain of industry." I went to RCA. I'd had offers from RCA and IBM and Bell Labs. I picked RCA. I worked for them from the end of June through the end of August, took a military leave and went in the Army for two years. As luck would have it, I ended up spending the entire two years in Fort Devens 40 miles from here in Massachusetts. My Army service branch was the Army Security Agency, which at that time was the predecessor of what's now called the National Security Agency. Its business was listening in on what the other guy was saying, seeing what you could figure out. And I was trained as a traffic analyst. But when I finished my training at Fort Devens, which was about five months, they said, "Gray we want you to stay here and not take a field assignment in your specialty, but stay here and teach GIs how to operate and maintain this fairly sophisticated electronic equipment."

INTERVIEWER: Listening devices and the like?

GRAY: Listening devices, yeah. Which we did. We stayed right at Fort Devens for the whole two years. And that experience of teaching, which was really my first shot at teaching-- I'd run some tutoring sessions in the fraternity for a freshman and things like that but had never before taught an organized subject-- that left me convinced that, a, that I enjoyed teaching a lot, and secondly that I needed more knowledge, more understanding. So my second mentor in life was a man named Thomas F. Jones. During my undergraduate years he was an associate professor in EE. During my graduate years, three years, 1957 to 1960, he left MIT to become head of the Department of Electrical Engineering at Purdue. He tried very hard to recruit me to Purdue when I finished. A few years later he was Dean at Purdue. And by 1975 he was president of the University of South Carolina. But he was my second mentor in life. I worked for him as a student assistant all three years, sophomore, junior and senior year calibrating instruments for the laboratory. And I looked up to him as someone with a career and a style that I wanted to emulate. So that's more than you asked, but that's how I got back here.

INTERVIEWER: What was the conversation? I mean what were you going to do and what did he say to you? "No, no, no this is what you need to do?"

GRAY: He had pushed me very hard, when I graduated with a Master's degree, to accept the teaching assistantship and take a military leave. He said, "If you do that and you come back, you'll have two years seniority and you can start writing then." And I said, "No, I'm not going to do that. I've had enough of higher education" He kind of smiled at that. Eighteen months I came back to see him. Eighteen months later, six months away from my discharge from the Army, I came back and said, "Can I get readmitted, and could I get an appointment?" Which is what happened.

INTERVIEWER: So was there something about the Army that frustrated you? Was it the teaching experience that led you back to MIT? Was it some nostalgia for actually maybe that place wasn't so bad? Or was it a combination?

GRAY: It was a combination. I mean I'd mellowed about MIT over the two years. But I also had a strong urge to understand things to a higher degree than I then did. And by that point, by 1958, semiconductors were beginning to be everywhere. And I understood almost nothing about semiconductor devices. It was not in the curriculum in the early '50s. I mean the invention was 1948 and you might have wondered why it didn't come in earlier than that. And it was touched on in the electronic subjects, but just kind of touched on. This is something that's interesting.

INTERVIEWER: But you probably understood the one thing, that is you could produce a rectifier.

GRAY: Yeah I understood valves and I recognized that this was a different kind of valve. INTERVIEWER: Different kind of valve.

GRAY: And a much more useful kind because it didn't get hot.

INTERVIEWER: Lower current.

GRAY: Lower currents, lower power. So it was both. It was it was mellowing a bit, but more importantly a recognition that I wanted more education.

INTERVIEWER: So in the course of your graduate study at MIT, what were your goals? Aside from just getting more understanding, was there a particular field you wanted to be a part of? Was there some sort of Cold War dimension to your studies? Security dimension to your studies? Certainly that was your background in the Army.

GRAY: No, there was nothing attached to the Cold War or to national security at all. When I came back I was appointed instructor, sort of one notch above teaching assistant. And so I taught every semester, and started out my teaching doing a section alongside Harold Edgerton, Doc, Papa Flash. And as I got involved in teaching, I found it enormously satisfying. Demanding, but very satisfying. And somewhere in that two-year interval, with teaching every semester, I came to the conclusion that this is what I want to do with my life. Sometime during that three-year interval when I was back here as a graduate student, teaching every semester, and finding challenge and great satisfaction in that experience, it became clear to me that this was what I wanted to do with my life. So I was fortunate at that point because MIT was in the process of greatly expanding the graduate program. That expansion was enabled by the changes that occurred in the wake of the Sputnik episode.

INTERVIEWER: Describe how you learned that?

GRAY: Well, I was in graduate school that October, the first October back here. And suddenly this happened. And all of a sudden there was, I wouldn't say panic, but there was great concern that, "Oh my goodness! The Russians are way ahead of us in science and technology. They can put a satellite up."

INTERVIEWER: Where were you when you learned the news?

GRAY: I'm not sure. I don't know. That doesn't stick to me. There are a few events in life like the Kennedy assassination where I can tell you exactly where I was. But Sputnik didn't come to that level.

INTERVIEWER: But if the Russians could put a satellite in orbit bounce a signal off it--

GRAY: They didn't bounce a signal of it, they just had it transmitting.

INTERVIEWER: They had a transmitter up there. That meant they had some expertise right in your area of study. Correct?

GRAY: Absolutely.

INTERVIEWER: You couldn't do that with vacuum tubes.

GRAY: No, had to be transistors.

INTERVIEWER: So how did that change your research or accelerate it? Or what sort of passion did that give you?

GRAY: Well at that point in the first year back I had not yet selected a research area. And part of the process of selecting a research area for any graduate student, is to find somebody who's got support. Who can support me part time and carry me through the research. And at that time a large degree of interest in the government and elsewhere was being expressed in what were called thermoelectric materials. Materials that were thermoelectric at higher temperatures than previous thermoelectric materials. Compound semiconductors which could be thermoelectric and produce temperature differences of 50 or 60 degrees centigrade, imagining their possible use in refrigerators or things like that. And one of the faculty, in whose area my office was, had a extended contract for work in that area and was looking for graduate students to work on it. And it was related to semiconductors, not to valves, but to a different application of semiconductors. And that's what led me into it. And indeed that's what I did my thesis in. It was a question of finding a topic which enabled me to be supported to do it.

INTERVIEWER: Your career up to this point is a journey along a path that began with kind of intuitive knowledge about electrical circuits from your experience with your dad, to acquiring general knowledge of how electromagnetism works, to eventually reaching the edge of knowledge itself.

GRAY: In an area.

INTERVIEWER: And investigating things that hadn't been investigated before. How important is it for students to take that full journey?

GRAY: I think it is the key element in a journey to enable one to continue educating oneself without the benefit of a teacher. And for somebody involved in either science or engineering, the fields will continue to evolve and change, with new ideas coming along. So that if you don't stay up to date, if you don't educate yourself to stay up to date, you become irrelevant. An engineer who isn't involved in continuing education right away, in one form or another, will eventually become irrelevant, and find it hard to find employment. So I think it's crucial and something we might talk about later, the Undergraduate Research Opportunities Program, was an effort to try and bring students to that level of understanding. The level being how do you proceed when there's no one to ask? How do you proceed with a novel question that no one has answered? How do you get your head around that? How do you learn how to make progress? And a good UROP can produce that experience for an undergraduate. It's the kernel, of course. It's the essential part of either a Master's thesis, and to a greater degree an ScD thesis.

INTERVIEWER: Do you recall the moment that you realized that you were out of the sort of general knowledge area and were actually focused on something that was fundamentally new?

GRAY: Yeah-- because I had to make these materials. I had to create these compound semiconductors in an induction furnace. And it was not easy to learn the techniques. Nobody to teach me the techniques, to how to do this in a way that would produce crystalline materials. It was a real challenge.

INTERVIEWER: Did you have any conversations with your dad about the sorts of things you were cooking up at that point in your career?

GRAY: Not a lot. Not a lot. He was interested in me having as much education as I could get. And so he was pleased when I came back to graduate school, I think. He was not so pleased when I decided to stay on at MIT, and I'll tell you about that later perhaps. But, no he was not a significant influence in any way on that at that time. I was at that time, we'd been married, we were married in 1955. Yeah '55, this was 1957 when I came back. We had one child, another one on the way. Priscilla was dealing with soon-to-be-two daughters, and I was eager to get on with it and get to the point where the cash flow was reversed. Because while I had some support from the Institute, I didn't have full support and it wasn't easy to keep the family functioning on an instructorship.

It helped by the fact that she had worked, my wife had worked, two years as a school teacher while we were in the Army. One year as a school teacher while we in the Army. She left then to have the baby. And that money in the bank proved invaluable. The other thing that mattered enormously to me was that Harold Edgerton, Doc Edgerton found me a summer job at EG&G which made all the difference.

INTERVIEWER: EG&G?

GRAY: Edgerton Germeshausen and Grier, the company that he and his two partners founded. It was a company that was founded to do the instrumentation for the atomic weapons testing and then it branched out into other high-speed measurement technology.

INTERVIEWER: Wow. So when did things gets a little more comfortable as you proceeded? Because you were recognized almost immediately as a great teacher at MIT?

GRAY: Well things got more comfortable when I got the ScD and then was appointed assistant professor. I said before that I was very fortunate in the timing of things. The Ford Foundation had, in 1959, made a ten-million-dollar grant to MIT -- that was really a big money in 1959 -- to the School of Engineering. And the dean then, Gordon Brown, used four million dollars of that money to create four professorships, the Ford engineering chairs, and a great deal more of the money went into what were called Ford Postdoctoral Fellowships. So you got appointed assistant professor you were on a Ford Postdoctoral Fellowship for three years, I think, which gave you more freedom of action than if you were out scrambling for research dollars to start your own research program at that point.

In fact, I did not start a research program up at that point. I'd finished the work on thermoelectrics, and by 1960 there were three other colleagues in the Department of Electrical Engineering-- Richard Adler, Dick Thornton, and Campbell Searle-- who were just beginning to put together the idea for a revolution in the teaching of electronics: to put the vacuum tube aside and base the entire structure of the curriculum on semiconductor electronics. And I got involved in that with them right away, and started writing materials. We eventually wrote seven textbooks. We produced two educational films, and we produced a whole range of laboratory experiments on semiconductors that people could easily do, including making a simple grown-junction transistor. This was before monolithic technology in silicon transistors it was all in germanium. And we got a major grant, a long-term grant, from the National Science Foundation to support this activity. And I named these four people who were here, but we also brought in people from industry and we brought in people from other universities to work on this. So this was a large scale undertaking, it involved Stanford and Berkeley. It involved IBM and Raytheon. There were many partners in this. And it went from 1960 to about 1966 or 1967.

INTERVIEWER: And the mission was really to address an issue that educational methods for electrical engineering in the United States were possibly antiquated? That there was a need for many, many more engineers given the security and technological requirements? And you were at right at the head of all that.

GRAY: Right. What had happened up to that time is the curriculum in electrical engineering, here and elsewhere, had been tinkered with to bring in semiconductors. But what it needed was to say that we're done with vacuum tubes for all practical purposes except for some high power applications, and people who need to learn it can learn it, but semiconductors are going to be at the heart of everything we do. By that time the monolithic silicon device had been invented. Integrated circuits were being made. The integrated circuit inventions, the patents were in 1959. And it was clear. We thought it was astonishing when we saw, we held in our hands, integrated circuits with 30,000 components. And now we're working up towards a billion components. Integrated circuits had just come into being. And an MIT alumnus named Bob Noyce, who was one of the two inventors of the integrated circuit, had set up a company in California to make these things, and he came back and gave a series of seminars. And he showed us chips which had on them 30 or 40,000 components, which at the time seemed almost unbelievable. Now, of course, commonplace, millions of transistors, a hundred million on a chip, and we soon will see a billion on a chip. There are probably structures of that density now available on a test basis. So it was clear that things were changing very rapidly and what needed to be done was to toss out the old curriculum in electronics and start from scratch with the physics of semiconductors, with the physical electronics of semiconductor devices, with their modeling and then their circuit applications.

And the seven books that we prepared in a series called the Semiconductor Electronics Education Committee, the SEEC series. They were slim books, a couple hundred pages on different topics. But it started with physics and ended up with design. And I wrote a separate volume by myself as kind of an introduction to the first volume called, Introduction to Semiconductor Electronics, which was not an SEEC undertaking but one that I undertook myself. Because we needed something in front of that first book for somebody who hadn't studied any electronics at all. And that was a great experience. I had not only the opportunity to participate in the writing of these materials, but I taught them all, along with the other folks. We all taught it. And it was being taught elsewhere. And it revolutionized the teaching of electronics across the United States over a period of five to 10 years and it's still doing that in other places in the world.

INTERVIEWER: It also made MIT the place to come to jump onto a fast track towards cutting edge research into semiconductor design.

GRAY: Yes it did.

INTERVIEWER: And computer engineering and all that.

GRAY: It did.

INTERVIEWER: And did you understand how huge that was at the time?

GRAY: No, I don't think so. I understand in hindsight thought that we made a mistake. The question arose around 1970, 10 years after this exciting decade of the '60s, "Should MIT create a full scale facility in the fabrication of monolithic semiconductor devices... a fab lab? And the decision was reached in the department, that no, we shouldn't because the technology is changing so rapidly that it will be very difficult to keep it up to speed, to keep it up to the front here. And we have to rely on partnerships in industry to do the fabrication for us. Berkeley and Stanford took a different track. They each created those facilities and that's why Silicon Valley is Silicon Valley. I mean we missed a beat there. I wasn't involved in the conversation at the time. I was doing other things, but it was a discussion that was carried on earnestly and thought to have come the right conclusion. But with the benefit of hindsight, it was a mistake, we missed the beat.

INTERVIEWER: Interesting.

GRAY: We might have had the 128 version of Silicon Valley instead.

INTERVIEWER: May yet. The first book that you wrote, the introductory volume to the series, did you send a copy to your English teacher?

GRAY: Yes, I did. I did. She was retired at that point but I sent it to her.

INTERVIEWER: Did she have any reaction?

GRAY: I don't remember.

INTERVIEWER: Red marks.

GRAY: No she didn't send it back marked up.

INTERVIEWER: Well, it must have been a proud moment for you to send that off to her.

GRAY: It was, yeah.

INTERVIEWER: During this period that you describe I think you went from teacher to associate dean for student affairs, dean of engineering, provost, chancellor-- I mean these jobs came fairly quickly. Did you have a favorite? Can you describe what you were exploring as you ascended in management of the institution?

GRAY: Well, you have to understand that all of those jobs up to dean of engineering were part time. People ask me, "How do you get be president at MIT?" And I say, "Well, it happened accidentally," and there's a good deal of truth in that.

The first job I took on in 1962, I was advising freshmen. All new faculty advise freshman. And so in 1960 I had 20 freshman advisees. And there was something called a Freshman Advisory Council which was the group of advisors who met a couple times a year, typically before the term started, to talk about things that were of issue. And I'm at a couple of those meetings and the person who then dean of students, a man named Kenneth Wadleish, said that the present chairman, who was a mechanical engineer, "...has served his term, would you serve as chair?" I said sure I'll do that. It wasn't a big deal. So I became chair of the Freshman Advisory Council. And in 1965, three years later, a committee which was chaired by Jerrold Zacharias, who was the great physics curriculum innovator of the 1950s and early '60s, chaired a commission which recommended major changes in the undergraduate curriculum starting with the freshman year to begin in 1966, fall of '66. At that point Ken Wadleish said, "I need somebody to help manage this transition. Will you become associate dean of students half-time?" I said, "Okay, I'll do that." I was still a professor. I had graduate students working generally in the area of high-temperature superconductivity which was the hot topic of that time. Turned out four or five PhDs in that area in the in the '60s and a lot of Master's students.

So I said I would do that. And I worked at that for three years I guess until 1968. And at that point Jerry Wiesner, who was provost-- Howard Johnson was president and Jerry was provost-- Jerry asked me to come to work in the provost's office as associate provost. With the same responsibilities only broadened out to look at undergraduate education beyond the freshman year as well. I stayed in that position until fall of 1970 when the then dean of engineering resigned suddenly to go off and head the National Science Foundation. And Howard and Jerry, desperate to have somebody manage the dean's office, asked me if I'd serve as dean. And that was the first full-time job. That was the point at which I had to stop fooling myself that I was still a professor and part-time administrator. Because suddenly it was learning a new job at very much a full-time capacity. And then seven months later Jerry was elected president and the Corporation asked me to serve as his deputy as chancellor. So that's how that evolved. And I explain that to people and say this is what I mean by being accidental. A whole set of positions which I earnestly took thinking these would be short-term, half-time assignments, and I'm going to be really a professor here. By that time I had that Class of 1922 chair-- which was given by the class, I was the second holder of it, the first holder retired-- was given to someone who had shown exceptional ability in teaching. I was very pleased with that. I had to give it up when I became chancellor, had to resign as a faculty member. Suddenly I was full-time administrator; both Jerry and I had to resign. In those days the rules required that you couldn't be a professor and a Corporation member at the same time, so we resigned. He gave up his Institute Professorship, I gave up the chair, and we were full-time administrators.

INTERVIEWER: Any favorites on your way to the presidency of those jobs? Or is professor just top of the list?

GRAY: Well, of those part-time jobs, the favorite was working for Jerry as associate provost. Edwin Land, Din Land, had in 1968, the year I went to work for Jerry, had created a charitable lead trust which was going to provide MIT with a half million dollars a year for five years to be expended on undergraduate education. And so almost the first thing out of the box when I went to work for Jerry in the fall of '68-- I should say I had my one sabbatical from February of '68 to September of '68-- when I came back from sabbatical, we went right to work on how we're going to spend this money. And that's a longish story.

But also in April of 1968 Martin Luther King was assassinated. June of '68 Robert Kennedy was assassinated. The small number, 30 perhaps, of African American students at MIT, created the Black Students' Union at MIT. And in september they presented Howard Johnson with a list, not of demands, but a list of requests of things to do to increase the presence of African Americans at MIT. That's another long story which we should talk about. But those were the two things that I got to work on through 1968 and into 1969. Part of that money, a big chunk of that money, was expended in the effort to start UROP and that also is a longer story we should talk about. Other monies were spent on creating experimental programs two of which still exist. And having that opportunity to have real money at your disposal to spend in trying to improve undergraduate education was very exciting. And having a set of folks which were Jerry, Walter Rosenblith (associate provost), Jerrold Zacharias (who I mentioned earlier is always full of ideas), and Benson Snyder. Those four people, plus me, created a group that met every week to talk about what we were going to do for undergraduate education and it was a tremendously exciting time. It was also exciting on the front of increasing African American presence here.

INTERVIEWER: What was the perceived need for greater diversity in the MIT student body, and how did you go about achieving it?

GRAY: The movement toward greater diversity started around 1960 and I was not involved in it at that point at all. Prior to 1960 there were fewer than 20 women in every class. Classes of 900 to 1,000. And the number of women in the class was determined by the capacity of a boarding house with a housemother on Bay State Road. Many more women applied to MIT. There had always been women at MIT, back to 1866, but few. There were more around World War I than there were in 1955 for reasons that I don't understand. But the fact that it was limited to 20 out of a much larger pool meant that the women that we were admitting were really very well qualified. And there was an urge to be able admit more.

Along about that time, 1961 or so, Mrs. McCormick-- who was the heir to McCormick reaper family fortune, her husband, Stanley, had been institutionalized most of his life and had died long before-- she gave money to build a dormitory for women. The first tower was McCormick Hall, and eventually she doubled it and it became twice the size. That enabled the percentage of women to increase by 1980, by 1970, to about 10 percent... almost a 100 in a class. And then the change beyond that for women and the change for underrepresented minorities beyond women, began to really come to fruition around 1968, 1969. When I came back from sabbatical leave in the fall and Howard had this list of requests on his desk from the Black Students' Union, and he said, "Let's figure out how we're going to deal with this." And asked me to bring a group of students and faculty and staff together. We called it the Task Force on Educational Opportunity, to work through that.

INTERVIEWER: Why isn't there more sort of moral tension? I mean this is a time of extraordinary drama and tension and people giving up old assumptions. Yet here when people describe this process it's very much just a kind of, "Well, let's solve the problem. Let's get the tools and we'll make it happen." What was going on, that that was the approach here?

GRAY: There was a stab at this a year earlier, when the Admissions Office, at the urging of the faculty committee, admitted twice as many African Americans. That meant we had 12 per class instead of six. There were more black Africans in a class than there were African Americans. And that was the first change, but it was an incremental change. It was a doubling, but nonetheless incremental. What needed to be done, and what didn't get done until 1968 or 1969, was a high-level recruiting. You had to broaden the pool, which is what we finally did. And the class that entered in 1968 had 47 African American kids in it, and it's grown considerably since then. That's something we might talk about. How that came about and what was necessary to make it happen.

INTERVIEWER: Well, how did it come about?

GRAY: Okay, the students brought their requests to the task force. And they involved recruiting, they involved greater financial support, they involved a tutoring program, a summer leg-up kind of program. All these were ideas that they laid out. We started that fall, we hired a fellow named John Mims, who was African American, to come in and be an assistant director of admissions to help us on a recruiting front. We sent a lot of present MIT students-- not very many of them; there were about 30 in the BSU -- we sent as many of them who had time and would go, out to recruit in predominately black schools in the major cities. We asked the College Board to give us the addresses of students who had above some threshold score on the SATs and on the achievement tests and who were African American, who had recorded themselves as African American. They gave us those addresses and we did mailings to all of them. We created a summer program called Project Interphase which still operates. It ran for eight weeks and was staffed largely by African American students, graduate students, and was overseen by a young man named James Bishop who had just got his PhD in chemistry here and was very interested in this issue and supervised that. All of these activities were started by the task force and that enabled us to get the numbers up. It was a bit like, how to describe it? I mean we were admitting students whose qualifications looked very different than the traditional admits. And so the task is to figure out, to figure out whom we should admit so that we don't put a significant number of people at risk in terms of their career. You don't want to admit students here who are going to grind and grind and grind and go away disillusioned. So it's a moving target. We changed the standards year after year... tinkered with them for the next five years trying to get it right. And I think we did probably bring that first year some students for whom it was not the right thing. Some of them left. But we also brought some students who in the past would never have been admitted, and So one of them now holds the chair in physics at that's how it came about initially. I was involved in that up to about 1975 as chancellor.

INTERVIEWER: Do you take a significant degree of personal pride in that story right there?

GRAY: I do. Maybe the most important thing I did around here.

INTERVIEWER: Really?

GRAY: That plus the things we did in the '70s and '80s with respect to women.

INTERVIEWER: Again why not angry debates over quotas and fairness and all that in the course of bringing this policy about? I mean you can read all about the University of Michigan's experience. There are a lot of other institutions that have gone through this. Here there seems to be a sense of clarity that is mystifying to me.

GRAY: Well, a sense of clarity, but it was late. You know, we could have done this five years earlier. We could have and should have done it five years earlier. But up to that time up until 1968, MIT had never recruited anybody. We waited for applications to come. We got three or four thousand applications a year in those days and admitted a class of a thousand. They were very good students. Why recruit? It just wasn't somehow on the agenda. But with respect to underrepresented minorities, at first African Americans then very quickly including Hispanics and Native Americans as well, you couldn't do it without recruiting. You had to deepen the pool.

INTERVIEWER: And was there no sense that, hey physics is physics, science is science, we just want the best... forget all of this sociologist business?

GRAY: There has always been some of that. There's always been some of that. There'll be some of that probably today. It wouldn't, well I don't what it would focus on today if it exists. I just don't know. But there was some of that at the time. Now, in the spring of 1968, April of 1968, when we were well embarked on this, we had admitted the first class, we went to the faculty because we needed approval on some things. We needed approval for the summer subjects. We taught get-up-to-speed subjects in physics and math. There was a humanities program. There was an athletics and social program. And we needed to have that blessed by the faculty.

And we reported at that meeting on what we had done in terms of admissions and why we had done it and what the class coming in looked like. And we got approval for the things we needed approval for. And that was perhaps the most, at that time in April of '68, was probably the most intensely emotional faculty meeting I'd ever been to. And that was eight years of faculty meetings at that point. And a couple of people came up to me afterwards and said, "I had tears in my eyes when you made this presentation." I didn't make it all; the black students made it, the graduate students made it... made a large part of it. And the faculty overwhelmingly accepted. But there were surely people, some of them came to me later, that said, "What are you doing? What are you doing to these kids? Is this a good thing? What are you doing to the quality of the MIT student body?"

INTERVIEWER: How did the sort of culture and, I don't know, the sort of intangible qualities of the student body change during this period?

GRAY: Well remember now it's changing in two dimensions. More women coming and there are large numbers of students who weren't seen here before. One of the early, early happenings was the creation of what's now called Chocolate City. We have one dormitory here called New House which has six entries. It was designed on a model in which each entry would house about 50 people and it would be a more cohesive living group than if you had 300 people in one undifferentiated building. Six separate entries each with kitchens on every floor and so on. Chocolate City emerged. Not because anybody said we needed it, it just happened. People gravitated. Admitted students gravitated to congregate with other African American kids and Chocolate City over a period of a few years came about.

INTERVIEWER: And this was explicitly understood as Chocolate City?

GRAY: Yeah, that's what they call themselves. That's the name. And that's how they recruit every year for student members, new students coming in, entering students.

INTERVIEWER: And did you learn some new music? Just figure out a whole part of the world that maybe an only child in New Jersey didn't necessarily have much chance to learn about growing up?

GRAY: Well it was a new experience for me. I mean I had not ever had an African American in my classes through high school. And there were 15 or 16 in my freshman class at MIT and I didn't know a single one of them. Never had them in class. I didn't have a woman in my class at MIT until my junior year. So those were new experience for me. I should say we did a lot. We also created some new subjects on the African American experience and had them team taught sometimes by inside people and sometimes by people we brought in from the outside.

INTERVIEWER: You sort of off-handedly remarked that you had sort of had it with undergraduate education when you left during your career 1954-55. In observing the changes that were happening on campus, more than a decade later, did it occur to you now as an administrator that the MIT campus was getting a little more fun? With all these changes.

GRAY: Yes. A lot of things were happening in the '60s of course. The revolution came to Berkeley before it came east. But eventually, beginning in fact in 1968 coming to a crescendo in 1970 or '71, there was a good deal of antiwar activism here, which really dominated for a couple of years. The activities and the focus of the leadership of the institution, to keep it from flying apart. It wasn't as serious here as it was at Harvard, but being located in a major metropolitan area with a higher density of colleges and universities than any other place in the country, when there was some function at MIT in the form of protest, people showed up from all over greater Boston. And it got to be fairly intensive in terms of trying to keep the school working and keep the peace.

INTERVIEWER: Part of the revolution you described was the UROP program.

GRAY: Yes.

INTERVIEWER: What was the mission there and what need did it address?

GRAY: I have to back up to 1957. MIT in the '50s had what was called the Arthur Dehon Little Memorial Lecture Series. A.D. Little, Arthur D. Little was an alumnus. And it was a lecture delivered every year by some prominent person. In 1957, Edwin Land delivered the lecture which he titled, "The Generation of Greatness," and in it, he made the argument that colleges and universities, particularly those with a focus on science and engineering, fields like science and engineering, tend to drive the creativity out of 18-year-olds, that they come off to college all fired up, full of ideas, enthusiastic about getting on with things. And then they're faced with the requirements. The curriculum. And in his view, it drives out the creativity.

He said, what you ought to have instead, is every student who comes in ought to have someone he called, I think, a guide. A mentor. A faculty member. Who would take that student in hand, learn about what his or her interests are, what she or he wants to study, lay out a program, stay in touch with that student throughout, and guide them through the four years. Not sure he called it a guide, but he had a word for it. 1957.

In 1968, when we suddenly had a large chunk of money-- five years worth of it coming, two and a half million dollars in all from Din Land-- everybody in this group I described, the five of us who met said that we ought to go back and look at the ADL lecture, and see if we can in some way push in that direction. And out of that came the thought that we should, because the place has a very rich research environment, with all faculty involved in research, and with many faculty involved in overlapping areas, it's a rich environment. We ought to be able to find a way in which interested students could pair up with a faculty member, and work on a real project. Not a cooked project. But something real, something that would be useful to the faculty member, and learn how to proceed when you don't understand how to answer the questions, that key step in education.

In the winter of 1968-69, I recruited a young woman who was an MIT graduate, had a PhD in materials science. Her name was Margaret MacVicar. She died in 2002 of lung cancer. Never smoked in her life, but somehow lived one year after diagnosis. And I said to her, "There's this idea we'd like to try. Would you want to work on it?" I learned about her from Jerrold Zacharias, who had known her as an undergraduate. And he said, "This is the kind of person who has the drive, the personality who could make this work."

At that point she was an instructor in the physics department. Not an assistant professor, an instructor. She became assistant professor the next year. And we laid out what the idea was. And she said, "I want to work on this. I'll work on it full-time, starting in the summer of 1969." And she made it happen. All I did was run interference for her with department heads. Because we said early on, you've got to talk to key department heads, because this can't come as a surprise to them, that their faculty are saying, "Hey I've got this undergraduate working with me on something called UROP." That was her invention, that name.

So as she went around to talk to department heads. Many of them including my own department head in electrical engineering and computer science, pushed back and said, "That's never going to work. It's going to be just one more burden on the faculty, one more thing to have to do, and it won't work." Well, I tried to run a little defense on that, and say give it a chance, then we'll see what happens.

INTERVIEWER: What was your argument?

GRAY: Well, my argument was that this was worth trying. And we had the money to try it, and we ought to give it a good shot, and see if it'll work. And if it turns out to be something the faculty can't stand, we'll stop it.

INTERVIEWER: And the potential upside was what?

GRAY: The potential upside was that this would be a way in which students could-- for the first time perhaps in their years at MIT-- come to terms with an unsolved, real problem, something where they could make a genuine contribution. Exciting prospect. And it started that fall with a little thin booklet of opportunities. She'd talked with enough faculty to have a range of things one could do, and it was sent to freshmen, or given to freshmen at Orientation. And I don't know how many signed up that first year, but there were 50 or 100 something in that range, perhaps. And it just grew like Topsy from then on.

INTERVIEWER: And this wasn't just bottle-washing and Xeroxing.

GRAY: Oh, no. There was one rule. The only rule was that what you do has got to be worth academic credit. And it has to be signed off on by a faculty member. That was it. This was a non-bureaucratic deal. There was no committee formed to figure out how to do it. It was just one person who was making it happen. And it was as unbureaucratic as it was possible to make it. You can do anything you want to do as long as you find a faculty member who's willing to say, "Yes, I will supervised this, and if done properly, is worth academic credit."

Now, students had a choice. They could do it for academic credit, or they could do it for pay. And at that point all students here had self-help requirements. And many of them would do it for pay, because they wanted to not borrow the money instead. But in either case, the sign-off had to be that it was credit-worthy. So it was not washing bottles, no. Now, some 80 percent of the undergraduates do UROP while they're here. And the number doing it any particular term is about half the undergraduate body. And many of the alumni will tell you this was the most important thing they did it at MIT. It's what they remember the most, and what was the biggest deal for them in terms of their education.

So the program took off. It's never been bureaucratic. If the program office disappeared tomorrow, the program would still continue because the faculty appreciate it. Young faculty, particularly, thought this was a grand thing, because it gave them smart hands to work with them. At much less cost than a postdoc. Or much less cost than a graduate student who had to be supported. Young faculty thought it was a grand thing. And other faculty have piled in as well.

INTERVIEWER: Has the program been replicated outside of MIT?

GRAY: There were intensive efforts to replicate it. Once this got going, not in 1969, but by the early 70s it was being written up in the Chronicle and there were pieces in the general press about it. And a lot of folks came to us calling, saying, "Help us make this go." The key thing that it takes, I'll say two things that it takes. One is you have to have a rich research environment. You have to have lots of research activity. You can't do it if research is on a small scale because there aren't enough people to match students up with. So you have to have a research environment that's broad, covers a wide range of subjects, and is rich.

And secondly, you have to have the genius that Margaret MacVicar brought, to make it non-bureaucratic. Stanford came and said, "Watch this, we see how it works, and we're going to start it." The first thing they did was appoint a committee. Committees kill things. They write the rules! And you only need that one rule, faculty members have got to approve it. Some places have it. There are programs like it, but none quite on the scale that it is here, which I attribute entirely to her genius.

INTERVIEWER: But nevertheless it's also something that you have a certain amount of personal pride over.

GRAY: Yeah, I mean, I was just her supporter in this. But she did all the hard work. She deserves the credit for it. I was delighted to have it happen. And I think Din Land was delighted to have it happen.

INTERVIEWER: As president of the university, you faced a situation that was somewhat at odds from what you describe as your good fortune, coming through MIT in the 1950s where there was a good deal of support from industry and the government for research at MIT... and for supportive education at MIT. When you became president, suddenly there was a lot more hesitancy on the part of particularly government institutions to support scientific education at a place like MIT. What was going on then, and how did you begin to address it?

GRAY: Well, the problem actually began about the time I became chancellor. If you look at the history of research support at MIT, there was very little. Prior to World War II, it was almost nonexistent. Occasional faculty members would have a grant from a company from industry, to support a graduate student. We had graduate students whose doctorate was earned in those years, but there were very few. And it was the World War II experience which we should talk about at some point, the influence of the Radiation Laboratory. That left the government understanding that if we supported research in graduate education in universities, it would have benefits for the nation. It all came out of that report that Vannevar Bush wrote, called "Science: The Endless Frontier," when he said, "If we continue this partnership between government providing research dollars to universities, it would have benefits to the economy, to public health and to the general welfare, to job creation."

INTERVIEWER: And the template for that partnership really came out of the Radiation Labs.

GRAY: It did. Well, no, it was broader than that, John. I mean, the template for this continuation of research support grew out of all these laboratories that had been created around the country during the war. It was the Rad Lab here, it was the jet propulsion lab at Caltech. It was the applied physics laboratory at Johns Hopkins, and how many others I don't remember. That was the template for the continued research support. If you look at a graph of research support, it starts out in the late 40s, and it increases continuously, and then there's a big increase in the slope, on the Logarithmic coordinates. There's a big increase in the slope in 1958 because of Sputnik, and it continues right up to 1968. And in 1968 Lyndon Johnson realized he couldn't have simultaneously the war on poverty and the war in Vietnam.

And research support began to be cut back. It fell in real terms until the start of the Carter administration, in what was that... '76? It came up a bit in '76, and then was largely stagnant in real terms through the 80s; didn't get another boost until really into the 90s. Its effect on MIT was not as great as it may have been on other institutions. We were more or less flat in constant dollars. We were not, at that point, increasing the graduate population... didn't have the capacity to increase it because of the funding constraints. But there still was a very rich research program going on here.

If you look at the larger picture, what has happened from World War II up to the present is that much of the research support in the post-war era came from the Department of Defense. It was what in the jargon of the defense department was called "6.1 Funds." That is basic research. It was not targeted research. It was not related very directly to applications at all; it was quite fundamental. They created the materials science laboratory here, with Department of Defense support.

But as time went on, the NSF became more prominent. The National Institutes of Health, which is now the single largest source of research money here, became much more prominent. And the Department of Defense funding decreased, I think starting early in the Reagan years, when he was determined to build up our defense posture. And was taking money out of the 6.1 category and putting it into higher levels of research, development tests, and production. So the Department of Defense's support dropped; the other two increased greatly. The problem with the NIH support is that every congressman's got his favorite disease, and a lot of that money gets earmarked, not always in ways that are fully constructive. It's by and large pretty good, but there are also some problems.

And we've had to adapt, of course, to that shift. The research support was critical at the end of my time as president. When Chuck Vest became president, you may remember there was the great overhead scandal, which started at Stanford that year, where the expense of a yacht was being paid out of research overhead... satin sheets in the president's house, a wedding party in the president's house partially paid out of overhead... and Congress really came down very hard on reimbursement of overhead costs. The circular-- circular A-21 which describes all the rules-- got revised, substantially revised. We took a big hit. All universities took a big hit. Expenses that used to be reimbursable no longer were, and we had to adapt to that.

Chuck Vest, my successor as president, spent the better part of his first few years as president in Washington trying to persuade Congress not that MIT needed more support, but that research universities were important. That graduate education was important, and the government had an ongoing stake in this, which if it did not fill, was not going to get filled by anybody else. And he largely turned that around and was widely recognized for that. I think that's why he got the National Medal of Science.

INTERVIEWER: In your period as president, is it fair to say Japan replaced the Soviet Union as a competitor in science and technology? Perceived or in real terms?

GRAY: Yes, I mean, I think we learned following Sputnik somewhere in that interval, up to say the 1980s, there had been a number of happenings that led the nation to develop a more modest appraisal of Soviet science and engineering. I remember one of the crucial elements was a Russian pilot flew out of the country with a MiG, the most advanced MiG they were making at that point, and landed it somewhere in the Far East and the US got their hands on it. And the electronics in the MiG were still vacuum tubes, Sputnik notwithstanding.

And there were a number of events of that kind, which suggested that they were not as far advanced as Sputnik would have suggested. But certainly by 1980, everybody was talking about the Rust Belt. Japan was going to have not only our lunch, but breakfast and dinner too. Detroit was going to disappear from the scene, on and on and on. That led us to create the Commission on Industrial Productivity in 1985. And I have to say that among the people who were pushing us on that were some of the trustees, specifically, two of the trustees who served on the Executive Committee, both of whom had had careers in industry and understood the threat.

The Commission on Industrial Productivity included engineers, physical scientists, several economists, a couple of humanists, political scientists. It was about 15 people. It was chaired by Bob Solow, Nobel laureate in economics, and Mike Dertouzos, now deceased, but the former head of the Computer Science Laboratory. And they worked at this for two years with support from the Sloan foundation. And in 1986, '87, produced the report called, "Made in America," which had a whole set of analysis of what was wrong... what was wrong with manufacturing in the United States and what ought to be done to change it... and those recommendations went from the way managers in manufacturing are trained to the way in which designers and manufacturers don't work hand in hand. Throw the design over the transom and see if they can make it, to how we educate managers generally to how we deal with labor unions, and how do we develop a more collaborative relationship between labor unions and management?

And that report had I think considerable impact. It was widely picked up. The Japanese eventually approved one called, "Made in Japan", as kind of a commentary on it. It led also to our creation in 1987 of the program called Leaders for Manufacturing, which was a singular event and terribly important at MIT. It was the first time that the engineers, School of Engineering, the School of Management, and industry came together in a troika to build a new curriculum and say, "This is how the management of manufacturing should be taught." We raised 40 million dollars from five companies to fund that program, the first five years of it. And other companies came in at smaller levels, smaller than eight million dollars each. The program has been an enormous success. It's provoked imitators. It's spun off other activities at Sloan that are of a similar character. And I don't think either the book or the program can take a large share of credit for the way manufacturing in the US has changed, but it certainly has changed.

INTERVIEWER: You described some frustration when you were placed into second semester math as an undergraduate, that maybe theoretics weren't for you, that you were more interested in the applied. In the course of your career, particularly the years when you were president, MIT saw an extraordinary convergence of theoretical knowledge and applied knowledge, and cross disciplinary knowledge, as the real sort of engines of innovation and change throughout the economy and throughout sort of technology. Describe that change as you saw it, and how important do you think it was?

GRAY: Well, it came on gradually. I mean, you're right that it came on during that decade.

INTERVIEWER: And there were certainly a lot of people talking to each other who didn't normally, and you had it be in the middle of those conversations.

GRAY: Yes. You know, it was partly driven by funding, the flatness of federal funding during that period. We started in the 70s. And I was involved through the 80s, and a little involved in the 90s, raising research support in Japan and South Korea and Taiwan, and did pretty well at that. We raised a large number of chairs. And a chair funds a professor and provides some research support as well. And we raised a number of research initiation funds, which came from Japanese companies with remarkably few strings. Koji Kobayashi, who headed Nippon Electrics -- really created Nippon Electrics following World War II -- gave us a couple of million dollars for a research initiation fund in the general area of electronics.

And I think the funding changes, the fact that there were other relationships with industry being created. We created a partnership with IBM to support research in computer science. A long-term partnership; turned out to be 10 years. Started in the 70s then when on into the 80s. And there were others that I'm not going to be able to put a name to right now. But the fact that funding was now coming from people who had more interest in applications, although we were very careful to make sure this funding wasn't prescriptive, in a sense it was going to constrain what we did very much. I think that was part of the force that brought together basic research and applications. So that wasn't all of it, but it was part of it.

INTERVIEWER: You're something of an electrical engineering rock star in Japan... garnered some serious awards and notoriety. What's it like to be recognized by Japanese colleagues, particularly for some of the curriculum changes and innovations that you made at MIT that have had impacts far outside this university?

GRAY: Well, I have to say it was very satisfying. It came as a total surprise that I had that honor from the emperor. There was a funny family twist on this, because at that point my son-- we had three daughters and one son-- my son, who had been married for three years to a Japanese woman, a Japanese woman who'd lived most of her life in the US but was still very Japanese. Bilingual, completely bilingual... trilingual, she speaks French flawlessly, also. They were living in Japan at that point. He was working for Bridgestone Tire, and she was running her own business there... hard to do for a Japanese woman in the late 1980s. And one of the wonderful moments was they called us up one morning and said, "Do you know that Paul Gray is being honored by the emperor, because there it was on the front page of the Japanese newspapers?" We knew it was coming, but we hadn't told them, we hadn't told the kids in Japan, and it was a wonderful shock and surprise for them.

It turned out that I couldn't get to Japan at the time of the ceremony when these awards were going to be presented, so it was presented here in Boston at the home of the Japanese consul general in a black tie dinner, to which all our kids were invited, the ones in the US, and some other close friends. And then six months later, my wife and I were going to Japan. That time not on MIT business but to see our new granddaughter in Japan in 1991. And an audience with the emperor and the empress was arranged, so we did have a chance. We had a pleasant hour, just my wife and I, and the two of them, talking about Japan and the US and relationships. But it was exciting, and it was very pleasing.

INTERVIEWER: Why do you think MIT is unique?

GRAY: It's the only research university with this strong a focus on science and engineering, and that influences who comes here, graduates and undergraduates. It influences strongly the complexion and the interest of the faculty. That's its singularity, is the fact that those two fields embody 80 percent of the students, and about 80 percent of the faculty. And flavor much of what goes on around the place.

INTERVIEWER: How has the MIT student changed in the period you've been familiar with this institution, and we're talking almost three generations.

GRAY: Well, the most immediate answer is the change in the character, the change in the mix of the student body; 45 percent women now, somewhere in the range of 20 to 25 percent underrepresented minorities, lots of Asian students. I find myself explaining to visitors that we do not have a lot of foreign students in the undergraduate population here. We have 30 percent of the undergraduates who are Asian Americans. American kids of Asian background. And it's because they bring the same kind of passion for learning that the Jewish kids brought in the 1950s, when their parents had left Europe in the 30s, brought them over here, sent them off to places like MIT. And they were hardworking; I mean, they were distinguished by their compassion for learning. The same way with the Asian students. Back up. Those were the most obvious changes.

In the 1950s, students that I knew the best, who were in engineering at that point, regarded successes as working for a big company... a big engineering firm... AT&T, IBM, Xerox, or whatever it was. And jobs, at that point, were thought of as sort a lifetime commitment. I go to work for a company, I'm likely to be there my whole career. That's completely changed. Students today-- I still advise students, I have now 16 advisees, half of whom will graduate this year-- success now is working in a start-up, or better yet, if you can make it work, creating a start-up. Seeing how it goes. And in any case, it's not working for a big company. They'd much rather work in a smaller company, where they can get some sense of how the whole thing works, instead of being one of 100s of 1000s or 10s of 1000s in a big company. Really dramatic change in the career interests of the students I see.

INTERVIEWER: Now, some have described that as a substitute of shorter term business goals, for what maybe traditionally was a longer term basic research goal of the MIT graduate. Is that how you see it?

GRAY: No. No. At least not going back to the students in my generation, not many of whom went straight on to graduate school. Some may have gone on for a Master's degree later on. But the number of those who went on to PhDs in those days was not large. It was larger, I think, in the 60s and 70s to be sure... I mean, it was moving in that direction. But it was not the case in the 50s.

The variety of careers that students today are looking for has changed dramatically, as well. It used to be students did not go to work for consulting firms; now a significant fraction do. A significant fraction of the best students get recruited to consulting firms. A lot of them don't stay there very long... some of them stay and make partner. But many of them will have a few years at that and then go off elsewhere. A significant fraction go off to Wall Street; become quants. That didn't used to happen. But the majority that I see are still interested in working in a business where they can learn the ropes of how business works, with the eventual goal of maybe starting a company.

INTERVIEWER: Why are arts and humanities important at MIT? And why were you such a champion of those?

GRAY: Engineering is a socially derived activity. The business of engineers is to satisfy social itches, to meet the need that people perceive to exist, the needs that are expressed. That's not the all of engineering-- there's the sector of engineering that works for the government, in defense and national security-related things. But at its root, engineering is derived from society, and engineering graduates ought to understand something about the society, about the way it works, about how people behave, about how to relate to people, about how to communicate effectively. I've never met anyone in any field who was successful who wasn't a good communicator. And not everybody's a good communicator when they come here as 18-year-olds. Some of them learn a lot when they're here.

But it is learning about human nature. Learning about how societies work. Learning to communicate. Those are skills that you need to be effective as an engineer, and I would say even as a scientist, where increasingly non-academic science at least is bring driven also by societal needs, expressed or unexpressed.

INTERVIEWER: So after you've gone from undergraduate to president at MIT, what do you do next? It was an easy decision for you I guess.

GRAY: It was. For two reasons. One, there is the expectation at MIT that the retiring president will, if possible, continue on as chairman of the governing board, which at MIT is a full time job. That didn't happen with my predecessor, with Jerry Wiesner, because at that point there was required retirement age. And Jerry retired at 65. I don't think he wanted to do that job anyway. But, he wanted to be back as an Institute Professor and do what he wanted to do for the next 10 years which is what he did. Next 20 years... most of 20 years.

But, his predecessor, Howard Johnson, had become chairman of the board. Prior to that Jay Stratton had not, but Jim Killian had. So there was that expectation. I had started a capital fundraising drive in 1987 which was a five-year enterprise, ending in '02. And so I felt some responsibility to stick with that as chairman, instead of president, and see it through to its end.

The chairman at MIT, fresh out of the presidency, if the president moves fresh into the chairmanship, knows the whole donor community and continues to be effective in fundraising while the new president figures out the donor community, and who the new donors are going to be, and moves beyond the knowledge of the former president. And that ability to be effective in fundraising as chairman probably has a half life of about four years, because the donor community expands and changes. But I was able to capitalize on that for a few years. I stayed on for seven years as chairman, because I enjoyed it. And then at that point said I want to go back to full-time teaching, which I did for another 10 years.

I taught when I was chairman as well. I negotiated my agreement as chairman that I'd have time to teach one subject a semester throughout those seven years.

INTERVIEWER: And with all the experience of administration, how did that enrich your skills as a teacher when you finally went back, after all those administrative jobs, and taught for those last 10 years?

GRAY: Very little. Very little. I mean, when I came back to teaching in 1997, seven after 1997 when I was no longer chairman, I took responsibility, I guess five or six times in total, for running a large subject, a subject with two or three hundred students. This means giving lectures, managing the staff, and getting the homework written, and graded and problems and solutions produced, and producing exams and all that. But I'd done that in the 60s. It was not new. I knew I could do that. And whatever I learned of administrative skills didn't have much bearing on that, when I was in charge of those subjects. And as far as the students were concerned, I was just another grey-haired old guy. Most of them didn't know that I'd been president. The ones who were my students when I was still chairman knew, because they'd come see me in the chairman's office. But once I got back to an office in the EECS department, most of them didn't figure it out. At that point I was seven years away from the presidency, and the chairman is not widely known among students anyway.

INTERVIEWER: That seems like a lot of pressure. I mean, how you keep from being the grey-haired vacuum tube guy? Who's going to pay attention to him at MIT in 2007?

GRAY: Well, I had taught when I was president. A little. Not a lot. I did it to shame some of my colleagues, I have to tell you. And I taught a bit when I was chancellor as well. And I had made an effort to stay up with what's going on in the field of electronics. Not to the level where I would ever expect to teach graduate students. No way. But to teach the first course in electronics and circuits in electronics, yes... could teach it from somebody else's syllabus. We used a different textbook at that point and could do it effectively. To teach the first course in signals and systems, the same way. But I taught one upperclass subject; I taught the upperclass elective in microelectronics, again working from somebody else's book. So the grey-haired old guy was up to speed in those subjects, but not for anything much above that.

Now I say that I taught in the 80s for two years to shame some of my colleagues. In the middle 80s, the enrollment in electrical engineering and computer science was exploding. And it started out the decade at about 200 per class, 200, 250 per class. And by 1985 it was up to 350. And there was concern that if the trend line continued, it was going to go past 400. It was more than the department could staff and manage. And what's more it beggared all the other departments. Who said where are my students? They're all in EE!

And the department at that point was desperate to get more people to teach sections. And a number of folks who were faculty members of EECS, but were also laboratory heads, were saying, "Gee I just don't have time for that." So, I figured if I showed up and taught two sections for a couple of semesters, some other people might catch on. And they did. It made some difference. What happened in fact was that the trend line turned. Interestingly, the faculty had created, after enormous discussion and much angst, had created a set of rules, which would come into effect the next year if the enrollment of freshmen interested in EECS had gone up, and if the number who showed up as sophomores the next year looked like it was going to go up

And the rules were terrible. They were the best you could do, but they said, "You're going to have to divide the students who want to do EECS into sheep and goats, and you're not going to let the goats in." Terrible. Also, because there was great concern about ever putting these rules into affect. The Sloan school created a subject, which was a primary focus in computation. And the math department created a subject in mathematics and computation. And also civil engineering did the same. That drained off some of the students that otherwise would have thought they had to be in Course 6 in order to learn to be computer scientists. And so the curve turned down and we never had to do that. But that's how I got involved in teaching in those decades.

INTERVIEWER: During your time as president, the diversity of the MIT faculty didn't increase that much. Something you've commented on. It has since come about.

GRAY: Yes, it has changed. It's not where it should be. But it is changing.

INTERVIEWER: What is your view of what the obstacles were when you were president, and how they've been overcome.

GRAY: The principal obstacle that I faced in fact, faced in 1968 when I was associate provost and the Institute was required for the first time to write an affirmative action plan by the Department of Labor, I guess at that point. And we had to make projections of how many minority -- minority at that point still meaning mostly African American-- how many minority faculty we could hire over the next five-year interval. So we consulted a lot with departments. I consulted a lot with departments. Jerry asked me to take this on. And we eventually put together an affirmative action plan, which said we will hire over the next five years, I think the number was 28 African American faculty. At that time we had eight perhaps, six or eight. Thank goodness the Department of Labor didn't try to hold us to that, because we came nowhere close. We may have increased the number in the five-year interval to 12 or 15, but the basic problem was, there weren't people you could hire. There weren't enough African Americans going into PhD study, preparing for academic careers. And of the ones who did prepare for academic careers, many of them wanted to get out of academe and go to work in industry, wanted be paid a hell of a lot more, and have chance to make what they saw as a better career. We just weren't able to hire them.

What has made the difference in the years since is more evident and more powerful incentives, on the part of departments to hire minorities and to pay closer attention to what the record is. When appointments came up, even in the 80s when appointments came up who are non-minority, the department had to talk in some detail about what it had done in its effort to recruit a minority for that position. We offered positions to many more than were accepted over those years.

It worked into the fabric of the place, the idea that you had to work hard on this issue. And working hard meant establishing relations with African American or Hispanic youngsters, when they were in graduate school somewhere else, and bringing them in, and providing them with a mentor. And seeing that it took. That grew into the fabric I think.

INTERVIEWER: Through your enormous experience here at MIT, being in this community, I mean aside from the Red Sox winning the pennant twice, what's the most surprising and exciting change that you've seen over that period?

GRAY: It's the diversity. It's the change in diversity. It really is. Nothing else. It's not surprising. I mean, we worked hard at it. But it's appreciated, widely appreciated. It's important, and it's satisfying.

INTERVIEWER: And your English teacher was right about your decision to come here?

GRAY: Yeah. No question. She was right.