CHEMICAL HERITAGE FOUNDATION

RAYMOND E. MARCH

American Society for Mass Spectrometry

Transcript of an Interview
Conducted by

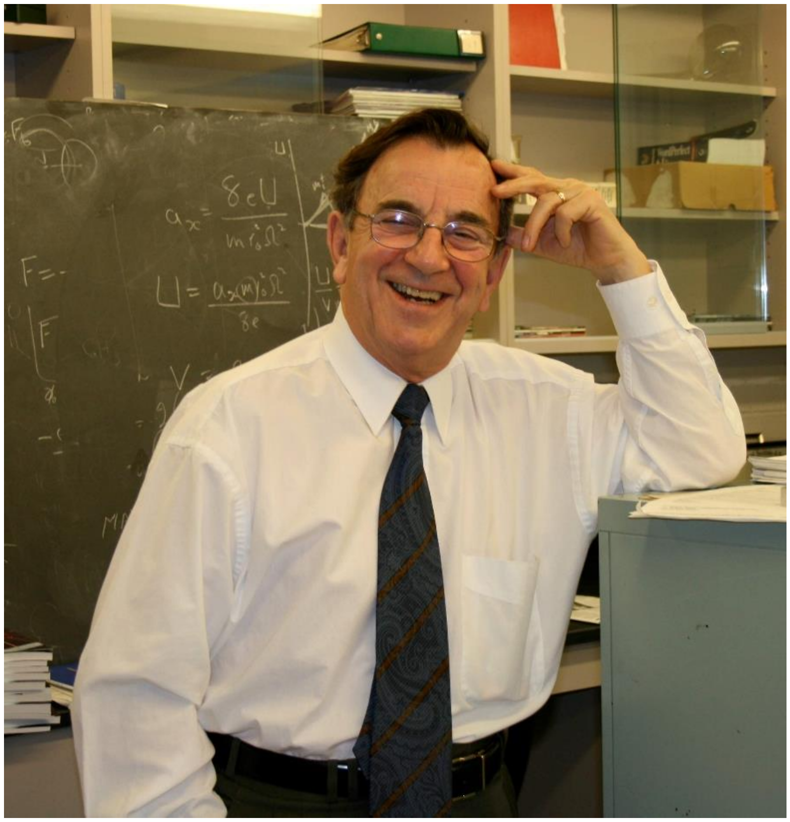
Michael A. Grayson

at

March Home
Peterborough, Ontario, Canada
on

27 October 2014

(With Subsequent Corrections and Additions)



Raymond E. March

ACKNOWLEDGMENT

This oral history is one in a series initiated by the Chemical Heritage Foundation on behalf of the American Society for Mass Spectrometry. The series documents the personal perspectives of individuals related to the advancement of mass spectrometric instrumentation, and records the human dimensions of the growth of mass spectrometry in academic, industrial, and governmental laboratories during the twentieth century.

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RAYMOND E. MARCH

1934	Born in Newcastle upon Tyne, United Kingdom, on 13 March

Education

1957	B.Sc., Leeds University, Chemistry
1961	Ph.D., University of Toronto, Chemistry

Professional Experience

	PAMETRADA Research Station, Wallsend, England
1951-1954	Apprentice Industrial Chemist
	Leeds University
1954-1957	Royal Air Force Voluntary Reserve, University Air Squadron
	Royal Canadian Air Force Auxiliary
1958-1963	Flight Lieutenant
	Canadian Industries Ltd (CIL)
1960-1961	Research Fellowship
	Johnson & Johnson
1961-1962	Research Scientist
	McGill University, Chemistry Department
1962-1963	Postdoctoral Fellow
1963-1965	Research Associate
	Loyola College, Montreal
1963-1965	Lecturer (part-time)
	Trent University, Chemistry Department
1965-1969	Assistant Professor
1969-1976	Associate Professor
1976-1999	Professor of Chemistry
1999-present	Professor Emeritus
	University of Kent
1972-1973	Research Professor

Queens University, Kingston, Ontario, Chemistry

1981-2000 Adjunct Professor

York University, Downsview, Ontario, Chemistry

1990-2000 Adjunct Professor

University of Waterloo, Waterloo, Ontario, Chemistry

1995-2000 Adjunct Professor

2005-2014 Trent University, Lecturer of Graduate Course in Mass Spectrometry

Research and Sabbatical Leaves

1972-1973	Sabbatical leave; Collisions Ionique, Orsay, France, with Jean Durup
1973	Visiting Professor; University of Kent, U.K., with John F.J. Todd
1975	Exchange Fellow; Collisions Ionique, Orsay, France, with Jean Durup
1980	Visiting Professor; Royal Society Research Unit, Swansea, Wales, with John H. Beynon, FRS
1980	Exchange Fellow; NRC-Royal Society of London, Swansea, Wales
1986 and 1987	Visiting Professor; Université de Provence, Marseille, France, with Jacques André
1987	Distinguished Lecturer; Bern, Neuchatel, Lausanne, Switzerland
1989 and 1992	Visiting Professor, Université de Provence, Marseille, France, with Fernande Vedel
1993 and 1995	CNRS Visiting Professor, Université Pierre et Marie Curie, Paris, France, with Jean-Claude Tabet
1995	Visiting Scientist, National Research Laboratory, Padova, Italy, with Pietro Traldi
1999	Visiting Professor, Université de Provence, Marseille, France, with Yves Zerega

Honors and Awards

1950	Whitley Bay Grammar School, School Certificate Prize in Mathematics
1978	Fellow of the Chemical Institute of Canada (FCIC)
1995	“Recognition Award”, Canadian Mass Spectrometry Society
1995	Distinguished Faculty Research Award, Trent University
1997	“Distinguished Contribution Award,” Canadian Mass Spectrometry Society
2000	D.Sc. from Leeds University
2008	Docteur (honoris causa), Université d’Aix-Marseille
2009	Gerhard Herzberg Award, Canadian Society for Analytical Sciences and Spectroscopy

ABSTRACT

Raymond March was born in Newcastle upon Tyne, England, one of two children. His father was an electrician and his mother a shop worker. March's childhood was shaped by World War II, and by a mysterious polio-like paralysis which caused him to miss a great deal of school. He took an apprenticeship with PAMETRADA (Parsons and Marine Engineering Turbine Research and Development Association) Research Station, where he learned his way around a lab. He continued to attend school part time, and he passed his exams, gaining admittance to University of Leeds. There he majored in chemistry and was in the University Air Squadron, learning to fly de Havilland Chipmunks. He was intrigued by a visit from John Polanyi, but it was the change in national service requirements from two to three years (if one wished to fly) that provided the impetus to accept a scholarship to the University of Toronto, where he worked on flash photolysis with Polanyi. He returned briefly to England to marry; his wife became a teacher in Canada.

March developed a needle loop technique at Johnson and Johnson, then ran into Frederick Dainton with Polanyi and Harold Schiff at McGill University. He took a postdoc position in Schiff's lab at McGill, where he worked on methyl metals and microwave discharges; on atmospheric chemistry; and on aluminum trimethyl and impact work for Gerald Bull**,** who built the supergun. Attempts by the Front de Libération du Québec (FLQ) to secede from Canada caused March to accept an assistant professorship at the brand-new Trent University in Peterborough, Ontario. On a sabbatical in France March learned mass spectrometry and ion traps from Jean Durup and has continued to specialize in quadrupole mass spectrometers and to refine ion traps.

Becoming interested in flavonoids, March established the Trent University Water Quality Centre and added an interest in antibiotics. He talks about insect-induced metabolite changes and surfactants in blood; he developed an analysis of furans, PCBs, and dioxins for Varian Medical Systems; and he is collaborating on the problem of proteins and drugs and competition on proteins between drugs and contaminant molecules.

March discusses his contributions to the establishment of Trent University and his pride in Trent's progress; his role on the editorial board of the *International Journal of Mass Spectrometry*; and his ongoing argument with Joseph Loo, editor of *Journal of the American Society for Mass Spectrometry* (ASMS). He also talks about his many friends and colleagues; his trips to Europe; funding; and his patents. March considers his most important publications to be his works on high mass resolution; on collisional migration, written with Durup and Ronald Bonner; and on competitive binding for drug molecules and contaminant molecules. He concludes with an encomium of the quadrupole ion trap mass spectrometer on the Rosetta mission to characterize a comet.

INTERVIEWER

Michael A. Grayson is a member of the Mass Spectrometry Research Resource at Washington University in St. Louis. He received his BS degree in physics from St. Louis University in 1963 and his MS in physics from the University of Missouri at Rolla in 1965. He is the author of over 45 papers in the scientific literature. Before joining the Research Resource, he was a staff scientist at McDonnell Douglas Research Laboratory. While completing his undergraduate and graduate education, he worked at Monsanto Company in St. Louis, where he learned the art and science of mass spectrometry. Grayson is a member of the American Society for Mass Spectrometry (ASMS), and has served many different positions within that organization. He has served on the Board of Trustees of CHF and is currently a member of CHF's Heritage Council. He currently pursues his interest in the history of mass spectrometry by recording oral histories, assisting in the collection of papers, and researching the early history of the field.

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INTERVIEWER: **Michael A. Grayson**

LOCATION: **March Home**
Peterborough, Ontario, Canada

DATE: **27 October 2014**

GRAYSON: I'm going to start this morning by the normal formula, which is to say that my name is Mike Grayson. I'm at Peterborough, Ontario, Canada, and this is the twenty-seventh of October, Monday, 2014, and I am interviewing Professor Raymond E. March, mass spectroscopist of note, about his career. So with that kind of informative statement about who we are, what we're about, and that kind of thing, I think we can go ahead and get started. You did get my kind of general list of things we're going to talk about in the general way. I noted that I also, if we can remember to think about who, what, where, when, how, and why, and provide those details as we go along, because that's part of the record that makes it useful, particularly any dates that are significant, and individuals that are significant. So what I'd like to do is really get a bit of background of your family. From what I understand, you grew up in the UK [United Kingdom].

MARCH: Yes.

GRAYSON: So this was in the late thirties?

MARCH: I was born in Newcastle upon Tyne, in the north east of England, in 1934, on the thirteenth of March.

GRAYSON: Oh, early thirties. What was the date? I'm sorry.

MARCH: Nineteen thirty-four, March the 13.

GRAYSON: Okay. Very good.

MARCH: Newcastle is famous for its soccer team, Newcastle United, which I see won yesterday. And also, there's a new musical on Broadway, I think written and directed by

Spine—I've forgotten his name now. Shrimp or something like that. And it's about human problems in Wallsend near Newcastle upon Tyne, and that's where I first began working, Wallsend on Tyne.[1]

GRAYSON: So can you tell me about your parents, their names and what their occupations were?

MARCH: My mother was called Violet. Her maiden name was Waterhouse. She was of limited education. She was born in 1909, and was therefore of limited education, and worked in a number of shops during my lifetime. My father was called Alfred Ernest March, and he was an electrician, an industrial electrician and, [during the Second World War], worked principally [. . .] on [submarines and] ships in Tyneside.

GRAYSON: So Newcastle was close to the coast?

MARCH: Yes.

GRAYSON: Very good. And now so you say neither of them really had very much in the way of higher education.

MARCH: No.

GRAYSON: I see. Now did you have brothers and sisters?

MARCH: I had one brother, Sydney Ernest, and he died when he was fifty-two. He also was an electrician.

GRAYSON: Okay. So was there kind of an emphasis on education in the household that you noticed particularly, or—

[1] John Logan and Brian Yorkey, "The Last Ship," directed by Joe Mantello, premiered June 10, 2014 (Chicago: Broadway, 2014).

MARCH: Yes, encouraged, but I started school in September 1939, and that date is better known as the beginning of the Second World War. And so things became quiet chaotic for the next six years. I had an uncle [George March], a brother of my father, who was in the [Royal] Air Force, and stationed essentially at home, because he was involved with a radio monitoring station in the North of England. So with his help, I learned the Morse code, and he built a little tapper, and with a light signal also, and we would practice this on visits when he and my aunt came to visit us. And [. . .] at that time, I was about seven when we started, and I was absorbing stuff like **<T: 05 min>** this wonderful paper that you get, of blotting paper. Anything I heard, I could just take in, and so I became quite adept at semaphore. And we would take back and forth, and it was enormous fun.

GRAYSON: Well, now, you must have had some pretty interesting experiences being in the UK during that time period. Do you recall much of the war activity there and how things went?

MARCH: Yes. I would read the news. The newspapers, of course, would tell you a lot. They would have little photographs of each casualty in the services from that area. The nine o'clock news, the BBC [British Broadcasting Company] News at Nine, was listened to by almost the entire country every night to get some idea of what was going on. It was very sad for a long time. It of course was dark at night. That part of the world gets dark early in the winter, and so it could be dark from half past three in the afternoon to after eight the next morning. And no streetlights, of course. The windows were all covered in sticky paper so that flying glass wouldn't cause injuries, and so you had to be very careful moving around. My mother had sight only in one eye, through an accident just after she was born, and so I would have to walk with her, to take her arm, and say, "We're coming to the curb, down, and curb, up," just to guide her. So I was her eyes, although we seldom went out at night. I remember going out to visit a friend in the next street, a friend from school, and then returning, and then there was an air raid that night, and it happened that there was a land mine that was dropped, not—there were bombs which came down freely, and land mines, which floated down with parachutes. And this was a land mine, and it hit his house, and some neighbors, and of course, they were all killed, and I never saw them again. And for the rest of the war, the places where those houses had been stood empty, as a constant reminder of that. Shrapnel was one of the delights, shrapnel collecting. If you could get a fin from an incendiary bomb, that was a real prize. The tail piece from that. And we would trade shrapnel back and forth. And there was always the odd wag, who had found a finger that had been blown off, and would show this in a matchbox or wrapped in cotton wool with a bloody—it was actually his own finger, of course, stuck through the bottom. But all sorts of things happened in those days. And then in 1945, the war ended in Europe, and I had been involved in helping to organize a street party for that, and in May, 1945, and the day before I had appendicitis, and then off to hospital for an appendectomy, so I missed the whole thing. In August was the end of the war in Japan, and then the peace started. The peace was little better than the war, because food and—the conditions were very, very poor.

Let me jump and say I've just finished writing with John Todd a retrospective lecture on the development of mass spectrometry in the last sixty years, and we've opened our paper by talking about the Queen [Elizabeth II] in 1952 being crowned and approved by Privy Councils of various countries in the Commonwealth as Queen, and that she was twenty-five at that time, and at Leeds University, there is a plaque commemorating the award of a Nobel Prize to—and I'm going to forget the names. The names. To Bragg, father and son [Sir William Henry Bragg & Sir William Lawrence Bragg].

And the son was twenty-five when he and his father were awarded the Nobel Prize, and he's still the youngest Nobelist award, in physics, certainly, in physics. He's not the youngest Nobelist. That was 1952. And in 1952, I remember **<T: 10 min>** going to a place called Rutherford College in Newcastle in the evening, so it was dark. It was November-ish. And the lights came on, and sweets and candies were no longer rationed. And I came to the shop, and its windows were full of candies and sweets. I had never seen that in my life. I guess when I was less than five I wasn't out at night, so I never saw one lit up, ever. At that time, 1952, I was eighteen. And I remember being astonished at that sight. So—

GRAYSON: So you'd gotten used to such a deprived environment that—

MARCH: Yes.

GRAYSON: —to see something as simple as a shop full of candy was an astonishing thing.

MARCH: It really was. I've never forgotten that. And that's why [this experience was included in] the introduction to this retrospective lecture.

GRAYSON: So basically, you had a fairly—I mean, going to school during that period must have been a little bit of a challenge, you know, grade school, with the war going on.

MARCH: Yes, it was. Of course, we didn't fully appreciate, when you're just a young lad of six or seven, the value of education. And one always had in the back of the mind that if there was an air raid after ten, then you didn't need to go to school until ten in the morning. There was an hour, you see, leeway, so that you could sleep a little longer. And so that was in some strange way, actually, a little treat for us, yes. But there was a range of shelters, bomb shelters, that I recall. The worst type, which I never had to use, was when they would come to your garden and dig in, and then put in corrugated steel to make a little safety device, shelter, and then covered that with soil and grass. But of course, it was below ground level, and so with all the rain that one usually gets, those things were always wet.

And it was—they were just miserable. That was one type. Another type was to have a sturdy brick shelter with a concrete roof, down the center of the streets. There weren't many cars in the war, during the war, and so everyone would go out at the sound of the siren, and you would go to a certain place and lie down. And the children, we had on our siren suits, which were essentially like track pants and track shirt, but you quickly get into it and zip up, and then you're carried out and put down to sleep. And my brother was there, and he was next in line with another young fellow, and the fellow had impetigo on his feet, and then his feet were touching my brother's head. And my brother got impetigo, and oh, it was terrible. He had to have his whole head shaved and treated, and so on. So that meant that he could not be evacuated. So we'll come back to that, perhaps, if I remember. So that was the long street shelter.

You would have a similar type in your back garden. At least it was above ground. It was dry. And a concrete roof, and a blast wall in front of the door, and there was part of one side which was very lightly mortared in, and you could easily break that, should there be a direct hit, and get out. The sand would flow from the rocks. So there was that type. Then the fourth type I remember was one that you would have here, in a room, and it was rectangular. It was about this height [75-80 cm], stainless steel, about a half inch stainless steel roof, and supports, and then a mesh around each side. And for some quite considerable time, my brother and I slept in one of those. It was bigger than this table. It was perhaps out to there. And you could use it to play on, put ships on, and whatever.

GRAYSON: So it sounds like some of them, people would buy them for their families. Is that—or were they provided by the government?

MARCH: I think they were all provided. I don't know anything about the financial arrangements for them. No.

GRAYSON: So they wanted to at least provide as much protection for the civilian population as possible.

MARCH: Yes. Yes.

GRAYSON: And so this part of the country, was it as—I **<T: 15 min>** know London, [United Kingdom], I think got quite a bit of attention.

MARCH: Yes.

GRAYSON: The Newcastle upon Tyne area, was that also a place where it was—the Deutsch—Germans thought would be worth attacking, or—

MARCH: Yes, because you have London here on the South Coast, and up—and the Wash, and then up, and this is the Scottish border, and here is Newcastle. So there's a river there. The main railway, of course, goes up through Newcastle, north-south railway, and then distributed: here was coal mining, and shipbuilding, and ship repair, and goods. So this area had a lot of activity. And that controlled—it was the main route to Scotland. There was another one here, but not quite as—and so that was attacked a number of times.

GRAYSON: So in your actual school day, I guess the school administration had to be concerned about moving people to a safe place, or was there was much bombing activity during the day?

MARCH: Very, very little.

GRAYSON: Very little during the day.

MARCH: Yes. Yes.

GRAYSON: So it was always at night?

MARCH: Yes.

GRAYSON: Oh, okay. Oh, that was fun.

MARCH: We had practices, and there were shelters, but I don't recall ever being exposed to a day raid. There were in other places, but not in Newcastle.

GRAYSON: So in your education at this point, somewhere along the way, maybe you started to develop an interest in science, I guess. Did it start in grade school, or lower grades, or—

MARCH: No. No. I don't remember having any—not until—Morse code was the biggest interest I had up until I was eleven. The war ended when I was eleven, so I then went—oh, there was eleven plus exam, the end of sort of junior school, or elementary school. That was a great divide. There was the washed and the unwashed. The young—the washed went to grammar schools. The unwashed went to other schools. I went to a grammar school. My brother went to the other school. So I was in the first post-war class at Whitley Bay Grammar School.

GRAYSON: Whitley Bay?

MARCH: And that's about twelve miles northeast of Newcastle, and we were right on the coast. So that class still has an annual reunion. We came to school certificate in 1950—that was five years, and there's still the reunion, and I went last year, when I was seventy-nine. So they met this year, and they've done so for about thirty years now. So it's quite a reunion.

GRAYSON: I can imagine.

MARCH: Yes. Because you remember all the names. It's not Richard. It's Dickie. And his wife looks at—[laughter] It's a lot of fun. But that then was serious, going to the grammar school; and that process was a selection, and a very important selection in England. I think it still is important, but it's more flexible now. You can crisscross later. But at that time, really, you couldn't get in at a later date.

GRAYSON: You either made it or else.

MARCH: Or else. Exactly. And so we were very well taught. The first two years, it was mainly women teachers and old men. But the physics teacher was Martin Bung, all sorts of names. Bung was just wonderful. I don't know how it arose, but it was—oh, his name was Young. Mr. Young. So he was called Bung, bung being a chemical or rubber thing. And there was a Mr. [Jack] Fawcus. Also a Harry Hardman. He was the chemistry teacher, and **<T: 20 min>** he was very instrumental in my later interest.

GRAYSON: Do you know—just to back up a second. What it was that you did on this test that got you into the washed crowd? I mean, the test was on I guess reading, writing, arithmetic, I suppose.

MARCH: Yes. Yes. It was about I think three exams, which you're trained for, and we were like—we were a team. We were being trained for this. We were looking at old exam papers. Going through. We were up for it. But basic arithmetic, grammar, sentence structure, reading comprehension, and then some intelligence-type questions, which were great fun.

GRAYSON: Yes. And important, too, as well.

MARCH: Very important. Yes. More than we knew.

GRAYSON: Okay. Okay. So then you were saying that Hardman—Hardman? He maybe got you interested in chemistry.

MARCH: Chemistry. Yes. Methods of determining molecular weights. Vapor density. So some beautiful physical chemistry done with some nice apparatus, and then close reasoning, and so on. So I was very impressed there. After I think a couple of years, we had some teachers coming back from the war. One, Charlie Russell, had been—an English professor had been in a prisoner-of-war camp, and he had been the librarian. He was an English graduate, you see, so he was made the librarian. And he had a very nice dictionary, which had to be hollowed out to put the radio in. [laughter] And then someone came back for mathematics, and he was really very good, and I enjoyed mathematics.

GRAYSON: Do you remember that name, [that teacher]?

MARCH: No.

GRAYSON: Maybe it'll come later.

MARCH: Yes. So—[Ah, Mr. Milner, he was known affectionately as Tubby Milner].

GRAYSON: So when you say mathematics, this would be algebra, trigonometry—

MARCH: Trigonometry.

GRAYSON: —maybe calculus?

MARCH: Yes. Yes.

GRAYSON: Okay. So you basically start to start thinking about—

MARCH: All the way through. Yes.

GRAYSON: —sophisticated mathematical tools.

MARCH: Yes. But I enjoyed Latin, which I took for two years, and alas, I didn't work enough at it. It's an endings language, and I didn't work enough at it. We were doing French also at the same time, history, geography, art. There were nine—

GRAYSON: So you had a certain broad educational scope, not—

MARCH: Yes. But I found Latin very use—I mean, for example, desiccated. Do you know how many times I have had to correct the spelling of D-E-S-S-I-C-A-T—it is desicco, to withdraw water, which is one S and two Cs. Not two Ss and one C. And it comes straight from Latin. And it's amazing how much you see that has a Latin root.

GRAYSON: It is indeed.

MARCH: So it was marvelous.

GRAYSON: So this would be the equivalent of like high school, we'd call it high school.

MARCH: Yes. Grammar school, high school. Yes.

GRAYSON: Now was this—excuse me. Were these classes, was this school all boys, or was it mixed boys and girls?

MARCH: Mixed.

GRAYSON: Mixed at that time?

MARCH: Mixed. Yes.

GRAYSON: Okay. So that was—and girls, though, their education, even though they were in this upper level of education, were they expected to go on to anything educational-wise, do you know, or was that just happened that they were promoted into this better school?

MARCH: They were in this better school, and some of them became scientists, veterinarians, doctors, administrative hospital people, and business. Some of them did very well. I found that out because I went back. My wife was from the same school, and she ended up as a principal here in Peterborough, [Ontario], from kindergarten to principal. So there was no different—the only differentiation was that the girls had to take domestic science, and the boys had to take workshop. Now the only thing was there was no equipment in the workshop. There was absolutely nothing. Never even got to **<T: 25 min>** hold a chisel. We were told in theory how to sharpen a chisel, and we had to do drawings, fine drawings of—friezes, for example.

A frieze, something like this. You would have to draw that. That was to polish your drawing skills, an appreciation of shape and form. But there was no workshop. [laughter] I felt cheated of that, because now, owning a house for about fifty odd years, you really need some skills. And there's an organization called Habitat for Humanity, and they have asked me to take part in this a number of times here in Peterborough, and I've said, "I wouldn't dare. I wouldn't dare. I hardly know how to handle a hammer, and you don't want me anywhere near a house." [laughter] I remember going to buy an outer door for the back here, a sun door, to keep the insects out—a screen door. Screen is what I was thinking of. And I went to Home Hardware [Designs LLC], and the man was saying, "Are you going to install it?" And my wife, I didn't know was just behind me. She's saying, "No, no." [laughter] And it wasn't. I have just no skills.

GRAYSON: And all because you didn't have any tools in the shop.

MARCH: Yes. I mean, it was a critical age, eleven, twelve. I'd have taken to it like a fish to water if we had the stuff, but this was the end of the war. There was—it was gone. Yes.

GRAYSON: How big were the classes?

MARCH: The classes were almost twenty-five. There were four, 1A, 2A, 3A, and 4A, and each contained about twenty-five people. We had about one hundred people admitted each year to the local grammar school. But that had been the same size in the year before, with a Ms. Beatty, and we had done very well as a class in the scholarship eleven-plus exams. We had entered a choir competition, and we had won, in Newcastle. And then we gave a dancing exhibition. There was a Ms. Jacques, who was trying to teach us dancing, and pointing our toes down the floor, deportment. All very useful later. [laughter] Yes? And so we had done that with—in our last year in the elementary school. So that had been quite nice. When I got into grammar school, I was still in the Scouts. And at that time—

GRAYSON: That's Boy Scouts?

MARCH: [Yes], Boy Scouts. At that time, there was a fellow called Ralph Reader, nothing odd about his name. He had been a producer of West End shows in London. He was a musical fellow. And he had been called into the RAF [Royal Air Force], and he organized concerts throughout the war for troops and military personnel. He was a very keen Scouter. He came back and he wrote gang shows. A gang show is a musical—a mixture of musical numbers, and skits, and a whole group, large choir singing numbers, put on in a local theater. Seven performances, Monday to Friday, and two shows on Saturday. At the end of that, you were really exhausted, because you've got school as well. And traveling up. But the—

GRAYSON: Was this something that you volunteered for, or—

MARCH: Yes.

GRAYSON: —were volunteered for?

MARCH: No, no, no. Volunteers. You tried out. But because I had had this dancing thing, see, with Ms. Jacques, I was put into the tap dancing class. So in the evenings, "Stepping out, stepping out." [laughter] It all helps. So the first was in 1947, and was something like—there was a song and after fourteen long—no, no. That was another one. Nineteen forty-seven, and the gang show's back in town. So it had been there before the war. But that was a great recovery. So I was—

GRAYSON: Now he organized these things as part of the scouting activity?

MARCH: Yes. So this was really something that he had developed for the Boy Scouts to participate in.

MARCH: Yes. In London, Glasgow, [Scotland], major towns. We had our local **<T: 30 min>** producers, [Ted Potts, and his sister Nellie Potts]. Nellie was the dancing instructress. And you would always go in Boy Scout uniform, always in uniform. Practices were in uniform, until you got to the dress rehearsals and things. The main opening number, the end of the first act, the end of the second act, the finale, always in uniform. The only change would be a common necktie.

GRAYSON: So did you do any, like, more traditional scouting activities, like campouts and that kind of thing?

MARCH: Oh yes. Yes. Yes. Became a King Scout. King George [V] died 1952, so I was in just before died, went to Windsor Castle, and was given the King's Scout badge by the Chief Scout at that time.

GRAYSON: And what size were your troops, your scout troops? Did you have a—

MARCH: Oh, size, the number of people in the twelfth Whitley Bay Troop, there would be about two dozen.

GRAYSON: And participation pretty good in these things? I mean, you know, sometimes Scout troops are kind of like so-so, and then others are more gung-ho. Was your participation—

MARCH: Well, this was after the war. We couldn't go during—there were Wolf Cub Packs during the war, because they met late in the afternoon. But there were virtually no Scouts. It was just too dangerous at night. So this was a new thing that we could do, and there were a number of Scout troops—almost every church in our area, Whitley Bay, had a Scout troop.

GRAYSON: Okay. I was just kind of curious, because my sons went through Scouts, and it was an interesting experience for them. And I'm thinking a dance troupe and what not—[laughter]

MARCH: Well and dancing, you know, it's a discipline. It's a lot of exercise. We were taught by dancing instructresses—instructors you'd call them today. And there was no messing about. The discipline was firm during these rehearsals. We would take the local Theater Royal with four levels of [seating for the] audience for a full week. It was a major expense. And so you can't mess around.

GRAYSON: [Yes]. And then these shows, were they given gratis, or did you charge for the shows?

MARCH: Oh, no. Charge. Yes. Seats—every seat was charged. Yes. Yes.

GRAYSON: And so you did this for a number of years with Scouts?

MARCH: About six years. Yes. And some years with my brother, and '51, then after that, I took ill. That's what changed things. So it was '45, and then '51. In '51, sometime late in '51, I got what they thought was polio myelitis. There was a lot of it going around. Paralysis of the legs and so on. So I was later—I'm just trying to think.

GRAYSON: [Yes], that was bad. I remember even, you know, myself in my youth, that that was a big problem. There was so much concern about polio.

MARCH: Yes. Yes.

GRAYSON: But they thought you might have had it, but obviously that wasn't it.

MARCH: No. No. Recovered. There was a loss of feeling in the legs, one more than the other, but then eventually it recovered, and I managed to get out of bed, and walk, and then life went on. But I had lost some schooling, and the schooling was in what we called the lowest sixth. I had done five years in grammar school. Then you do two more years, lower sixth and upper sixth, when you're doing a school certificate examinations to higher school certificate examinations. These names have all changed. But there was a difference, and of course, higher school was required to get university. So I had missed that time, **<T: 35 min>** so as my health was unsure, I didn't want to just wait and do nothing and go back in the next year. And so I applied for a position as an industrial chemist, apprentice industrial chemist, at Wallsend on Tyne, and Wallsend is where this musical in New York is being shown.

GRAYSON: So you were—how long were you not able to go to school? Was it like—

MARCH: About two months.

GRAYSON: About two months?

MARCH: Yes.

GRAYSON: And this is what kind of set you back?

MARCH: Yes. Yes.

GRAYSON: So the apprentice, that was like the only thing open to you at the time, or—

MARCH: Well, this is the middle of the year. The life in Britain was fairly simple in those days, but highly structured. And if you drop out of one year, there's nothing else to do really except find a job, do something. Deliver newspapers, whatever. So I saw this advertisement, and at least it was chemistry. It was in a chemistry laboratory. And I thought it would be interesting, and it was.

GRAYSON: And what was the name of this outfit that apprenticed?

MARCH: PAMETRADA Research Station. And I'll let you write it out, because the name is interesting. Parsons and Marine Engineering Turbine Research and Development Association.

GRAYSON: Okay. [laughter]

MARCH: Parsons, of course, were very active in making optical instruments and simple gas analysis systems. Turbine research was gas turbines, coming from aircraft, and [Air Commodore Sir] Frank Whittle's work with aircraft, and looking to put these in destroyers. If you put them in destroyers and send them off, the problem is that they like to run on kerosene, and the supply of kerosene around the world is very uncertain. What is certain is the supply of crude oil, and so these turbines had to be able to run on crude oil.

Well, there's a lot of sodium and vanadium in what we call the ash of crude oil, so when it's burned, and the—what's this called? Not incinerator. In the flame, the fuel is heated, and then it's atomized, very much like electrospray. So you get tiny droplets, gouttelettes in French, in a hot air, and they evaporate fairly quickly. So they of course give a lot of energy in the combustion, and the ash is made of sodium vanadates, which at the temperature of the turbine can be quite corrosive. And so they would land on the blades and stick and corrode the turbine blades. So what had to be done was to try to find some additive to be able to put into crude oil and prevent this ashing problem. So it was very interesting. Vanadium comes from—a very small amount of vanadium in organic plants, but of course, the oil has come from plants, and so the vanadium is still there.

GRAYSON: [Yes]. So what part did you play? Were you just part of the hands on?

MARCH: Oh, I cleaned the lab. I cleaned the bottles. I cleaned the sink. I did this. I did that. I did everything. I made coffee in the morning for the three—we had a metallurgist and two chemists, and then our boss, who was a physicist, would come in, and there'd be something like five would come in, and I would make coffee in beakers for them. It was lovely coffee, and I knew just what each one wanted. And the value was I got to listen to their conversations, because they weren't discussing the girls in the office, they were discussing the work. So **<T: 40 min>** this was—I did anything I could to—

GRAYSON: So you were learning all about this chemistry?

MARCH: Yes. It was really something. And as I got to be eighteen, close to eighteen, you had to go into the National Service; there was conscription. However, if you were in a registered apprenticeship program and going to classes, that would be delayed until you'd finished your program.

GRAYSON: Okay. So while you're in this apprenticeship, you actually were going to the school?

MARCH: I had one day off a week. I had to be given one day off a week, so I went four days to work during the winter term, four days to work, and one day to Rutherford College of Technology in Newcastle.

GRAYSON: Okay. Okay. So you had kind of dropped out, but you hadn't dropped out?

MARCH: Yes.

GRAYSON: In a sense.

MARCH: Yes.

GRAYSON: And so that one day a week, what were you studying? Were you, like, continuing with that program?

MARCH: What they called the national certificates now, not the school certificate, but the national certificate, which was industrially based. And there were a series of examiners and examining boards that set up these national and higher national certificate examinations.

GRAYSON: Okay. So you were not completely unwashed, but not completely washed?

MARCH: That's right. That's right. I'd switched to the more technical part, but doing mathematics, physics, and chemistry. And then I took a couple of courses in the evening, so I did a day, and then two evenings. And then eventually as this went on, I managed to get an extra half day off and took another course. So I was doing five courses as well as working three and a half days a week. And so it came to the end of this was taking eighteen exams, I applied to three boards, university boards, you see. And they had eighteen—and they didn't overlap. They didn't, so I didn't have—

GRAYSON: So the reason you had to take eighteen was because you were applying to three different schools, or because—

MARCH: I was applying to university, and I didn't want to be caught on one exam by one school board, and there was variation, and of course they changed each year, the exams. But by this time, I knew—nothing goes on steadily forever. There are discontinuities. And so if you look at back exams and say, that's going to happen for the next twenty years, it's not so. So you have to be wary that things are going to undergo a disruptive change. And so I applied for these eighteen, plus experimental laboratory exams. Anyway, I got through. I got the whole lot.

GRAYSON: So you had selected three different schools?

MARCH: No, no. Boards. Then universities, I applied to Durham University, which was the name of the university in Newcastle upon Tyne. King's College Durham at that time was in Newcastle. Now that is called the Newcastle University. The name has changed. But I applied there, because that was local. I applied to Nottingham University, which was very nice. I also applied to Leeds University. Leeds I was very impressed with, went down for a visit, and there was this huge building at the front, and went in there, and there was a parquet floor, it covered the whole—it was a very Romanesque building. And then passed through, and on the side of the wall was this—I've forgotten the word, this plaque for father and son Bragg team. [Readers of the plaque were informed]: "Near this site was the laboratory of father and son Bragg team."

And then went into the library, the big circular library, which is very similar to our Parliamentary library in Ottawa, [Ontario]. And there was a picture in today's paper of this circular library. The Brotherton Library was the name. And I really liked it. And—can I jump? That was spring of 1954. Can I jump now to 1986?

GRAYSON: Okay.

MARCH: **<T: 45 min>** Thirty-two years later. Thirty-two years later, my supervisor at U of T [University of Toronto] not only got himself onto a Canadian stamp—

GRAYSON: Oh, wow.

MARCH: —but he won the Nobel Prize. He won the Nobel Prize first, and then he got himself—this was the year of chemistry.

GRAYSON: So his name was—

MARCH: John C. Polanyi. And if you go to the University of Toronto, you will find, just as you go in the building on College Street, a plaque which says, "Near this place is the laboratory of John C. Polanyi." It's a repeat of the one I saw in Leeds. And Chester Sadowski and I, who were his first students, arranged for the university to install that plaque on the wall.

GRAYSON: Okay. You decided to attend Leeds?

MARCH: Yes. So 1954, I entered the honors chemistry program at Leeds University.

GRAYSON: Ah, okay. And that was because of your ability to pass all these exams, that you were able to take that as an option?

MARCH: And make very good coffee; for my bosses. [laughter] I didn't have to continue doing that once I got to the university. The university was a wonderful place. There was Professor [Sir Ernest Gordon] Cox, Professor [Fredrick Sydney] Dainton, who'd became Lord Dainton, and some very other famous people. Inorganic crystallography. And Professor Dainton, physical chemistry. Dainton, who was a leading light in the study of radioactivity and its use for irradiating people.

GRAYSON: So this would be like for curing disease?

MARCH: Yes. Particularly cancer.

GRAYSON: Oh, okay. And he was doing this work at Leeds?

MARCH: Yes.

GRAYSON: And he was one of your instructors?

MARCH: [Yes].

GRAYSON: Okay. And what part of the chemistry was he studying about radioactivity?

MARCH: He was physical chemistry.

GRAYSON: Physical chemistry.

MARCH: Yes. Chain reactions, gas phase chain reactions, and energy transfer, and irradiation. When you irradiate someone with a beam, it's not like Beer's Law. It doesn't just go as a beam straight through and just moderately attenuated. It is rapidly attenuated. So the particles slow down, and then they're almost arrested, and if you do it correctly, you can have them be arrested at the site of the cancer cells. And then they continue to radiate, and it's almost as good as injecting something directly in—so yes.

GRAYSON: Interesting. So he was developing this science at the time?

MARCH: Yes.

GRAYSON: Wow. Okay. Now was this during your undergraduate, or—

MARCH: This was undergraduate.

GRAYSON: Undergraduate?

MARCH: [Yes].

GRAYSON: And by this time, you were liberated from working as an apprentice?

MARCH: [Yes].

GRAYSON: And obviously, they paid you, I guess, did they, for the apprentice work?

MARCH: For the apprenticeship?

GRAYSON: [Yes].

MARCH: [Yes]. I was paid for the apprenticeship, and went to university with the permission of PAMETRADA, and blessing of PAMETRADA [Limited] company, as the first apprentice to do so. But having gone with their permission and blessing, at vacations, particularly the summer vacations, I could go back and work as long as—until I had completed the five years. And I did that, and at the end of five years, I got a certificate saying, you've completed the apprenticeship.

GRAYSON: So the apprenticeship program was formalized to the point that you—there was a **<T: 50 min>** fixed amount of time in which you were an apprentice, and then essentially graduated from the apprenticeship?

MARCH: I was indentured to that company for five years. Yes.

GRAYSON: Interesting. And what did that certificate provide you the rights and privileges of?

MARCH: Oh, being an industrial chemist. Yes.

GRAYSON: So that was basically you could apply for a job as an industrial chemist anywhere in the UK and—

MARCH: Yes, at the lab bench.

GRAYSON: At the lab bench.

MARCH: Yes.

GRAYSON: Very good. Interesting. So it was a learning experience as well as being—I mean, as an apprentice, you were actually learning some—

MARCH: Oh, learned a great deal, and it was really a very modern type of institute. I told you last night about the NATO [North Atlantic Treaty Organization] conferences, how the waiters would line up and take you in to a table, and then the next table. Well, that's one way of doing it. The other way, of course, is to fix the tables, and you have a seat at a table. This company [PAMETRADA] had a dining room, and it had two lunches, one at twelve and one at one. And there was a table for eight people. One, two, three, four; one, two, three, four. That was my seat. At my table were two physicists, one other apprentice, someone from the financial office, and an engineer. Marvelous discussions, of course. Every day we met for lunch. And there was an Austrian—[Otto] Kantorowicz. Dr. Kantorowicz. We were very rude.

I've just remembered the rude name that we used to call him. And it was—there was always some cookies or little pastries left for dessert, and he would grab the plate and say, "Which boy is most deserving?" moving it around the table so quickly you couldn't take one, and then he would take it himself. [laughter]

GRAYSON: This guy, what science did he bring to the table? Do you recall?

MARCH: Oh, physics.

GRAYSON: He was a physicist?

MARCH: Yes. They would talk about the problems of these jet turbines, the velocity, wind defects, the flame, optimizing flame characteristics, transfer of energy, viscosity, just so many.

And because we were the same people each day, people just talked. I mean, they didn't say, oh, he's an apprentice. I won't talk to him.

They just addressed the table. It was interesting that a similar thing happened when I went to France in 1972. I joined a group at Orsay, [France], and they didn't have a table, but they all went to eat from the laboratory at the same time, for lunch, perhaps eight, ten people around a table. Now it was hell, because the English would speak one at a time and have a discussion. The French, three or four would speak at one time, and so trying to follow three or four conversations in a foreign language is virtually impossible, and it just blows your mind. Your ears are wide open. Really a difficult time. I enjoyed the fellowship, but the language was—

GRAYSON: So where did you pick up French? The ability to—

MARCH: Oh, in school.

GRAYSON: That was in your—

MARCH: In the grammar school.

GRAYSON: —grammar school.

MARCH: Yes. Yes.

GRAYSON: So that was taught as well as Latin?

MARCH: Yes.

GRAYSON: Oh, wow. Okay. So I guess you became sufficiently proficient in French that you could manage—

MARCH: A little bit, yes. Yes. And at one time, I had gone to a jamboree in France, oh, I had—I don't think I mentioned that. In—

GRAYSON: As a Boy Scout?

MARCH: As a Boy Scout. In 1950, I went to Germany. I went to Düsseldorf, [Germany], a town **<T: 55 min>** called Neviges, [Germany]. And to meet a German troop. This was an organization called Die Brücke, the Bridge, an attempt by some enlightened citizens to try to bring English and German young fellows together so that they'd learn that there's more than just war ahead.

And it was very, very good. We went to Bonn, [Germany], saw the Parliament building in Bonn. Went to the—Krupp, [Friedrich Krupp Aktiengesellschaft], went to the works of Krupp at Essen, [Germany]. And went to Cologne, [Germany]. Now these were all of interest later. At the Krupp's works in Essen, there was a paternoster. You went in the door. There was a reception desk at the right, and then just continued around, and there was a paternoster. A paternoster is an elevator that goes like this and has no doors. The first time I'd ever seen one. Damned dangerous, I thought. But it stuck in my mind. Gosh. And it just kept going. You go up, get off. The same thing happens with the Eye in London. The big Eye in London doesn't stop. It goes sufficiently slowly. You just walk on the platform and step on and off. Same principle.

GRAYSON: Eye. The big Eye?

MARCH: The big Eye. That's a conveyance of some kind?

MARCH: That's right. Yes. Put up by a tremendous difficulty, and they were helped by a German company that brought over a platform and helped to assemble it. They put it up like a wheel of a car, of a bicycle, put it up like this, and they had problems. [laughter] Anyway, so that was Krupp's—the rest of the factory was just a mess of tangled, rusted steel.

GRAYSON: I was going to say, if you went to Germany in 1950, it was probably still pretty much in bad shape.

MARCH: It was. Düsseldorf, there were the beginnings of reconstruction in Düsseldorf. In Cologne, all the rubble had simply been taken from the road and put into the interior of the buildings, and they were just stark. The cathedral was still standing, some of it minor damage, and there was a new bridge across the Rhine [River].

GRAYSON: So there was an attempt to get the German and English Scouts to communicate on a peaceful level?

MARCH: Yes.

GRAYSON: That must have been a terrible event for everyone—

MARCH: Yes, it was.

GRAYSON: —at that time. Because I saw recently there's actually—I think it's on the internet, this filmmaker, Hitler's filmmaker had created this documentary, and a lot of it shows the German youth being indoctrinated.[2]

MARCH: [Yes], they were.

GRAYSON: With the Nazi, you know, world view towards—it was a very interesting documentary. I should recall the person's name. But it really is probably the most powerful propaganda film that was ever made, because it was, you know, shown to the German people, and really convinced them that this was the way to go. And pretty scary.

MARCH: Hitler I think picked up on Baden-Powell's [Lieutenant-General Robert Baden-Powell] idea and took it to extremes.

GRAYSON: Now—so Scouts actually started in the UK, right, with Baden-Powell?

MARCH: Yes. Yes. About 1907, I think, Brownsea Island, [United Kingdom].

GRAYSON: Sure. Okay. Yes. So it's not unusual that you would be involved in Boy Scouting.

MARCH: No.

GRAYSON: And that would be kind of a typical thing. Was it pretty much a common thing for most kids?

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[2] Leni Riefenstahl, *Triumph des Willens* (Reichsparteitag-Film, 1935) 35mm filmstrip, 114 min.

MARCH: Yes. Many kids. Yes. And we'd have a church parade once a month, go to the local—well, it was a church troop, so you would go to the church, and I've been an Anglican ever since.

GRAYSON: Okay. Interesting. Okay. So we were talking about in—

MARCH: Oh, Krupp's. Yes. Krupp's. There's a wonderful book called *The Arms of Krupp*.[3] And I read it in France one time, and **<T: 60 min>** it took me back to something that I had been associated with. I'm sorry. There are streams, like streams of warmer water in a river, which is continuous, but it's not the same as the water beside it. So there are stories that go through. Krupp's, I was at McGill. So I had finished. This is 1962, and I was at McGill University, 1962, '63. And there was a fellow called Gerry Bull. Bull. He was the youngest PhD at University of Toronto, something like nineteen. He wanted to build a—what we call a—oh, I've forgotten the name. A cylinder through which you would pass air, high speed.

GRAYSON: A wind tunnel?

MARCH: A wind tunnel. A wind tunnel. And so he built the wind tunnel. The tunnel as he built it happened to go through a corner of the dean's office, but that was all right. He had come in at the weekend, [laughter] and took it through. And he became a professor at McGill University. So he was a graduate of University of Toronto, professor at McGill when I was there, and he had a contract to investigate micro-meteorite impacts. Even in 1962, there was not a great deal of knowledge of what—

GRAYSON: What was out there?

MARCH: What was out there? Yes. If you put something up, a stationary satellite, which it was not stationary, it was around the same point, same time as the earth, to what impacts would it be subjected? What's there? What's their velocities? Etc.. So he built this hydrogen gun, a long cylinder, and with hydrogen you can get high speeds, and he would fire plastic bullets, about that size, Mike. [Cylindrical in shape, about 2 cm in length and 1 cm in diameter.] Perhaps slightly bigger diameter, but about that size. Polyethylene. And they would go about thirty-three thousand feet per second.

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[3] William Manchester, *The Arms of Krupp*, 1st ed. (Boston, Massachusetts: Little Brown, 1968).

And they would smash into a block of aluminum or zinc or iron or steel about that size, [about 24 centimeters by 24 centimeters by 5 centimeters in depth] mounted in an evacuated sphere. I had a spectrograph focused on the point of impact. And, you know, this block of metal would be almost entirely vaporized.

GRAYSON: Oh, really?

MARCH: Oh, tremendous energy, even from the small mass, at thirty-three thousand feet per second. It's the velocity squared—the mass is linear, the velocity is squared. Very, very interesting stuff. He went from there to proposing a gunshot to launch satellites from guns. Naval guns. World War I naval guns, in particular, and he managed to get two from the U.S. government. And they landed them for him in Barbados about 1960, and they were transported, they made a small railway, and they were transported to the second beach near the airport in Barbados. There is one beach, and then there's a cliff, and there's another beach, and then another cliff. And this was on the middle one. And I've been there. I've seen it. Two—it's [the gun, having a bore of 40 centimeters is] 119 feet long, and mounted almost vertically. And they would load in a payload, and they would ram **<T: 65 min>** in the fuel for the gun, and then fire it off.

GRAYSON: Straight up?

MARCH: Straight up. About eighty-seven degrees, or something. To the horizontal. And then they had two islands with lighthouses that could triangulate on the signal. Now he fired stuff up to 137 kilometers. He was doing great guns. There's a wonderful story. It's called the HARP, the McGill's High Altitude Research Program. He was doing very well.

GRAYSON: And what was the purpose of this vertical shot?

MARCH: To explore the atmosphere.

GRAYSON: So he was going to upper atmosphere levels?

MARCH: Upper atmosphere levels, yes, and to investigate the possibility of launching satellites into orbit from a gun, not from a rocket. The other people, mainly in the States, were of course building rockets and rocket sites to launch satellites. And that came directly from the German rockets, which were seized and transported to the States, so he was in competition with that.

GRAYSON: So—but he apparently—it didn't fly? In the end, it didn't win.

MARCH: He didn't get any money. He met with a high government official called C. [Charles] M. Drury in Ottawa. I think Drury was the head of the Treasury for one of our governments, and he was to listen to this presentation. So Bull gave the presentation, what he wanted to do it, why he wanted to do it, benefits, the cost, etc., and then Drury made the big mistake of asking something, and Bull put down his chalk and said, "You don't know a damned thing about science." That was the end of that.

Didn't get another cent. No. No. No. No. The interesting thing is that there is a border between Canada here to the north and the USA to the south. There's one in New York state, and it's horizontal. It's east/west. And Bull had access to—I think this is called Highwater - it was about one hundred acres, and he developed a gun, his own gun. [Space Research Corporation operated from this site.] He had done lots of experiments in Barbados, particularly with the size of the grain and the propellant, and the rate of firing or of combustion of the propellant, and the acceleration of the body as it went up, and then the effect of having a longer barrel. And he bet that at some stage he could fire a gun from Canada to Mexico without touching the U.S. [laughter] So now there was a dean, Dean Mordell, at McGill. He was the Dean of Engineering.

By strange coincidence, this was amazing, he [Dean Mordell] owned a property adjacent to the border, and directly opposite Bull's property. So this was Mordell, and this was Bull. So they could have people come and visit Mordell and spend the weekend in his cottage, and shooting, whip across here to Canada, see Bull's demonstrations of his gun, and go back again, and nobody knew they'd been in Canada. There was no record. [laughter] So he got money from the States. He was granted honorary citizenship [upon the recommendation of US Senator] Barry Goldwater.

I have a record of this **<T: 70 min> b**ecause he needed to get access to Hanscom Field [Airport] something like that. I have the details written down. I was going to write a book about it. My wife protested. [laughter] So I have a lot of details. But he was encouraged to do this, and he was supported, and he developed his gun, and there was a strange story of off the coast of South Africa, twenty, thirty miles off the coast of South Africa, Cape Town, there was an explosion one night. Now we have satellites. Satellites pick up signals. [The signals from the explosion] had the signature of a nuclear explosion. And it was thought that Bull had taken one was of his guns, and had fired a nuclear device with the help of the Israelis.

And it had exploded here, it hit a ship, a target ship. But that was it. I'm cutting the story a little short. Anyway, Bull went on to develop this gun, and he developed the supergun. And he then sold the supergun to Saddam Hussein, which started the Gulf War. But before that, he'd been involved in Africa in a number of minor wars, and it was the G50 gun. And this was a gun of really extraordinary length in the barrel.

GRAYSON: Fascinated by guns, was he?

MARCH: [Yes]. Oh, he's fascinated. Oh, yes. The Big Bertha of the First World War, absolutely fascinated with that. He wrote many things. So this gun in Africa would fire shells—now it's not as though there were huge—but the shell was fired with such velocity that if it hit, so we'd have something here, and then something—so we fire the gun, and here's the top of the hill. When the shell hit the top of the hill, the top of the hill would disappear, there was so much energy being dissipated. So this played a major role in the various battles in Africa, right about 1960, late fifties, 1960. So he developed the gun, which had enormous terminal velocity in coming out of it, and he made it much bigger, one meter [in diameter], and he was shipping this to Saddam Hussein when it was spotted in England, at Middlesboro. I actually went to visit the customs officer at Middlesboro who had spotted this, and I was told, "He's no longer working here. He has been shifted to another"—"Do you know where?" "No." [laughter] Nothing. It was a big to-do.

GRAYSON: So while you kind of—we kind of leapfrogged a little bit here.

MARCH: Yes.

GRAYSON: But I just want to get one point. You were working at the time when he was at McGill?

MARCH: Yes.

GRAYSON: Looking at the—focusing on spectroscopic tool at the back of this plate that was going to be—

MARCH: Yes.

GRAYSON: And what you were going to find out, the energy that was dissipating, the—

MARCH: Actually, the energies of the lines of the lines produced that were detected by the spectrograph.

GRAYSON: Okay. And essentially, this was a scientific effort to understand the result of a high velocity impact of a particle on different types of materials?

MARCH: Yes.

GRAYSON. Basically, you're saying it just vaporized the material?

MARCH: Yes.

GRAYSON: Just because you had the velocity at such a high speed?

MARCH: Yes. So he was building or constructed part of this supergun in Iraq, and he was assassinated [March 22, 1990].

GRAYSON: **<T: 75 min>** We can guess by who, I guess.

MARCH: Yes. He was assassinated in Brussels, [Belgium].

GRAYSON: When did that happen?

MARCH: I guess that was 1990.

GRAYSON: And that pretty much put the kibosh on the big gun?

MARCH: On the big gun, but you recall that [H. Norman] Schwarzkopf [Jr.], who was in charge of the Gulf War, the troops landed, I think it was June—August, 1990.

GRAYSON: Yes. I don't remember.

MARCH: I think it was August, 1990, the troops landed, the NATO troops, and they were held back until January. Not a soul moved. In January—the only people who went to war were the aircraft, and they went on bombing, because Saddam had something like six hundred of Gerry

Bull's guns, and each of them with a little computer and a truck, so they were mobile, and each of them outdistanced the tanks available to Schwarzkopf. They could fire thirty, forty miles. So he waited until the aircraft had destroyed, brought this down to about sixty or so. And we had thousands, hundreds of thousands of people sitting on the ground for four months, and no one was—

GRAYSON: [Yes], I remember there was this kind of long period where we were waiting—

MARCH: Yes.

GRAYSON: Everybody was antsy, because everybody was wondering, what's going to happen, and are we going to do it or not.

MARCH: If only Canada had given him a half million dollars a year to continue his research, none of that would have happened. Yes. We have people giving money out in Canada, they have no idea why they're doing it.

GRAYSON: Well, that's another story.

MARCH: That's another story.

GRAYSON: Okay. We got to kind of back up a little bit, because I think we got a little bit off the path. But you've got your apprentice—I guess it's not a degree. It's a certificate.

MARCH: Yes.

GRAYSON: And you're going now—you've gotten into the school that you want to go to, are you still undergraduate at this point?

MARCH: Yes. Nineteen fifty-four, undergraduate. Went to Leeds. I went into residence, which was very nice. Devonshire Hall, and this was to have some aftereffects when I came to apply to Trent [University], years later. But Devonshire Hall. And it was really a very nice arrangement. And I still had to do conscription, and didn't fancy going into the Army and carrying a heavy rifle, so I managed to get into the Air Force Squadron, so I became a pilot on Chipmunks.

GRAYSON: Chipmunks?

MARCH: Chipmunk was a De Havilland Chipmunk, which were made in Canada at that time. And they were fully aerobatic, and they were the aircraft assigned to all of the University Air Force Squadrons. So remember, in Britain, there was still the Cold War going on. This is 1954. We needed pilots. We had the Survival Project with Berlin, when Berlin was encircled by the Russians, and had to be supplied—that was done by aircraft, even though it was very difficult to land and so on. But there was—Berlin was kept alive through pilots, and there was a big demand for pilots. So that's what I did. So the chemistry was marvelous at Leeds. The residence was great. I learned to fly, which was enormous fun. I played a little rugby for Devonshire Hall. And I boxed a couple of times for the university.

GRAYSON: Oh, wow. Busybody.

MARCH: Yes.

GRAYSON: So this pilot—you learned to actually fly this Chipmunk?

MARCH: Yes.

GRAYSON: Was this a prop plane or a—

MARCH: Yes. And was it like one, two, three, four engines—

MARCH: One single engine. There's a [photograph of a] Harvard [aircraft] just behind you [on the wall]. **<T: 80 min>** That was more powerful [than a Chipmunk]. The top left there. That was more powerful. We had a few hours in that. But most of our training was in Chipmunks. But it's very much the wings down and the—rather like a Spitfire or a Hurricane.

GRAYSON: Okay.

MARCH: But it had a fixed undercarriage.

GRAYSON: Okay. So wheels down all the time.

MARCH: Yes. But you could, you know, go up to eight thousand feet, and then put it down, and do a falling leaf, and barrels rolls, and stuff. It was absolutely [marvelous]—and that was what we had to do. We had to practice those, and land it safely, of course, at the end of the day.

GRAYSON: So you never really saw any military action?

MARCH: No. No.

GRAYSON: There was just—you were prepared to be able to fly?

MARCH: Yes.

GRAYSON: I guess if you could fly that, then you could also—were capable of flying several other airplanes of similar vintage or type or—

MARCH: Yes.

GRAYSON: So that conscription period was—now you volunteered to go to the Air Corps because you didn't want to lug a rifle around.

MARCH: Yes.

GRAYSON: This was for a specific period of time? I mean, when you signed up, you—

MARCH: For two years.

GRAYSON: Two years?

MARCH: Two years. Yes.

GRAYSON: Okay. So that was full-time or part-time?

MARCH: Full-time.

GRAYSON: Full-time?

MARCH: Conscription was full-time. Yes.

GRAYSON: So you were basically—that was totally what you were doing for those two years?

MARCH: Well, no, it would have been. I'm still in my three year undergraduate, '54 to '57, training, doing pilot training and so on, ready at '57 to go into the Air Force and fly for two years.

GRAYSON: Oh, okay. Okay. Okay.

MARCH: If you fly, you see, when you go in, you have a batman.

GRAYSON: You what?

MARCH: You have a batman.

GRAYSON: Batman?

MARCH: A batman, yes, and a batman in the Air Force is somebody who polishes your buttons, and your shoes, and brings you tea in the morning, and tells you the weather forecast. [laughter] A batman. It's essentially a military servant.

GRAYSON: Oh, that's cool. So during those two years when you were totally devoted to your military—

MARCH: Which I never was, but that would have happened.

GRAYSON: Would have happened.

MARCH: Yes.

GRAYSON: Okay. So what happened in lieu of those two years?

MARCH: So, well, as I was coming to the end of my degree program, 1957—

GRAYSON: This is undergraduate?

MARCH: It's undergraduate. There was a visit to Leeds University from John Polanyi. He was a graduate of Manchester [University], and he had just obtained a job at the University of Toronto the previous year. So he was looking for graduate students. He had been to Manchester, and now he was at Leeds. Of course, he was a physical chemist. He knew Professor Dainton, and so he was just seeing if there were any bodies around.

GRAYSON: So he was just kind of starting his academic career?

MARCH: Yes. And I was chair of the undergraduate chemical society. We had an undergraduate chemical society. We had rooms and a small library and a study place near the university, and I was elected president in my last year. It was very, very little work. But anyway, as such, I had to go and have lunch with [Professors] Polanyi and Dainton.

GRAYSON: Okay.

MARCH: And then I promised I would pass on all the information. I'd make an announcement to everybody [in the final year of study of Chemistry] and pass it on. Any questions, I would, you know, funnel appropriately. Then I learned, after [that] lunch, I learned that people going into the Air Force for national service and wishing to fly had to sign on for three years. All of a sudden, the supply of pilots was really more than their needs, and so they were insisting you sign on for a longer term. And so I asked—went to see the CO [commanding officer of the Air Force Squadron, Wing Commander Phillips] and asked if—I don't mind doing that, but if I'm cut from flying, can one revert to the previous two years? And he asked. "No. Once you sign on for three years, you're signed on for three years. Whatever you do is up to the government's choice, and not yours."

Yes. So now that was very different, going in for three years. That was a longer time away from academia. I wanted to do a PhD. It meant a longer break. So I wrote to Polanyi, and the university sent me the application forms, and I applied for a scholarship, and so on. And I was accepted. **<T: 85 min>** August the twelfth of 1957, I landed in Canada.

GRAYSON: Well, Polanyi was in the UK, right?

MARCH: No, he was at University of Toronto.

GRAYSON: Oh, he was at Toronto. Okay.

MARCH: He had started there in 1956.

GRAYSON: Ah, okay. I was confused there, but—okay. So you were able to—by getting into this postgraduate program, you were able to not have to satisfy any further obligation with the Air Force?

MARCH: No, no. Dodge. I was a draft dodger.

GRAYSON: Ah. You left the country.

MARCH: I left the country. [laughter] I left the country. I had trained for three years, and the government changed the conditions.

GRAYSON: [Yes].

MARCH: So I didn't feel at all embarrassed to say, no, I'm a draft dodger because they changed the rules. When I was in—there was no grandfathering, you see. They had changed the rules abruptly. And so I said, "I'm going." So I went.

GRAYSON: So at this time, did your parents have anything to say about this, or feel any feeling one way or the other, or were they still around to—

MARCH: Oh, my mother, of course—yes. They were both—my parents had divorced, and so my mother was living with my stepfather, and they were all disappointed, but supportive. But supportive. Now the other fly in the ointment was that by this time, my sort of steady girlfriend was Kathleen, and her parents didn't like this at all. Not at all. Anyway, she came with my mother and stepfather in a car to see me off at Prestwick, [United Kingdom], an airport near Glasgow, [Scotland]. And I set off. I set off in a four-engine prop plane, which took twenty-four hours to get to Toronto, [Ontario], twenty-four hours of flying time. We had three eight-hour stints, to Reykjavik, [Iceland], to Gander, [Newfoundland], and Toronto, in this noisy, terribly noisy aircraft.

GRAYSON: Where was that second stop? I'm familiar with Reykjavik, but—

MARCH: Reykjavik, and then Gander, in Newfoundland. Gander has always been used by the Russians and the Cubans. Canada has always allowed them to land there. As Canada has been sort of supportive—we don't have the same attitude to Cuba was does the U.S.

GRAYSON: [Yes], well, the U.S.'s attitude is something else, but I won't go there. At any rate—

MARCH: No. It means that we have the best of both worlds, the U.S and Canada. Each can take their own stance, and business goes on, as you—yes. There we are.

GRAYSON: So it took you twenty-four hours of flying time to get here.

MARCH: Yes.

GRAYSON: Wow. That's got to be pretty rough.

MARCH: Yes. And I was met at the airport by two graduate students, Ian Chapman and Jim [James] McCowan. Ian Chapman. Chapman was a nephew of Sidney Chapman, a well-known mathematician. But they met me. They'd been sent to meet me by Mrs. T, the secretary of the department of chemistry. It was short for [Thompson]. It's like M, you know, in the James Bond things. Yes. And so they met me, and took me to Toronto, the town, and university, and settled me in a room in—I've forgotten the name of the college. University College. University—no particular—University College. I thought I was going to die with the heat. It was August the twelfth, and I thought, I'm going to die, and my mother doesn't know where I am. [laughter]

GRAYSON: Toronto doesn't get that hot in the summer, does it?

MARCH: Oh, it can get up to forty [degrees Celsius].

GRAYSON: Well, what is that in Fahrenheit?

MARCH: Fahrenheit, well, it was—

GRAYSON: That's about, what, a hundred degrees [Fahrenheit]?

MARCH: Yes, about a hundred, just over—yes. I've been hotter later, but—

GRAYSON: [Yes].

MARCH: —it was hot. Yes.

GRAYSON: [Yes].

MARCH: And **<T: 90 min>** of course, I had thick clothing on.

GRAYSON: Oh, [yes].

MARCH: Next day—I remember that well. My mother—I'm going to die and my mother doesn't know where I am. And with that thought, I went to sleep. [laughter] And the next day, I woke up, and we went for lunch, sitting under the trees on the campus, and I realized I would probably never go back to England to live.

GRAYSON: Oh, really? Right then?

MARCH: Yes. Right then. Like a revelation. Like making up my mind to move to Canada. I didn't apply other places.

GRAYSON: [Yes].

MARCH: I just made that decision, though Polanyi was just a young lad at the—he was only five years older than me. And then this thing of knowing—and I would say that's happened a number of times. I've made a decision—later on, in an elevator in McGill, I was expecting to meet Lord Dainton, who was to give a lecture, and instead, it was Polanyi. This was after I had finished my PhD. And with another fellow called Schiff, Harold Schiff. Because of that meeting, I went to work for Harold Schiff as a research associate.

GRAYSON: Oh, wow.

MARCH: That's how I got to work with Gerald Bull, and then [John] Hugh MacLennan. I got to know him, and he is an author. So—

GRAYSON: So you finally—

MARCH: I've only applied for one job, I think. That's—no, I've applied for two jobs in my life. One was the apprenticeship, and the other was applied to Trent. Everything else has just happened.

GRAYSON: Kind of happened.

MARCH: Yes.

GRAYSON: Okay. So basically, Polanyi—you filled out the forms, and it was agreed that you could come to Toronto and work for Polanyi.

MARCH: Yes.

GRAYSON: And I mean, now at this point in your life, there's a certain—you realize that this is a big step, and things have changed.

MARCH: Yes.

GRAYSON: You're going to be a Canadian for—now are you a Canadian?

MARCH: Yes.

GRAYSON: Okay. So you're a Canadian citizen. What is the relationship between—I mean, you're a citizen of the UK, or—

MARCH: Yes.

GRAYSON: So, I mean, do you have dual citizenship, or is—do you have Canadian—

MARCH: I have two passports.

GRAYSON: You have two passports?

MARCH: Yes.

GRAYSON: Okay. So that must be fun.

MARCH: It means you can visit a number of countries without bothering about visas. Yes. Most of the countries in Europe, and most of the countries in the Americas.

GRAYSON: With your Canadian passport?

MARCH: With one or the other.

GRAYSON: One or the other?

MARCH: Yes.

GRAYSON: Okay. Okay. Well, that's one convenient—

MARCH: Oh, yes. It's very convenient.

GRAYSON: Nice. And so after you get over heat stroke. You have to get down to doing your graduate work.

MARCH: Yes.

GRAYSON: Okay. This was 1950—

MARCH: Seven.

GRAYSON: Nineteen fifty-seven.

MARCH: Yes.

GRAYSON: Very good. Okay. Well, you want to take a little bit of a break for a while? [. . .]

[END OF AUDIO, FILE 1.1]

GRAYSON: We are recording again, the continuing saga of Raymond March's scientific career. And I think we stopped—where did we stop at?

MARCH: About 1957.

GRAYSON: You had just started with Polanyi.

MARCH: I just started with Polanyi.

GRAYSON: At University of Toronto.

MARCH: Or, sorry, ’57.

GRAYSON: Nineteen fifty-seven.

MARCH: Fifty-seven. Yes. With Polanyi at [the] University of Toronto.

GRAYSON: Now obviously, he had quite a reputation. Did that show at the time? His brilliance?

MARCH: Well, his father was well-known, Michael Polanyi. Also Michael Polanyi’s brother Karl Polanyi was professor of philosophy at the University of British Columbia. And Michael Polanyi was at the University of Manchester. [. . .] He worked on unimolecular rate theory. So Polanyi had yet to make his own reputation, but he came very well-connected.

GRAYSON: [Yes]. So you started, like, a typical graduate curriculum with courses and then also working with Polanyi to come up with a research program?

MARCH: Yes. Now one little thing which I discovered later is that Polanyi had been very active in that first year, in a musical called *Spring Thaw*. If you’ve spent a winter in Toronto, you really look forward to the spring thaw. And he was involved in putting on this musical presentation. I guess he had done that when he was at National Research Council in Ottawa. Yes. And he had applied to Toronto and McGill. At that time, those were the only main universities in Eastern Canada that had international reputations. McGill turned him down because of his interest in *Spring Thaw*, and they thought he wasn’t sufficiently well-motivated.[4] [laughter]

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[4] Dora Mavor Moore, *Spring Thaw*, directed by Mavor Moore, premiered April 1, 1948 (Toronto, Canada New Play Society, 1948).

Toronto took him in. He took me in. And we set out to look at a pulsed photolysis program that would make rapidly—we really needed lasers, but we didn't have them—that would make a bunch of free radicals, and then at a later time, another bunch of free radicals, and then see how they interact as a function of time. Nothing terribly complicated chemically, but the technique was interesting. So we had to develop TV tubes, television tubes, and fill them with a gas, and put windows on them, so we had a lot of fun with that. It was more the type of work that [Sir] George Porter had done at Cambridge. He had been awarded a Nobel Prize for flash photolysis. He was, I think, quite a good friend of Polanyi, because we saw him often.

GRAYSON: Were you one of his earliest graduate students?

MARCH: There were three graduate students. There was Ken [Kenneth] Cashion, who came as a PhD student, already with a master's. He was a Jesuit scholar, Jesuit priest. Cashion. So he already had his master's. Then there was Sadowski that we've talked about previously. Chester and I were both starting in at the master's level, and then we didn't—in those days, you didn't have to complete. You could convert. And we both converted to PhDs, and then we both walked together and graduated in the same ceremony in 1961.

GRAYSON: So you were basically the earliest of his students?

MARCH: Yes.

GRAYSON: Okay. That's interesting. And this **<T: 05 min>** flash photolysis experiment was—you were kind of following up on a flash photolysis type thing now.

MARCH: Yes.

GRAYSON: Okay. So how many years did that take to get going to the satisfaction that you could feel like you've made some progress?

MARCH: Well, two years, and then really settled down for some more results, and then to do some calculations. And Fortran was just coming in as a subject to be taught, and I had a choice of either using an electric calculator or taking a course in Fortran and working it out and I decided, no, I wasn't going to do Fortran. I was much better off with this calculator. And did it, and finished, and that was that, so—

GRAYSON: Oh, okay. So this was the old—oh, I can't think of the names of these things now, these calculators that they had at that time. They were—

MARCH: You could roll them this way or turn them this way. Align them, and it would zip along.

GRAYSON: So you did your theoretical work with essentially a hand calculator rather than messing with taking the learning Fortran programming at that time it was probably a good choice, anyway, because you'd create all these card decks and all—

MARCH: Yes, it was all too new. I got into that when I got to Trent. That was fine.

GRAYSON: So now by this time, you're committed to Canada.

MARCH: Yes. But '57, I started. Fifty-eight, I got a letter from my dear fiancée, returning my engagement ring. There had been a kerfuffle over who should be invited to the wedding. The wedding was to be in the spring.

GRAYSON: So you had planned for a marriage?

MARCH: Yes. In the same church as I had been in the Scout troop, and the youth club, and that's where I met Kathleen [May Peacock March]. And so we were to be married there, but then her parents were not very happy, and this came to a head, we would say, over the invitations or the people to be invited to the wedding.

Yes. And in particular, a niece of mine. The niece of mine was a youngish girl at this point, perhaps twelve or fourteen, but she was the only daughter of my Uncle George, and my Uncle George had been instrumental, you'll recall, in teaching me Morse code and spending time with me during the war, when my father was trying to build and repair submarines all around. So she was very close to me, and so was my uncle and aunt. And so he [Kathleen's] father said no, and so Kathleen sent the ring back. So what do you do, Michael? What do you do? Letters take about—a good letter will take seven days to reach. So what do you do?

GRAYSON: I don't know. You go back.

MARCH: Immediately. Yes. It's no good writing, no good telephoning. Go back. So now my salary was, as a graduate student, was minuscule. The airfare, I think, was one-third of my salary, return airfare. So I went back. You don't have to put all of this in, but to give you the flavor, I went back, landed at the same airport [from which I had departed the previous year], went across from Glasgow to Edinburgh, [Scotland], down to Newcastle, took the train to the coast—

GRAYSON: Now this was the same twenty-four hour way back into—as long to go back as you—

MARCH: No, it had speeded up. We now had jet aircraft. So it was direct, Toronto to Prestwick. That was a change, in just that short period.

GRAYSON: Yes.

MARCH: It changed. That changed in the short period, and then later, the transatlantic ships died in a short period. These things happened very quickly. So I went back, walked through the snow—this was February. Got to her house, knocked on the door. Her father came to the door and said, **<T: 10 min>** "It's you." And I said, "Yes." I said, "Hello. I'd like to speak to Kathleen." "I'll see if she'll talk to you," he said, and closed the door. [laughter] That was the end of any attempt to be friendly. And so I thought he was silly. An older man should have at least had courtesy, which I thought he was lacking. Anyway, as soon as Kathleen saw me, she goes, "Ah, yes." And that was a Sunday, and we were married on [the following] Saturday.

GRAYSON: Oh, okay. [laughter]

MARCH: Yes. There we are. Okay. So now I have—

GRAYSON: You've got to come back to the States.

MARCH: Yes come back to Canada. Now fortunately, there were no computers at that time, so coming back into the country, there was no way the immigration officer could look up and see if I had been—was I due for national service or something like that. It was a risk, but there wasn't, so I got into the country and I got out of the country. I didn't go back for eleven years after that.

GRAYSON: So you were actually taking a chance that if they determined that you still owed them three years of service, conscription, that you could have gotten stuck back in the UK for a while. So it was—

MARCH: I was risking just about everything. But so great was my love for—[laughter]

GRAYSON: And then you managed to pay another arm and a leg to get both of you back.

MARCH: Yes. Kathleen by that time was teaching, so things went steadily better.

GRAYSON: [Yes]. And so you settled in Canada, back in Toronto I guess at that time.

MARCH: In Toronto. Kathleen taught in Toronto, got a regular position as a teacher. Toronto of course was expanding.

GRAYSON: Well, it's still expanding.

MARCH: Still expanding. And she taught at schools all over, particularly [in the] Scarborough, [Ontario], area, that is, the area to the east of Toronto. And a wonderful experience. And then she got a regular job, and in those days, as we came to the end of the time, as we came to the end of the graduate time, I never applied for a job anywhere. No one in the lab did. People would come and search you out, people from companies, government, would come. They would come and search, what chemists have we got about to graduate this year, they'd ask me, and come around, and make appointments, or take you out for lunch or dinner or—yes. Never wrote.

GRAYSON: So just to back up a little bit why did you decide to into graduate school?

MARCH: Why?

GRAYSON: I mean, it wasn't really to get away from your military service.

MARCH: Oh, no. Oh, no. No, no. I'd have enjoyed the military service. Had I gone in for two years—

GRAYSON: Two years.

MARCH: —three years I thought was a bit too much.

GRAYSON: But you knew, even at that time, the reason why it was too much was because you knew you wanted to go on with your education.

MARCH: Yes. Two years I could take. Three years I thought was too much, and it was unfair. And I had really been impressed by Dainton, and I had a very good tutor. He had huge hands, huge hands. He wasn't exceptionally big, but huge hands. So I asked him about this one time. And he had been a prisoner of war in Japanese hands for four years.

And he had worked on the Burma railway line, and he was in charge of a group of prisoners. He celebrated his twenty-first birthday in charge of a group of prisoners. And he was allowed to carry a revolver. The revolver was not to shoot the Japanese, but to shoot any elephants that came near and tried to interfere with the construction of the railway. Yes. So he built and so on for four years, and his hands were—

GRAYSON: Now he was a prisoner of war?

MARCH: He was a prisoner of war.

GRAYSON: And he was in charge of a group building this railway in Burma?

MARCH: Yes. Well, he was in charge of a group of prisoners, yes, the Japanese arranged all of it. I mean, they're all in a prison camp. The prison camp would move. **<T: 15 min>** But that was his responsibility.

GRAYSON: Interesting.

MARCH: He was a graduate at that time.

GRAYSON: And so he was part of the guys that you were working with at—

MARCH: At Leeds.

GRAYSON: —Leeds?

MARCH: Yes. He was my tutor in physical chemistry. Peter J. Wheatley was his name. Yes. So I'd been very much taken by kinetics. I mean, gas-phase kinetics, unimolecular rate theory. They were exciting, exciting topics, and you began to see how you could predict reaction rate constants, looking at all the translational and vibrational, rotational modes, and the change, and the partition functions that describe them. This was really exciting stuff, and the possibility of computing being able to help you was very attractive. And I had thought that Dainton was really quite a clever chap in studying chain reactions and things. And he was a very good teacher, and he was enthusiastic. He had a little book on chain reactions, and I've still got it.

GRAYSON: So it's just kind of the example of your teachers—

MARCH: Yes.

GRAYSON: —that got you interested so much that you felt that pursuing a degree, postgraduate degree, would be the right thing to do?

MARCH: Yes.

GRAYSON: And then you happened to hook up with Polanyi, and the rest is kind of—

MARCH: That was serendipity.

GRAYSON: [Yes]. Well, life is a lot of serendipity. I've become convinced of that.

MARCH: Yes.

GRAYSON: With time. And so you're graduating from Toronto with your PhD in physical chemistry?

MARCH: Yes.

GRAYSON: And people are coming to you saying, you know, we'd like you to work for us. So you entertained various kind of shall we say suitors from industry?

MARCH: Yes.

GRAYSON: From academe?

MARCH: Yes. Government. Yes.

GRAYSON: And the whole lot, and now you—all were interested in a PhD in physical chemistry to do something?

MARCH: Well, this is shortly after Sputnik. Universities are beginning to increase in number in the Western world, because with the Sputnik, the science race had really changed gears at this point. And so people wanted to get hold of young scientists.

GRAYSON: So you were a commodity in demand?

MARCH: Yes.

GRAYSON: But now you've got to decide—you have a PhD, and you still want to stay on the academic side of things.

MARCH: Well—

GRAYSON: Or did you just find—

MARCH: I was very interested in Chalk River [Laboratories]. Chalk River had been very active in the development of the atomic bomb, and they of course had the reactor at Chalk River, and did a lot of very good work, world-class work. And so I was invited to go there, into the physical chemistry group, and so took my wife up, and we were shown around. I was shown around, and interviewed, and talked, and were taken to a house for dinner. And the wife was telling us, it's a lovely garden here, but we have mosquitoes, and we have black flies, and there were bears that wander through. That was it. [laughter] My wife wouldn't go anywhere where there was a bear going to wander through the garden. And she said, "I'm sorry, I'm just too scared. I can't do it." So that was that. So instead, I went to work for a rather suave fellow, [Dr. Don Muir], at Johnson & Johnson. In Montreal, [Québec].

GRAYSON: So this was kind of like a commercial operation?

MARCH: Yes.

GRAYSON: Doing what?

MARCH: Very interesting—well, physical chemistry, absorption, bandages, diapers, feminine napkins. I know a lot about a lot of things that one doesn't normally talk about. [laughter]

GRAYSON: How long did this last?

MARCH: Just over a year. Yes. It was lovely. I mean, Montreal was a marvelous city at that time.

GRAYSON: Oh, [yes]. Definitely.

MARCH: And I really enjoyed it, and I had an idea for wicking away. You have an injury, and you want to wick away any fluids that come out, and there were various ways to do it, but I thought a good way to do it would be to make little holes and push some fine hairs through, loop them through. This is called needle looping **<T: 20 min>** in the textile industry. And so I had some material, a roll of material. I had to take it down to New Brunswick, New Jersey, where they had a needle loom, and they needle loomed some viscous rayon in, and rolled it up again, and I brought it back. Had a bit of a problem coming through customs. They said, "Has it been improved?" I said, "I really don't know. It's got thousands of holes in it." "Why did you do that?" And eventually one said, "Well, where have you been?" Now I've forgotten. It's just gone. Anyway, I got through with it, and this stuff worked very nicely, this needle loop thing. And we started to sell, and they made quite a bit of money on this technique.

GRAYSON: So how was getting back and forth, US, America, Canadian border then? Was it—

MARCH: Oh, no problem. No problem. No. No, no. It's very easy, carrying stuff. They were just curious, you know. Oh, is it any better? Because if it was better, you know, they can tax me. So that worked out all right. I had been working hard during the graduate time, and now I had a job from I think it was 8:50 to 5:20. Well, at twenty past five, I wasn't ready to leave. I mean, for one thing, there was a rush hour, and I had to get back over the Jacques Cartier Bridge, because I lived on the south side of the river, and so I would stay and look at things like patent reports, patent lists, and things.

Go through them. And my colleagues didn't like that. They complained. So I got a little fed up in having to defend myself. So I went to listen to Dainton. I told you about the lecture. He was giving a lecture at McGill, so I went to listen to him. And got on the elevator, and who should be on the elevator but—not Dainton, but Polanyi, with this guy Schiff, Harold Schiff, and because of that, I switched and went to work for Schiff.

GRAYSON: What was he doing at the time?

MARCH: Atom chemistry, glow discharges. Microwave sources of oxygen and nitrogen atoms.

GRAYSON: Oh, okay. And he was at what school?

MARCH: At McGill.

GRAYSON: At McGill.

MARCH: Yes.

GRAYSON: So he didn't just say, "Why don't you come to McGill?" I mean, you had some kind of interaction—

MARCH: Oh, no. "Who are you? What have you done? What are you doing now?" etc., and he happened to be looking for a research associate. He said, "Well, we do this. Why let's make an appointment, and come, we'll have lunch, and show you around." And there was somebody else working with him, a faculty member but in the same group, who actually had a mass spectrometer, a fellow called John Goodings.

Now Goodings had been an undergraduate when I first started graduate work at U of T, so I went into year one of graduate work, and Goodings was in the fourth year as an undergraduate. So he was doing a project. So we saw him in the labs, the research labs. His father [Alfred Goodings] had been a graduate of Leeds in color chemistry. I had been invited my first Christmas to spend an evening with them, have dinner and spend an evening with them.

It was very nice, really very nice. I've been friends with the Goodings ever since. The dinner was memorable because his father decided to light a fire in the living room. Now this was, you know, December, and they hadn't had a fire in the living room since the previous winter, so Margaret [Goodings] had the dinner going well, John was there with his father, and the pair of them lit the fire. Well, no sooner had the smoke started going up than the smoke started coming out. There was a creature had built a nest— [laughter]

The whole house was filled with smoke, and Margaret, the mother, was just livid that they were **<T: 25 min>** messing up her dinner. And the doors had to be cast open. Of course, it's about, you know, minus five, minus six. Windows open. We put on our coats and waited until it cleared. [laughter] So that was that Goodings, worked with him, as did a fellow called Diethard Bohme.

GRAYSON: Sounds like a Deutsch—

MARCH: Yes, well, his father I think was a German ambassador to the U.S., and Diethard was in fact an American citizen. But anyway, he was in Canada. He's been at York University in Toronto for years, [the past] forty years. So when I joined, we eventually got a sailboat, and so the three of us [Harold, John and I] would sail, and Diethard was at that time the graduate student. He's a big fellow, and so we put him as ballast. We didn't treat him very nicely, but it was a lot of fun. Anyway, so that's how I came to go with Harold. He was interested in microwave discharges and these atoms. Now Polanyi had been working on a relatively simple chemical scheme. He was—A plus BC goes to AB, plus C.

GRAYSON: Oh, yes, that's about as simple as it gets.

MARCH: Okay? That's pretty simple. And hopefully there's a delta H here, an exothermic reaction. Now he had something like Cl plus H_2 to give HCl [hydrogen chloride] plus H. Okay? So that has a potential energy diagram, something like that.

GRAYSON: [Yes].

MARCH: This is the transition state. This is the HCl plus H atom. And there are about six *v*—the six vibrational states here. So this is the heteronuclear diatomic. It will absorb infrared radiation and it will emit infrared radiation, unlike a homonuclear diatomic, which will do neither of these things. All right? So he then said, "This is going to give us HCl†, where the dagger [†] here represents a vibrational state from one to six, will give us HCl† minus [*hv*]." So it perhaps comes from—it has done that transition.

That frequency will tell us where it started. It will tell us the nascent distribution of products, the newly born distribution of products, some of which we don't know. And that was his contribution. He called this the molecular dance, because it comes down, and there are lots of other systems, but this is the simplest. Now Harold was interested in simply the reactions of atoms in the atmosphere, so that was the connection there. I remembered this, and I had an idea that if we ended up with N_2 here, so perhaps N plus NO [nitric oxide], to get N_2 plus O—that's the same type of reaction. We'd end up with N_2. Now N_2 has a very high energy. That is, energy of formation. So if you put it on a diagram here, it's about nine electron volts, if you go from atoms to the molecule. Nine electron [volts]—that's huge. Huge. And so my idea was this will **<T: 30 min>** not emit infrared radiation because it's homonuclear. But if I can ionize it by electron impact, I should be able to look at the first negative system and look at changes due to the change in population of vibrational states. So that was a problem, which I did later at Trent with a young lady [Professor Barbara Finlayson-Pitts] who is coming to give us a lecture next week [at Trent University].

And she graduated around about 1970 from Trent. But you see the connection running through. So this was Polanyi's work. The atoms were Schiff's work. And then this was Barbara Finlayson-Pitts, and Jim [James] Pitts, Jr., was the fellow who worked on the smog in Los Angeles, [California]. Riverside. A great hero in California. The House of Representatives closed business on the day he died this summer.

GRAYSON: Oh. That was your first project when you started working with Schiff?

MARCH: Yes.

GRAYSON: And this was at McGill?

MARCH: McGill University. So there are other interesting compounds, like aluminum trimethyl. I had worked on metallo-organic compounds involving methyl radicals, because methyl radicals had been the radicals that I was producing with these pulses of light. So I had done some work on methyl metal compounds.

GRAYSON: Methyl metal?

MARCH: Type of—methyl metal. [Yes]. Type of Grignard compound. And then Schiff wanted to work with aluminum trimethyl, because this with oxygen gives out this plus O_2, or oxygen atoms, gives AlO [aluminum oxide] excited in the atmosphere.

This you would see if you had a grenade and threw a grenade. This aluminum in the grenade, and you get excited lines from AlO. And this would react spontaneously with oxygen, O atom, if we sent it up into the atmosphere, and so Bull was interested in using this in his gunshots in Barbados. So I was doing some of the basic chemistry of that system. Now if we go from aluminum to mercury, Cl [chloride] and also mercury dimethyl [$(CH_3)_2Hg$], very nasty substances in water. And where would you expect to find mercury in fresh water? What sort of localities. Any idea? Paper.

GRAYSON: Paper?

MARCH: They used mercury in paper production. Yes. And it's lost. Lost in the water, and then forms this, and then the fish eat this, and then the Indians eat this, the fish. And it's not good. So where you have paper mills, and paper mills are scattered all across Canada, and this is a general problem. So I have a colleague now in our water quality center [Trent University Water Quality Centre], whose main interest is mercury and dimethyl mercury in lakes and rivers. So there's a succession. Okay?

GRAYSON: [Yes].

MARCH: Now where were we?

GRAYSON: Well, you were starting with Schiff.

MARCH: Schiff. So with Schiff, I started doing this work of aluminum trimethyl, and using microwave discharge—do you know anything about a microwave discharge?

GRAYSON: Not a lot.

MARCH: Oh, well, very brief, you take a microwave, but **<T: 35 min>** make a cold thing here. This is a hyperbolic shape. This is that shape. And then you put in a little point here, and then this is hooked into a microwave generator, and this generates microwaves. Now if you take a piece of Pyrex tubing, Pyrex because once the discharge starts, it gets very hot, and—sorry, quartz. This is quartz. Quartz. No, quartz. And then you put the microwave discharge unit around it like that, and then just tickle this with a tesla, you get a discharge. Oxygen atoms, nitrogen atoms, nitric oxide.

GRAYSON: Oh, all that good stuff.

MARCH: Yes. You can titrate nitrogen with nitric oxide, and you can get colored extremes, and the dark, where you have exactly equivalent amounts of nitrogen and NO. So this means if you have a source of one or the other, you can begin to titrate the concentrations in the upper atmosphere. So the quartz, you can also in this type of apparatus make oxygen atoms, which with more oxygen will give you ozone. And so we studied ozone and nitric oxide.

GRAYSON: So this is all part of an atmospheric chemistry?

MARCH: Atmospheric chemistry. Yes.

GRAYSON: And that was just his primary interest?

MARCH: Yes.

GRAYSON: Okay. Was there much of a—how would you say, concern about the environment then, the atmospheric environment, as—

MARCH: No.

GRAYSON: —there is today? No?

MARCH: No. No. Jim Pitts, Jim Pitts—well, I haven't come to Jim Pitts yet. I haven't even met Barbara Finlayson yet. So no the problems of the environment weren't being tackled at this time.

GRAYSON: And this was in the sixties?

MARCH: This is 1962 to ’65. That’s at McGill.

GRAYSON: When did people start being concerned about the ozone hole?

MARCH: About the ozone hole? Oh, not until later. I think about 1985.

GRAYSON: Oh, okay. That might—

MARCH: We had a conference here at Trent, and I was asked to organize it with another fellow. Then he decided to run for Parliament and so I was left with the whole damned conference. And there was a fellow came from the Arctic Institute of the University of Cambridge, and I had to arrange for him to be interviewed by the press and CBC [Canadian Broadcasting Corporation], because the ozone hole had just been discovered. So it was about—I could look it up, but I think it’s about 1985.

GRAYSON: Okay. So this preceded that by quite a long—twenty years.

MARCH: Yes.

GRAYSON: So how many different systems did you work on with Schiff, or was it all those that you enumerated?

MARCH: Yes.

GRAYSON: All three, four?

MARCH: Those, and then, of course—

GRAYSON: And the aluminum and the—

MARCH: The aluminum trimethyl—that's trimethyl. This was for Schiff and for Gerry Bull, and then the impact stuff was done in a place on Montreal Island. Actually, it was done in the laboratory of Canadian Arsenals, where they make gunpowder. It was done there. That was also for Gerry Bull. [. . .]

GRAYSON: So how long did you spend working with Schiff at—I keep getting confused. McGill?

MARCH: Three years. Three years at McGill. So there was this upper atmosphere work. There were also graduate students to supervise and assist. There was the work with Gerald Bull. We worked also in collaboration with the U.S. Air Force [United States Air Force] to—Hanscom Air Force Base, I think.

GRAYSON: [Yes]. **<T: 40 min>**

MARCH: Hanscom Air Force Base.

GRAYSON: What was that about?

MARCH: Because they were interested in upper atmosphere chemistry. I'm trying to think of a scientist who works there now. Al somebody. [Al Viggiano].

GRAYSON: It'll probably come back to you in a minute.

MARCH: It may come. Yes. So this was really idyllic. Schiff and I lived close together on the south shore. Goodings came—he was always with us, visiting. He loved my wife's gravy, and he would have slice after slice of bread and gravy at—and the three of us decided to buy a sailboat which we could sail from the south shore. There's a village—part of Montreal called Préville, [Québec]. And we wanted to have a little sailing club, but then there was word they were going to put a big highway across the—so we went to see our MPP [Member of the Provincial Parliament], Pierre Laporte. He was absolutely charming. We had a [degustation]. That's a little wine and some nice things to eat, and some talk. And he arranged for the highway to go up and over. They would put a road underneath. And he would actually have built two walls of dirt and fill so that we'd have a harbor. They were constructing an island in the center of the St. Lawrence for the [Canadian Centennial] World Fair in 1967, and this work was underway at this time. And so there was lots of trucks and things, and he would have this done, and it was done.

GRAYSON: This guy, just because you three—you guys wanted to have a place to sail your—

MARCH: Well, no, we had the boat. We formed a club, you see. With the others. So it was an English-French club, for people in Préville. We had no problems with language or anything like that. We were all just interested in sailing, and race under various conditions, and so Laporte did that. It was idyllic. We really enjoyed that. But this was all happening at the time of the FLQ. [. . .]

GRAYSON: The what?

MARCH: The FLQ. The [Front de] Liberación de Québec [or Québec Libération Front] was a separatist paramilitary group founded in Québec in the early 1960s. Back into the terrorist times. Night watchmen being killed, bombs being put in mailboxes, dynamite hung from the Victoria Bridge, so they would close it, and then police would go and cut the dynamite off and drop it in the river and open the bridge again.

Not nice. Eventually, it became oppressive, so I decided to apply for another position. I was invited to apply for a position at McGill, a faculty position, but this was very, very unsettling. And McGill's situation was threatened. McGill had a lot of funds given by alumni and so on, invested funds. It was a well-to-do university. There was the University of Montreal, the other side of the hill, which was a town—a provincial university. New, no funding, from alumni, no alumni. So they couldn't—the Québec, government couldn't allow two universities, a French poor one, and McGill, a good one, and give them the same amount of money per student. No. McGill had to live off its investments until they were down.

Oh, man, it ruined a—McGill has come back, but it went through a rough, rough time. It had world-class people in a number of disciplines. So I applied to Trent, and fortunately, the president at Trent had been the faculty member in charge of Devonshire House at University of Toronto, and I had been a resident in Devonshire Hall at Leeds University, so the Devonshire connection. Plus, Polanyi was a **<T: 45 min>** scientific advisor to [Thomas Henry Bull] Symons—that was the president. And so I got the job.

GRAYSON: But Trent was kind of an unknown quantity?

MARCH: Trent was just—when I came for interview, it had only been open for about four or five weeks.

GRAYSON: Yes. I mean, the university.

MARCH: Yes. But I needed to get out of Québec. The value of my house was going down because of the migration of particularly English people to Toronto. Property prices were falling, so I needed to get out, go to Trent, perhaps stay there for five years, and meanwhile, look for a more permanent thing. Yes.

GRAYSON: Oh, okay. So as an escape valve.

MARCH: Yes.

GRAYSON: Okay. You'd take anything to get away from the situation that you were basically dealing with.

MARCH: Yes, because I was losing my equity. Yes. Didn't have a great deal, but losing it.

GRAYSON: [Yes]. So how long did the FLQ—

MARCH: Well, the FLQ, once I got to Trent, it became worse. [The Prime Minister of Canada, Pierre] Trudeau had to call out the military at one stage, and the FLQ kidnapped Pierre Laporte, [our MPP], and killed him. Yes. Killed him.

GRAYSON: So what did all this accomplish?

MARCH: Nothing. Nothing. They also kidnapped the British High Commissioner, and he was eventually found, really dramatic scenes when he was released, and to a police car, and taken away, and the others. They bargained to be taken to Cuba, so the three French Canadians were taken to Cuba, and they spent, I don't know, fifteen, twenty years there. One came back and wanted to be a lawyer. He applied to be a lawyer, and he was told, on the newspapers, "You have a criminal record of the worst type, you see. There's no way you're going to be a lawyer." So eventually, there was—

GRAYSON: I mean, so the FLQ even kind of followed you from Montreal to here, to Trent?

MARCH: Oh, it didn't follow, but it got worse after I left Montreal.

GRAYSON: After you left? Okay.

MARCH: Yes. So Laporte and the calling out the military by Trudeau, Pierre Trudeau, was about 1969 or 1970. And Pierre Laporte was killed at that—he had three children. It was a senseless, senseless murder, as most murders are. So that was a real shame. There was eventually a referendum, and it lost.

GRAYSON: The referendum being to—

MARCH: For Québec to separate. Separatist, okay, movement. Separatist thing, a bit like Scotland. Scotland recently rejected, of course, further separation. The only people—this is a joke. The only people who were in favor of Québec separating were the people from Newfoundland, because then, they argued, the drive to Toronto would be shorter, once the road to Québec had gone. [laughter] It was just a little joke. There. So here we are at Trent, a new university.

GRAYSON: [Yes]. This is quite an experiment for you, right?

MARCH: Yes.

GRAYSON: And was anybody else—I mean, the faculty was being formed, everything was starting up from the ground zero.

MARCH: Yes. There was a mixture of older faculty, I'd say fifty and slightly over, from various universities, who came and brought experience. And the rest of us had little experience other than through our graduate programs, undergraduate. I met up again with Ian Chapman, who had met me at the airport in 1957, and so that was nice. Just, of course, to go on an aside for a moment, Jim McCowan, who we met, I was an usher at his wedding in about 1960, and then earlier this year, fifty-four years later, I attended the memorial service for his wife, and I was the only one from the wedding party there.

But he had his career at Queens University, also in **<T: 50 min>** chemistry, and we still keep in touch. Chapman, alas, died a few year ago. So here we are, some young fellows and women, and some older fellows, and a couple of older women, and some people from the French and German classics. They're different altogether, and it was a great experiment, and it worked. Some of the things at the beginning I thought were very good, and some aspects were deleted later. The wearing of gowns, green gowns, it was very distinctive. You could see the students all around. It was really civilizing. And then everyone had a supervisor of studies.

That was simply—it was a formal registration. You had to approve the registration in that form, and after, the registrar's office. That was just a contrived meeting. There were three contrived meetings a year, and it worked very well. But the students one year didn't like it, and so it was gone, and it's never been restored. Well, the students lost on that. They lost the benefit of a lot of consultations on their careers, important—and just general academic conversations. They lost out. There was nothing to replace—

GRAYSON: So you say where they had—I mean, the students were wearing gowns?

MARCH: Yes.

GRAYSON: Oh, as part of their daily going about business on the campus, and so on?

MARCH: Yes. And we had formal dinners once a week. The faculty would go to the residence of the college, and dine with the students. We had our gowns on, and they had their gowns on. My wife still has her green gown, and she wore it a week past Saturday, because we had a reenactment of a parade. So in chemistry, we had to share laboratories, so I would make physical chemistry experiments on a board, and on a structure, and then we'd hoist these up to the roof, to the ceiling, rather, and tie them off at the side, in shipshape manner, disconnect them from the vacuum pumps, and so on; and then physics would come in, and they would go out; and biology would come in, and they would go out. Then it'd be chemistry again, in this one—why we planned the buildings on the campus. So we were downtown here in an old school, and planning the buildings to take place—yes, ma'am? [laughter] [. . .] So it was really quite exciting, forming—

GRAYSON: Who funded this?

MARCH: Oh, the provincial government.

GRAYSON: Okay. So there was enough interest—because of the Sputnik thing that the local politicians and the provincial government were willing to put up cash to get this thing going?

MARCH: Yes. We had wanted Niagara Falls, that's Brock University, Trent here, and Nipissing [University] up north, Laurentian [University] up north, Guelph was converted from an agricultural college to a university, Guelph University. And that's just in Ontario.

My colleague, I mentioned John Todd, he was at [University of Kent] in Canterbury, [United Kingdom], and Canterbury started a year after Trent. And there were a number of universities in Britain that started in 1964, '65, and '66.

GRAYSON: Okay. So this is kind of news to me.

MARCH: Oh, there was a great university expansion, both in numbers and, of course, in the number of students attending.

GRAYSON: [Yes]. Okay. So I think in the States, there was a—you know, more emphasis on science, but I don't think that any new schools were created. At least, I don't think so.

MARCH: Ah. Nope.

GRAYSON: None to my knowledge.

MARCH: Sociology, **<T: 55 min>** psychology, history, thousands of students came to the university. Of course, the university experience of the Canadian population was very low, and this was a say to improve it. Yes. Even if a person went for one year to a university, and then either couldn't go on, or didn't want to, went to business, they had that experience, that knowledge and experience of the university system, and therefore, were more kindly disposed as a taxpayer towards it. Your alumni love you. The more alumni you have, the more powerful you are, the more secure your position.

GRAYSON: Yes. Interesting. So there was this really kind of a national expansion of university-level education, just because of the Russians putting up the Sputnik.

MARCH: Yes. Of course, it was the culmination of experiments, going back to the German V1 and V2 rockets, because both sides, the Americans and the Russians, both sides got some of these things...

GRAYSON: Well, Wernher von Braun came to the U.S., and that was—

MARCH: He's more American than— yes. [laughter]

GRAYSON: So you were able to go ahead and get this thing going, the chemistry department. Obviously, you had a chair, I guess. How many people did you have starting out in the department? A handful, I guess?

MARCH: In the department, a handful, one, two, three, four, initially, in the second year. There were two in the first and two more in the second, so four of us. We didn't have a department, didn't have a department structure. That came after another year, but we were more occupied in planning the buildings on the campus. The campus is about four miles north of town, and if we have a chance late this afternoon, it's still light, I can zip you around there.

And it's very beautiful, the Otonabee River goes through, and so it's a concave format. My friend John Todd, he's at Canterbury, as I said, and-the University of Kent is convex. The university's built on top of a hill, and all of the four colleges look down through the main windows at Canterbury Cathedral.

GRAYSON: Oh, nice. So it's really a very interesting national experience. Now my understanding, you know, I was talking to Keith Jennings in the UK a couple of years ago, he was bemoaning the fact that the sciences are taking a hit, and a lot of the funding for chemistry and that kind of thing is going down, and also, from what I read in the news, the Australian government currently is kind of putting the kibosh on the CSIRO [Commonwealth Scientific and Industrial Research Organisation] and, turning down—you know, reducing funding and all that kind of stuff.[5]

MARCH: Yes.

GRAYSON: So is Canada still on the upswing with regard to—

MARCH: Just. Just.

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[5] Keith Jennings, interview by Michael Grayson, at Leamington Spa, Warwickshire, United Kingdom, 24 and 25 April 2008 (Philadelphia, PA: Chemical Heritage Foundation, Oral History Transcript #0419).

GRAYSON: I got the impression from Keith that the UK has really taken a hit in the sciences.

MARCH: Well, yes, it is, but UK has a lot of universities. I mean, they've got fifty million, fifty-five million people there, and Warwick [University], where Keith was, was one of these universities, started in 1960. I had an email from Keith just last week—

GRAYSON: How's he doing?

MARCH: He's well.

GRAYSON: Good.

MARCH: He's well. He favors river cruises to sea cruises. So I may go and see him in March. I lost my thread.

GRAYSON: Well, it was about the change in attitude towards science in the—

MARCH: Oh, yes. Yes. So what was happening I think in Britain, and I know it's happening in Canada, is that the fifteen or so major universities, those that think they're in the top fifteen, we're down in the soccer league, you know. Those in the premier division really should get most of the money. And that's happening in Canada. I've got letters to the head of NSERC [Natural Sciences and Engineering Research Council of Canada]—that's our national science funding council, and to the minister of state for that, and the newspapers, because Trent is not one of these. And the fifteen upper universities, they think only **<T: 60 min>** those fifteen should be doing research with graduate students. That has of course dreadful implications for the other forty-five or so institutions in the country. And that is NSERC. That's the Natural Sciences and Engineering Research Council. They give money and scholarships and things like that. We also have the CFI, which is Canadian Foundation for Innovation.

GRAYSON: So what about private schools? You know, there's a lot of private schools in the U.S.

MARCH: Not here in Canada.

GRAYSON: No?

MARCH: You're talking about private universities?

GRAYSON: Private universities like Harvard and Yale [University] and Tulane [University] and—none of that?

MARCH: No. None. Not one. I have two grandchildren who go to a private school that's in the next town. And actually, a week past Friday, Sarah and her mother went to look at Harvard. They had a tour of Harvard.

GRAYSON: Oh, wow. Okay.

MARCH: Yes. Sarah is very impressed by Harvard, but we don't have any.

GRAYSON: So all these schools are basically national government, Canadian government?

MARCH: Yes. Provincial government.

GRAYSON: Provincial.

MARCH: Provincial—education is a provincial matter. Yes. Science funding is a federal matter, but universities are funded by provinces. Researchers are funded for their money, research money, by NSERC, national sciences, and CFI gives money for instruments. Now we have three masters, and our masters don't view us equally. [laughter] Just completing our delivery of six and a half million dollars' worth of mass spectrometers to Trent. That's a lot of money. But CFI has a clientele now, which is virtually all of Canada, all the teaching institutions in Canada, and NSERC is concentrating on just the fifteen. So they now have different clientele.

GRAYSON: Okay. Let me get that. NSERC. So, that sounds like it's a recipe for some kind of, how would you say—

MARCH: Revolution.

GRAYSON: Revolution?

MARCH: Revolution. Yes. [laughter]

GRAYSON: So you're saying in the UK, there's so many more schools they're kind of going to a similar kind of a thing?

MARCH: Yes. And they had colleges. We still have colleges here, but they had colleges, technical colleges. I went to Rutherford Technical College, when I was an apprentice. That is now a university, [Northumbria University at Newcastle upon Tyne]. All the technical colleges became universities. They expected equal funding. The government says, "We can't do that." So now there's the elite, the Oxford, the Cambridge, the Manchester, London, etc., that want the money.

GRAYSON: [Yes]. Well, being on the top of the heap is always—wanting the money.

MARCH: Yes, and it's simple. If you simply—if you have a university in a town which has a football team in the premier league, they deserve the money. I mean, that's the rationale.

GRAYSON: Oh, I see. We have sports in there after all.

MARCH: Yes, of course. Yes.

GRAYSON: Oh, my. Now by football you mean soccer.

MARCH: Soccer. I mean soccer. Yes.

GRAYSON: Okay. So we'll get that clarified.

MARCH: Yes.

GRAYSON: But there is some Canadian—American football, right, teams?

MARCH: Some Canadian football teams. Yes. Yes. In the universities. Very few young men play Canadian football after the age of seventeen. See, they leave school, go to university. University is much more selective. When I was at Leeds, we had six rugby teams. You know, the first, the second, the third, the fourth, and the fifth. That doesn't occur in football, Canadian football. And of course, once they leave university, unless they get a professional position, there's nowhere else to play. None. So—

GRAYSON: So you're starting out at Trent.

MARCH: Yes.

GRAYSON: Were there any exciting tales to relate about that experience, of getting it ginned up?

MARCH: Well, we had to work with an **<T: 65 min>** architect, a fellow called Ron [Ronald] Thom. He was the university architect responsible for development of the campus, which is just up the road.

GRAYSON: So he was like the majordomo of the whole campus architecture?

MARCH: Yes.

GRAYSON: Okay. That's a pretty responsible position.

MARCH: Yes. And he put up some wonderful buildings, and I often talk about Ron Thom's buildings, because if you want to direct someone at Trent, it's very difficult. It's not easy. It's much better and easier to go with them, at least part of the way, and talk, whereas in France, the buildings are all like this, this, this, and this, and you can say up here, down there, and there. Here's my granddaughter. This is Rebecca [Hubble]. This is Professor Michael Grayson, dear. [. . .]

[END OF AUDIO, FILE 1.2]

GRAYSON: So we're back after lunch, and before lunch, you were mentioning something about the *International Journal of Mass Spec[trometry]*, and how you had first—did you know Harry Svec before you had this experience with him?

MARCH: No.

GRAYSON: And he was the editor?

MARCH: Yes.

GRAYSON: So you ended up sending papers in to the *International Journal*, and discovered that they came back rather quickly, even though there was no electronic communication. [laughter]

MARCH: Yes.

GRAYSON: And basically, you just figured out pretty much that he was doing the whole business by himself?

MARCH: I don't think he did that for everything that we published. This was the only one that was noticeable. And the others came back with, you know, referees' or reviewers' comments, but not too sure that it was Harry or not. But they just had a good way of doing business, and I liked them.

GRAYSON: And what particularly did you like? Just the rate of return, or—

MARCH: Fairness. Sometimes you get guidance on the reviewers' comments. You know, "This is perhaps reasonable, but it's not terribly important. You can skip this part," and so on. So you have some guidance as to how you might deal with it. So I was, you know, really pleased to get this, and I've been a member of the board for—for a long time, advisory board. Editorial board, for a long time, so—

GRAYSON: So I guess everyone has had this rejection problem in their life. I think most people have. Have you had a—that nice letter you get back from the editor saying, "We don't think you should publish this in this journal," or anything quite that—

MARCH: Until about three years ago, very, very seldom. I couldn't remember the last time I'd had a paper refused. In fact, I don't think I'd ever had a paper refused. No, I think I did, in the very late 1960s, [*Canadian Journal of Chemistry*], had one. But I got one from Joe [Joseph] Loo, and I was incensed, and sent him a response of nineteen points where he and the two reviewers had been in error. [laughter] But he wouldn't countenance any appeal. It's interesting, and the battle goes on. [Later,] I had a victory in a way. And the battle goes on because you can have a protein, [P, which is multiply-protonated to form $[P + nH^{n+}]$that can react with] something like ibuprofen. We know that proteins carry medications and drugs, so that this will give us a protein $[[P + nH^{n+}] + Ibu$ where Ibu is an ibuprofen molecule. The product of $[P + nH^{n+}] + mIbu^{-} \rightarrow [P + nH + mIBu]^{n+}$ is described as] a non-covalently bonded complex [with, it should be noted, no change in charge on the protein].

[A reviewer had disagreed with our conclusion that since the addition of PFOA—perfluorooctanoic acid—to a solution of L-FABP—liver-fatty acid binding protein—does not shift the observed charge states in positive mode, the PFOA must bind as a neutral species. The reviewer argued that, "The binding of an ionic ligand to a protein does not necessarily result in a shift in the charge state distribution observed in the ESI mass spectrum and thus the authors' conclusions are potentially incorrect and are very misleading to the readers of this journal." In agreeing with the reviewer, Joe Loo explained that, "In the case of PFOA binding to FABP, it could be conceivable that PFOA comes in as an anion, but upon interacting with the protein and perhaps with a conformational rearrangement, salt bridges and direct interactions with charged residues would neutralize the charge and would make it appear as a neutral interaction." Rubbish; if PFOA comes in as an anion and reacts to form a complex with no change in charge, it must be accompanied by a proton not associated with the protein, thus constituting a neutral system known commonly as a molecule. One cannot add a negatively-charged moiety to a positively-charged moiety without effecting a change of charge. He wouldn't accept that. He still doesn't. Still doesn't. And then he sent me a paper. A Chinese fellow had sent in a manuscript concerning a study of Bovine Serum Albumin [BSA] with some polybrominated diphenyl ethers.]

[The authors had] made up twenty-six or twenty-seven of these, and found only three reacted with BSA. BSA is a multiply-charged protein, and the most prevalent state or the base peak for this compound would be 17^{+}. And he added these things to BSA and found that only three isotopologues of these **<T: 05 min>** polybrominated compounds added to BSA, and then he showed the mass spectra, and that was it. And Joe sent me this paper and [invited my comments. By this time, we had published another article concerning the addition of neutral species [Ibuprofen] to BSA, and so I was familiar with the system.[6] I replied to Joe], "Well, the author must explain the results to some extent." And I sent [a sketch showing my understanding

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[6] Michelle L. D'Alessandro, David A. Ellis, Jennifer A. Carter, Naomi L. Stock and Raymond E. March, "Competitive Binding of Aqueous Perfluoroctanesulfonic Acid and Ibuprofen with Bovine Serum Albumin Studied by Electrospray Ionization Mass," Spectrometry. *International Journal of Mass Spectrom*etry, 345-347 (2013): 28-36.

of the results in the manuscript], and waited. Nothing happened. So I phoned [the editorial office to ask about the fate of the manuscript]. "No, the paper had been rejected." I was never told it had been rejected. I was incensed once more because what I had given some clues [my comments had not been communicated] to the author.

I had the address and so on, so I emailed the author, and said, "I'm awfully sorry. I was reviewing this thing. I was asked for an opinion." And I said, "My opinion was [that you should be asked to revise your manuscript by explaining the significance of the experimental observations shown in one or more figures in your manuscript. Apparently, this advice was neither accepted nor conveyed to you.] So I've expanded upon my results, and here, I think, is the explanation for of your observations, and it can be all summed up in reactions one, two, three, and four.[7] [. . .]

That's it. "I don't want to be an author, but I recommended this." So they did that, and it was accepted, it's been published.[8] And the beauty is there are two mechanisms for [addition of polybrominated diphenyl ethers (PBDEs) to BSA]. One is the addition of a neutral PBDE molecule, so there's no change [in charge of the BSA state], and the other is the addition of a PBDE anion. Both [reactions] occur. So if you look at the relative intensities of these, you can work it all backwards beautifully. Here we are. [laughter] Have some fun with the editors. Yes.

GRAYSON: So that wasn't submitted—is Loo on the editorial board of the Canadian—

MARCH: *JASMS* [*Journal of the American Society for Mass Spectrometry*]. Yes. Unfairly so, I thought. And I had got on well with Joe. Is this on? I was asked to sit on an ad hoc committee following the ASMS [American Society for Mass Spectrometry] meeting in Chicago, [Illinois], round about 2001 in fact, I think.

GRAYSON: I don't remember. I can find out that—

MARCH: It was the same year as 9/11.

GRAYSON: Oh, 2001, I think.

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[7] See Appendix I.

[8] Qiang Ma, Hau Bai, Choa Wang, Guang-Cheng Xi, Qing Zhang, Xian-Shuang Meng, Yun-Xi Chen, Jin-Rui Li, Hui-Juan Ma, Liang-Hong Guo, "Investigation of noncovalent interactions between hydroxylated polybrominated diphenyl ethers and bovine serum albumin using electrospray ionization-ion mobility-mass spectrometry," *International Journal of Mass Spectrometry* 357 (2014): 34 – 44.

MARCH: Two thousand and one. So it was June, May, June, 2001. Went to Chicago. Chicago is beautiful. But we had too many people. We had escalators up and down, and people were coming out of lectures, two or three lectures, where all lectures are simultaneously time-tabled and so there were lots of people moving in a restricted area, and I thought there was a problem, a real problem with that. I didn't say anything, but I was asked to go on this committee to deal with the success of the Society.

And I said, "I really don't think I should, because I have never really had much association with successful institutions." [laughter] And anyway, I got on it, and we met in Denver, [Colorado]. That was September, late September, following 9/11. The huge hotel lobby was empty, apart from a clerk and a waitress in the food area. It was scary. I got in, checked in, and then met up, and we had our committee, and only about half the committee was staying there, and the other half were, you know, local, from Boulder, [Colorado] or somewhere like that. And what's her name was on it. Ronnie.

Veronica Bierbaum. And Joe Loo. So we had our meeting, and then that evening we went out to dinner. And I asked him where were you when you couldn't get back from—he was in London [during 9/11], and he couldn't get back [to the USA because there were no flights]. So I said, "Oh, what did you do?" He said, "Oh, I went to the Science Museum." I said, "Of course." [laughter] "Why didn't I think of that?"

So he told us, that he had seen Aston's second mass spectrometer. And this was on show, and so on. And so we had the idea of perhaps trying to persuade the **<T: 10 min>** British Science Museum, to rent it out to ASMS, so that we could show it. We thought that was a good idea, so we corresponded [with the Museum though with little luck], and eventually, I was in England, and I spoke to Keith Jennings, and he said, "Why don't you go to Cambridge, [United Kingdom], and ask them?" He said, "I know Gordon," Gordon somebody. "Ask Gordon. He's the curator or something of the museum that they have there."

So I made an appointment, went to see Gordon, [Curator of the Cavendish Laboratory Museum, had a delightful lunch with him in the college, and the people in the Cavendish Laboratory workshop] agreed to make in the same workshop, facsimiles of about four instruments. So I went back, and they gave me an estimate, about twenty-five thousand dollars to make them and have them transported to USA. And it went to the ASMS Board of Directors, and the board approved it. And that's what we have. Those are still available to ASMS. They belong to ASMS. And they've been shown at some conferences. And that all came from that discussion between Joe Loo and me at that conference.

GRAYSON: Wow. So what did you decide other about the success of the ASMS and what to do about it?

MARCH: Oh, what was interesting, we said, there should be physically larger facilities. It's useless trying to get five thousand people into something that's only, you know, fit for three thousand. And there are fire regulations for these things. Also, you can't just have people sitting on the floor and standing in the aisles, etc. That's just inviting trouble, and it's foolish, and not a good example to set. So then somebody had mentioned the idea of televising it locally in the hotel. So that evening, I telephoned the hotel where we were going to be in 2002, and asked them if—did they have such facilities, if we wanted to do this. Had a good discussion with the person there, even though it was Saturday night. I think it was a slow time. And yes, they could do this, put it on, and they would put cameras in, and they could record, and they could broadcast later, simultaneously and later, could do all of this. So I went back to the meeting and told them this the next day. Well, what's her name, the executive director—

GRAYSON: Judith?

MARCH: Judith.

GRAYSON: Sjoberg.

MARCH: Sjoberg. Ex-wife of Jack—

GRAYSON: Watson.

MARCH: —Watson. Was furious. "How dare you phone the hotel?" I said, "Because, Madam, I am a Canadian, and I am free to telephone any hotel that I wish, in this country, or in any other." You see? I was really annoyed with her, because she took after me, and she shouldn't have done. So that passed—[laughter] But I wasn't giving an inch. I said, "I've got information. We could do this." And in fact, we ended up doing that. Each conference since that time has had a television link, so you can stay in bed and listen to the 8:15 a.m. lecture, drinking your coffee and orange juice, etc.

Some good things came from that meeting, because holding a meeting for—I think there were over six thousand people in Baltimore, [Maryland], as reported at the annual meeting, Thursday, I think it was. And managing that number of people well and safely takes a lot of skill and knowledge. So it was important.

GRAYSON: So there were some ideas that came out of the ad hoc committee that were adopted?

MARCH: Yes.

GRAYSON: I think ASMS is open to ideas, and you know, continue to be a viable—

MARCH: Yes. Well, I'm hoping, because I went on Thursday—this year, in Baltimore, I went to a workshop. I rarely go to the workshops, because I don't think they work terribly well. Anyway, I went to the workshop, and it was entitled something like, "Is the Time of the Quadrupole Ion Trap Past?" So I thought, "Oh, I'm going to go, and this will be great entertainment." So I had a free beer at the business meeting and then went to this workshop afterwards. Well, I was horrified. **<T: 15 min>** There was a little presentation by three people, which was really not very much at all, and then comments and questions. People were just asking questions about it. They wanted to know what is this mass range—the frequencies here, and this, and what about the diagram, and have you done this with traps? They just want to know knowledge, experimental knowledge about the traps. So eventually I got up and said, "You know, John Todd and I have produced seven ion trap books. We didn't just do it for fun. We did it to try to tell everyone about ion traps, not just our work, but about thirty-six laboratories contributed. And we didn't just take their papers." You know, there are some compendiums, like the first one by, [Fred] McLafferty he published *Tandem Mass Spectrometry*.[9] It's dreadful.

GRAYSON: Oh, McLafferty?

MARCH: Yes. McLafferty. The font is different for the various chapters. There are mistakes. I mean, they just simply put ten chapters together and published it.[10] I said, "Each chapter here has been scrutinized and edited by both of us until we agree, so that they're readily comprehensible, and the style is consistent throughout the entire book." And I said, "And clearly, not too many people here have availed themselves of that opportunity. Could I ask, how many people have read John Sykes?" And John Sykes was sitting there. And here is John. "How many people have read his chapter on the commercialization of the ion trap?" I said, "It's a fascinating story. How many people have—" Eight. "Of which I was one, John was one, and Rick Yost from Florida was another.[11]

GRAYSON: Yost?

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[9] Fred W. McLafferty, *Tandem Mass Spectrometry*. 1st ed. (New York, New York: Wiley, 1983). Fred W. McLafferty, interview with Michael Grayson at Cornell University Ithaca, New York, 22 and 23 2007. (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0352).
[10] R.E. March and R.J. Hughes with an historical review by J.F.J. Todd, Q*uadrupole Storage Mass Spectrometry Chemical Analysis Series*, vol. 102. (New York: John Wiley, 1989).
[11]John E.P. Syka, "Commercialization of the Quadrupole Ion Trap," chap. 4, in *Practical Aspects of Ion Trap Mass Spectrometry: Fundamentals* ed. R.E. March and J.F.J. Todd, vol. 1 (Boca Raton, FL: CRC Press, 1995).

MARCH: Rick [Richard] Yost was another. So there were only five people not associated with the book who had read the damn chapter. I said, "Let me ask you one more question. Vern [Vernon] Reinhold, wrote an absolutely splendid chapter on using MS to the seventh to determine the structure of essentially sugar complexes." "How many people have read that?" Three. Rick, myself, and one other guy I didn't know. Now I'd heard at the meeting that in the war chest of ASMS there was two million dollars sitting there. And so I wrote to Jennifer [Brodbelt]. Jennifer and I wrote an article on mass spectrometry and NMR [nuclear magnetic resonance], a paper, but a long one, some time ago, and she has contributed at least three chapters to these books [that John Todd and I have edited.][12]

GRAYSON: This is Brodbelt?

MARCH: Jennifer Brodbelt, who is now president, posting a question, "Can we not approach the publishers and attempt to get a much better deal, perhaps"—what's the word I'm looking for, ASMS supporting it with funds? What's the word? Not substituting. Not—underwriting or something. But contributing. Anyway, to the overall cost of to make these publications more available to our membership. And so I sent it off to her, and there two other people. There's one is publications, one is education, so I sent it to the three of them. And Jennifer said it's under consideration, so there we are.

It's the—gosh, I keep forgetting all my names. Who is the guy who wrote about *Oliver Twist*? *Oliver Twist*. *Oliver Twist*.[13] The villain in *Oliver Twist* was somebody called Sykes, Bill Sykes. Bill Sykes was the—so I've got the seven books behind you, plus one in Portuguese. And John Syka has a chapter there, and Vern's there. But it is a real shame, but—

GRAYSON: So basically, you're saying that the workshop where people were trying to learn, rather than—you know, it wasn't the equals talking about experiments. It was trying to help each other along, but it's more or less people who hadn't used traps wanting to learn about them, or learn more?

MARCH: Or perhaps had one and wanted to know more about trying to **<T: 20 min>** understand it.

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[12] R.E. March, R. and J.A. Brodbelt, "Analysis of flavonoids: Tandem mass spectrometry, computational methods, and NMR," *Journal of Mass Spectrometry* 43, no. 12 (2008): 1581-1617.
[13] Charles Dickens, *Oliver Twist* (London: Richard Bentley, 1938).

GRAYSON: [Yes]. Well, maybe you got some book sales out of it.

MARCH: Well, maybe a few. A few wasn't the objective. The first book was written really to say Peter Dawson's book exists, and it's there.[14] It's not easy for the novice to understand. The chapters are all different, by different sets of authors, and no attempt has been made to bring them into a coherent book. They have different styles, and so on.

But here is one that covers the materials of Dawson's book, and since Dawson's book was published in '74, I think, and ours came out in '89, [ours covers] the work since '74, and the arrival of the first commercial instruments, and so introducing them. And what work has been done by others in this field, on atomic clocks, for example, or in France. And so it was really quite a nice book, and it was well received, and that was successful. But it's not being picked by [newcomers to the field]—we know from the sales that it's not being picked up. It's been reprinted, but it's not being picked up by newcomers coming in.

And we discussed quadrupole ion traps, plus the quadrupole rod sets acting as linear ion traps, as quadrupole mass filters, and as transmission rods, because they really pinch in the beam of ions, so that you can get the ions through a much smaller whole, which reduces the pumping requirements.

[There is a] decreased cost and [improvements in the sensitivity associated directly with reduction in pumping requirements]. They're all linked. And then you have Mathieu's diagrams, stability diagrams, which were a real problem for people in mass spectrometry, teaching mass spectrometry, who were forty or older when the ion traps first came out. That's about 1970, '72. Only Graham Cooks, as being fairly well established [at that time, 1989], made an attempt. All of the other people, whether that's Rick [Yost] or [Scott] McLuckey's friend, Gary?

GRAYSON: Glish.

MARCH: Glish. They were all younger, you see, and so they took to it like duck to water. And the stability diagram was no challenge, but that stability diagram, you know the one I mean, this one?

Yes? That was an activation energy [barrier] to the understanding of quad—for a huge number of mass spectrometrists. Anyone who was born 1930 or before, it's true. Yes. And some even after. Yes. It was totally different from transmission through magnetic and electrostatic sectors. It was a little like ICR [ion cyclotron resonance]. There [were] some great similarities,

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[14] P.H. Dawson, *Quadrupole Mass Spectrometry and Its Applications*, 1st ed. (New York: Elsevier Scientific Publishing, 1976).

the frequency, etc., with ICR, but that was relatively few people—there were few people in France, Rose Marx [at l'Université Paris Sud in Orsay], and then there were [a few] people in the States, who had ICR. I used to always be at the end of the ICR session. [laughter]

[In the ICR sessions at ASMS, there were a number of ICR talks then, to end the session, there was a quadrupole ion trap talk], so I know a lot about ICR. Who did the first Fourier transform? [One] was the guy who is down in Florida now, they were both at UBC [The University of British Columbia]. It's gone. They were both at UBC at the time, but there was a Canadian who used to do ICR. Anyway, that's the end of that. [Alan G. Marshall and Melvin B. Comisarow].

GRAYSON: So I need to back up to let's go back to the beginnings of Trent. You had duties in the teaching end of the world, right?

MARCH: Yes.

GRAYSON: Did you have any duties in that regard when you were at McGill? McGill?

MARCH: Yes. Yes. I started out, because two things had happened to Schiff. **<T: 25 min>** One, he had accepted an appointment [as dean of York University] two years before I left [McGill;] York University is north of Toronto, by the airport. So he was at McGill, and he accepted this position at the new campus of York University. And so he would spend, you know, one week there, one week at McGill. Traveled back and forth, all sorts of combinations. And so that went on for quite some time, and then in the winter he broke his leg skiing, so I got a call one Sunday night, "Ray, I have a lecture, such and such tomorrow. It's chemistry 200-something. They're doing this. Can you stand in for me?" About three hundred students.

Now fortunately, I had been asked to do an evening class at Loyola University, Loyola College, so it's part of a bigger university [Concordia University] now. Loyola College in Montreal was a religious institution.

GRAYSON: Sounds Jesuit.

MARCH: Yes. It no longer exists as such. But I was asked if I would do that, and these were people who were really keen, about a dozen, eighteen perhaps, and it was a great joy teaching physical chemistry. So I was doing that. I wasn't without any teaching skills at all. So I started lecturing the class. And so, of course, his leg didn't repair itself in a few days. He had the damned thing in a cast for several weeks, six or seven weeks. So I had that experience of teaching.

GRAYSON: But you were called in to cover for him, but did you have any requirements to teach independently?

MARCH: No. No. Other than Loyola, no.

GRAYSON: Okay. But you did have when you got to Trent?

MARCH: Oh, yes.

GRAYSON: You were required to be a faculty teacher as a—so it was physical chemistry, or organic, or—

MARCH: First year chemistry, because we only had the first and second year [classes]. So I did part of first year chemistry, and then we had a second year physical, and I was developing and constructing the experiments for this course. That takes some time doing. But it was all exciting stuff, and—

GRAYSON: And class size with Trent when you start out was how big?

MARCH: Oh, well, the first year chemistry would be about forty, and the physical chemistry, perhaps no more than half of that.

GRAYSON: I guess most of the kids would be local? If you're starting up, I mean, it's somewhat of a risk for the kid, too, to go to a startup school like this.

MARCH: Well, it had a bimodal distribution. There were the local people, for whom the university was created, and the local GE here, General Electric [Company], almost every employee promised to give a certain percentage of his salary for the first two years of the university. Now it may have been twenty-five cents a week, because this was 1963, you see. That's thirteen bucks per person. It all amounts up. And they were all interested in Trent. They wanted it to succeed. And so the response of the workers from GE was really quite extraordinary. So that was very good. So we had people locally. We also had some Champlain scholarships. I think three or four of them—Champlain was a French explorer who had travelled through this valley about almost six hundred years ago. In fifteen hundred and something. So we had [a small number of scholarships commemorating Champlain's voyage of discovery]. And then we had a few other scholarships, and a few came just because they were curious. Lord, this is going to be really good fun, just one hundred students and twenty professors. You know, let's try it. You're not going to lose from an experience like that.

But we got this [wonderful student], Barbara Finlayson, from Ottawa. She was the student who came in with the highest standing of any student at that time, and it remained so for many years, if not still. And she maintained this Champlain scholarship for four years, and **<T: 30 min>** she went out, and I was talking by email yesterday with her on the arrangements for her to pay back—her husband has just died, and she is now approaching retirement age, and she wants to make arrangements for paying back a large part of that, and would that be good?

So I was arguing, and I think this is true, that if you have scholarships for good students, the good students benefit from the financial support, they come to the university, and the average to less than average students benefit from their presence. If you took away the top twenty percent, academic, of your students, you'd have a very different student body. And the students meet with these good students in lectures, tutorials, seminars, and residence, on the bus, wherever, and they know that it's possible for someone their age to work and perform at a much higher level.

It's inspiring. A university that doesn't have a fourth year can't hope to be as good as one that did, because the fourth year gets into research. And then if you really want your research year to be good, you've got to have a master's program above it, so that those people see what people are doing when they're full time at research, rather than just doing one or two course credits for research.

So we had this group that were attracted because of curiosity and scholarships, and recommendations from their counselors, perhaps. This is worth—so they came to us from Africa, Bermuda, Ottawa, India, there's one, Germany, from a number of countries. We had quite an international gathering. I think there were one hundred four students.

GRAYSON: At the beginning?

MARCH: First year. Yes.

GRAYSON: Now what is the student body today?

MARCH: Students, just over eight thousand.

GRAYSON: Okay.

MARCH: We have forty-four thousand alumni now.

GRAYSON: Okay. And so originally, you probably didn't start granting graduate degrees until a while.

MARCH: Sixty-three—so sorry, '64, '65, '66, '67. That was a three-year degree. And then '68 was the first honors degree. And we also had one or two PhDs, students who had come with faculty members from other universities.

GRAYSON: Okay. So it was a building-up process over a period of a decade to get to where you thought you had a really proper running university with regard to class sizes and programs and everything else?

MARCH: Yes.

GRAYSON: It took some time.

MARCH: And Senate, practicing Senate, and a faculty association, rules, eventually a union, to get the place organized. Otherwise, you'll find somebody will come in and try to run it as though their grandfather had owned it. That's the worst. And when we had a union, people regretted the necessity to have a union. We formed a union because one of the presidents went back on his word.

He had agreed about something, and went back on it, and said, "I can't do that." So the union came in, and it's been much fairer. If you have rules and procedures and agreements to which you have to keep, rather than the oddities and inequities of individual decisions and so on. It makes for a much better organization. Yes.

GRAYSON: So then you're trying to get a research program going.

MARCH: Yes.

GRAYSON: And you started at Trent in 1965. So according to my notes here, you didn't publish a whole lot in that early period, until you started getting interested in—

MARCH: No, there was my PhD thesis essentially was published, I think '63.[15] That was in the Royal Society with Polanyi. And then I did collaborate—using the facilities at York University, because I knew several of the people there, I traveled from Peterborough to York and did some work there, just outside Toronto. And I got an old pumping apparatus and did some experiments at Trent, here, on lifetimes of excited species in the atmosphere. And then eventually I got **<T: 35 min>** through to the first sabbatical, then started heating with gas.

GRAYSON: That was—get that chart, and trying to get number of pubs against kind of—so we can see how it kind of swings. It starts out kind of slow, but then it gets going under full gear, and about the time you started getting into the mass spec side of things.

MARCH: Yes.

GRAYSON: So really, I mean, your early part of your career, mass spec was not part of your experience, at the very early part?

MARCH: No.

GRAYSON: It was later—it wasn't until the ion trap things came along that you—

MARCH: No, it wasn't until 1972, '73, in here, that I went to France, and learned about magnetic and electrostatic sectors.

GRAYSON: France was—that was a sabbatical, or—

MARCH: Yes. And then at the end of that sabbatical, at the beginning, I read about the ion trap in *Chemistry in Britain*, and realized it was Todd, and there's a photograph taken I think 1955, outside the chemistry department, and Todd and I are in that.

GRAYSON: Okay. So you ran into him again?

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[15] R.E. March and J.C. Polanyi, "Photolysis by pulsed illumination," *Proceedings Royal Society of London* A273 (1963): 360-371.

MARCH: And in ’55, that’s fifty-nine years ago. So that was when I went to learn mass spectrometry, and then the ion trap, and came back, then built an ion trap apparatus, and then we took off through this period of about ’76 to ’77, through here. And then this was quite good, and this was very nice. This is when Varian [Medical Systems] got involved. And then I retired in 1999.

GRAYSON: It doesn’t look like it from the graph. So I have a question, though. Why did you decide on the sabbatical, you had the choice of places go to?

MARCH: Can you just get—reach that for me? Just to put it on that bound book—that’s it.

GRAYSON: I don’t know if I can get it over there.

MARCH: There, that’s up to ’98. This was prepared to support a petition for a Doctor of Science degree at Leeds. So that takes us up to here, and I think there are seventeen publications after that. Something like seventy-seven after that. I’m not too sure. Anyway, it’s not important now. So what was your question?

GRAYSON: Why did you decide—you have to select some place to go. What was the motivating factor to go to this place where you learned about mass spec?

MARCH: I was very touched when we were opening or laying the cornerstone for a major college at Trent. The campus was just empty. I mean, it was just fields. And we laid the cornerstone, and we had two premiers, Premier [John P.] Robarts from Ontario, and Premier Jean Lesage from Québec.

GRAYSON: And they were there for this event?

MARCH: For the laying of the cornerstone of Champlain College. Champlain, of course, was the great French explorer, and this was in Ontario, so we had to have both premiers there. And so I’m sure Robarts gave a rousing talk, and inspirational, etcetera, except I can’t honestly remember a single word of it. He was a fine fellow, a fine premier, etc., and I just can’t remember a word. Jean Lesage was just delighted to be there. He **<T: 40 min>** was in Québec, and difficult to get out. You know, if you were too friendly with the English, that was a stroke against you.

GRAYSON: Mm-hmm. Like being too friendly with [President Barack] Obama.

MARCH: It's like being too—exactly. Exactly. Yes. Your Obama is our French-Canadian fellow. Our situation is worse, because it's more difficult to distinguish, until they open their mouth. [laughter] But he said that he was glad to be here. He said, "When I come to English Canada, people often ask me, 'Jean, what is it that you French guys want?'" And he said, "Do you know what I say? I reply, 'What is that you English guys don't want us to have?" [laughter] And of course that summed up, you know, the referendum in Scotland, everywhere where there is disharmony, and you can't get an agreement, what do they want? What are we not willing to give them.

Yes. Not willing to give equality. You know, this, that, and the other. Very good. And so that meant that I should really pay more attention. I had lived in a French ambience, a French town, Montreal, and so I thought, I'll go back and learn a little more of the basic French, not just the language, but the understanding of the people, and I'll try to go to France. And I knew that Orsay was a very good. It's part of the Université de Paris-Sud, the sort of south end of Paris, [France]. And there was someone doing mass spectrometry. The French weren't so interested in the technique. They were doing ion-neutral interactions. They referred to the physics or the chemistry, not the interactions.

GRAYSON: So you decided then to go to Orsay, and then how long was that for?

MARCH: A year.

GRAYSON: That gives you a chance to do something.

MARCH: Yes.

GRAYSON: And that's where mass spectrometry became—where you really got your first serious exposure to mass spec.

MARCH: Yes. To ionization, to the control of trajectories, to mass resolution, different types of mass selecting devices, detectors, and the understanding of what's happening from—from all the signals, signal averaging, all of these techniques that are so necessary, for a really very, very simple reaction. I can tell you, very similar, let's take H^+, that's a hydrogen atom [less an electron: a proton, it is called]. My grandchildren all know what a proton is.

GRAYSON: Oh, really?

MARCH: Yes, because I tell them the story of the hydrogen atom that was crying in the street, in Peterborough, downtown, just near where we were for lunch. And another hydrogen atom came along and said, “Goodness gracious, my friend, what on earth’s the matter?” And he said, “Oh,” he said, "I’ve lost an electron.” And the second hydrogen atom said, “Well, are you sure?” “Oh, I’m positive.” [laughter] See, he’s positive, yes. Now the grandchildren all like that. And if we have—

GRAYSON: They all know what a proton is?

MARCH: Yes. Protons are very important.

GRAYSON: I’ll have to remember that. That’s—

MARCH: Well, you try changing a proton, a deuteron for a proton, and your life will stop.

GRAYSON: Oh, really?

MARCH: Oh, yes. Heavy water will not support life, as does ordinary water. Yes. If I kept feeding you with heavy water for a week, you would die.

GRAYSON: Oh, really?

MARCH: Yes.

GRAYSON: Just for a week?

MARCH: As long as I do a substantial replacement of the—it’s because the energy of—well, they can tunnel. Protons can tunnel through an activation barrier, and deuterons may not.

GRAYSON: So a lot of chemistry is going to be halted.

MARCH: Yes. Goldfish will die in about thirty-five percent heavy water.

GRAYSON: Oh, that's interesting.

MARCH: Yes.

GRAYSON: I'll have to tell my granddaughter that.

MARCH: Yes. [So this experiment in France involved the formation of protons, that is H^+, that were accelerated to a kinetic energy of about 1500 eV and directed into a collision chamber where they collided with atoms, such as xenon, or molecules such as N_2, O_2, CO, and NO. So we could say H^+ plus Xe or molecules AB (heteronuclear) and A_2 (homonuclear) give H^-, which has gained 2 electrons, plus, for example, N_2^{++}, which has lost 2 electrons]. H plus let's say A_2. H plus A_2. Now what do you think can happen here? Well, the one of real interest is for this [proton, H^+], to go to H^-, **<T: 45 min>** and this of course being N_2 and losing two electrons to go to N_2^{2+}. So doing it—an actual case, H^+ plus N_2 gives H^- plus N_2^{++}. And [possibly form N_2^{2+*} that is electronically excited, as indicated by the * symbol]. So you can then examine—[emission of light from N_2^{2+*}] and so [the product ion] will drop down to two plus, star prime, [N_2^{2+}. When the diatomic molecule is heteronuclear, a vibrational quantum can be lost resulting in the emission of infrared as this transition] is allowed. And you can then tell the states, the doubly charged states of ions, and then that can fit in with CO^{++}, and O_2^{++}, and NO^{++}, and so on. So you look at a whole number of product ions which have the same electron content. So that was the—so it was called double charge transfer.

GRAYSON: And this was what you were going to study when you went to Orsay?

MARCH: And that's what I studying at Orsay. Yes. With [Jean] Durup and his group.

GRAYSON: And so who funded this trip for a year abroad? That was Trent?

MARCH: It was the last year of a very good scheme. That is, if an academic went on sabbatical leave and stayed away from Canada for three hundred sixty-six days, they would not pay income tax for income drawn during that period.

GRAYSON: Oh. Leave the country and not have to pay tax?

MARCH: Had to be an academic, leave the country for that period, continuously, and could be paid their normal salary, but they would not pay any income tax for that period. The tax excused would help pay for the voyage and expenses and so on of taking a family. It was the last year [of this scheme].

GRAYSON: It was promoting people to leave the country?

MARCH: Yes. It was promoting—well, to go abroad and get knowledge and come back. So they said they were going to wipe it out at the end of '72. So the university paid me twice as much for the second half of '72. I got my full year's salary during that period, and didn't pay tax on it. And then the scheme died. So now the poor souls have got—[. . .]

GRAYSON: So they pulled the plug on that deal. That's too bad.

MARCH: Yes. It had a positive objective, and I don't think it could be abused, because people had to get leave, you know, permission to leave. Otherwise, they wouldn't have been paid their salary. So it had to be a university-approved leave to wherever they were going and what they were going to do, because you've always got to write, you know, an application. There's a system whereby you get a sabbatical leave, but it's not automatic. You have to justify that. So I thought it was shortsightedness [to curtail the scheme].

GRAYSON: But you were able to take advantage of it.

MARCH: Yes. So went to France, and this was a good thing to do, and that's what we did.

GRAYSON: And so, like you say, your mass spec experience started with that whole leave.

MARCH: Yes, but I had known a little about mass spec, because during my graduate work at U of T, I had sent some samples to Fred Lossing. Fred Lossing was—John Holmes will tell you about Fred Lossing. He's the father of mass spectrometry in Canada, although actually I think the fellow [Harry G. Thode], President at McMaster [University] was probably older.[16] So he had some samples, so I had to discuss those. And then, of course, the two years before I left Toronto, Alex Harrison arrived as a new professor.[17] And Alex is quiet, but nevertheless, I learned something. And **<T: 50 min>** then later, in the 1980s, you know, we got together, he and I and Bob [Robert] Boyd, and got money for a ZAB-Q. The first ZAB-Q to be made. A ZAB-Q was a reverse geometry instrument. With a quadrupole at the end. Yes. So it was a BEQQ; [that is magnetic field followed by an electric field followed by a quadrupole collision cell and, finally a quadrupole mass filter. Yes. Like that. With a maximum acceleration voltage of eight thousand volts].

GRAYSON: Oh, okay. You had to slow those puppies down before you send them to Q.

MARCH: Ah, that was the challenge that Waters wanted to work on. Yes. So we got a reconditioned ZAB with a new QQ added onto it.

GRAYSON: Oh, okay. So there were two Qs at the end?

MARCH: Yes. One was a quadrupole collision cell, and the other is the quadrupole mass filter.

GRAYSON: Yes. So that was after you came back from France?

MARCH: Yes. That was ten years later.

GRAYSON: And that machine was placed where?

MARCH: Toronto.

GRAYSON: But you helped get money for it?

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[16] John L. Holmes, interview with Michael Grayson at University of Ottawa, Ottawa, Canada, 12 December 2013 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0906, in process).
[17] Alex G. Harrison, interview with Michael Grayson at University of Toronto, Toronto, Ontario, 12 November 2013 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0905, in process).

MARCH: Yes. Yes. Bob Boyd at Guelph, myself at Trent, and Alex were all applicants on the proposal.

GRAYSON: And you got time on the instrument when it was installed?

MARCH: Yes.

GRAYSON: Okay. So you had to go over to Toronto to use it, right?

MARCH: Yes. But Alex was a splendid fellow, always helpful, always seemed to have time to help.

GRAYSON: Good. Okay. So let's see. You've now—this would have been how many—five years after you had started at Trent?

MARCH: So I'm now into the end of the sabbatical, came with a short visit to Canterbury at the end of my sabbatical, and that would bring me to the end of eight years at Trent.

GRAYSON: Okay. And you're pretty well established—you're still teaching, though, right?

MARCH: Oh, yes.

GRAYSON: But you've got a research group going?

MARCH: Yes.

GRAYSON: And they're studying what?

MARCH: Well, building the quadrupole ion trap, and electronics.

GRAYSON: Okay. So why did you get into the trap—there's a lot of people picked up on the linear quads, [linear quadrupole mass filter, not 2D-linear ion trap] and what was going on with them, but you got interested in the trap?

MARCH: Well, I had a linear quadrupole mass filter, and we were doing some work with Waters. First of all, 100, and then a 400 QXK [mass filters], something like that. One hundred range and a 400 mass range. And we were able to do some work with that, but we were building the ion trap, and we didn't know how to get the ions out mass selectively, or to measure the mass-to-charge ratio, so we ejected them into a quadrupole mass filter. So we had a QUISTOR [QUadrupole Ion STORe] quad operation. And we had to build the power supplies, and get it all together. We had a big oscilloscope with four channels, because—

GRAYSON: Now the quad was just transporting the ions away. The QUISTOR was doing the mass separation.

MARCH: It was doing the storage and manipulation of the trajectories. Yes. And then we could eject them all together. We could eject them with frequencies, but we did little of that. We'd eject them as a group, and they would be filtered by the quadrupole mass filter. So this was repetitive of filling, ejection, and the quadrupole mass filter would be moved along, as it was scanning, slowly scanning the mass spectrum.

GRAYSON: Okay. And in your quad?

MARCH: Yes.

GRAYSON: Right. So the trap was just a place to store ions and play with them in a storage—

MARCH: That's right. Yes. Of course, when I first saw it, I thought, it's like a test tube, with, you know, one cubic centimeter in the test tube. And we had done, you know, tests with—analytical chemistry with test-tube chemistry, when I went through, you know. In school, all sorts of colors and fizzes and precipitates, whether it be barium sulfate or silver chloride, whatever, or nickel dimethylglyoxime, a beautiful pink precipitate, very characteristic.

So **<T: 55 min>** here we had the ion trap volume, but no solvent. We could add solvent molecules if we wished, or not. We could study the ions themselves. Not hydrated, not complexed, just the straight ions. And we could, as we discovered, begin to affect their trajectories. We could focus them all in by putting in a little background gas and get to a cloud. We could then pass a laser through there if we wanted. Or we could then play the organ, dee

dee, apply about ten frequencies, you see, and ten species would start moving outwards. Or just one species would move outwards with one frequency. We could eject one species, and see how the others changed. We could eject one and then see at what frequency the next one went out, or we could reverse that and see if the density, that is, the space charge, had any influence on the frequency at which the ions were ejected. Of course, it did. There are effects of space charge. And so we got—

So there are lots of—and we could try to find out [the locations of] the ions in the trap, and if you haven't focused them at the center, how are they distributed in the trap?

GRAYSON: So it's just really understanding everything that was going on with respect to the quadrupole ion trap?

MARCH: That's right. And I had one fellow who was really very good. He would do experiments, and it would tell him something, and we would argue about it, and discuss it, and that was a fellow called John Fulford, and I'm sure you've never heard of him. [. . .]

GRAYSON: No. Okay. So what happened to John?

MARCH: He left me. He graduated from Trent, and he didn't do a research project with me. Did a research project with a colleague, so I didn't see him. So I thought, oh, John's gone. I don't know what he's doing. I wrote him a letter. These are the days, you write the letters.

He's down at the lake shore, [Port Hope], thirty miles away. I wrote him a letter. Lo, a reply came back. I had said, "You know, let me know what you're doing, and if you're not doing [anything], come up [to Trent], and I'll show you what we're doing in our lab, and see if we can interest you." [He replied], "Yes, I'll come up, and I'm not doing anything. Can I come and see your lab?" "Yes." So he came up, and he did a master's with me. So he did this work, and then he left me and went with SCIEX.

And then just a few weeks after this, there was what we call the Mississauga, [Ontario], disaster, and there was a train derailment just north of Toronto. There was styrene and chlorine released. And they started to react. A quarter of a million people were evacuated from Mississauga. It was a day a bit like today, clear blue skies, with a north wind blowing. Unfortunately, the wind blew [the chemical mixture] straight over Mississauga and into Lake Ontario. And John was with two other guys in a converted house trailer, driving around Mississauga, totally deserted apart from some soldiers, using a quadrupole mass filter to try to analyze what's happening, what's up there, and what's happening to it. So that was the training he had, and with masks on, of course. That was the training that he had in my laboratory for that.

He retired last year, vice president [at SCIEX]. He did a lot of work on the Elan, type of ion cyclotron resonance instrument. No, no. The ion inductively-coupled plasma, ICP [inductively coupled plasma]. That was the name of the instrument. It was elemental analysis, you see, for ICP. So the value of this training, that he really became very competent, very confident, and remained a productive fellow. Never got a PhD, and never felt the lack of it. No. No. One of his colleagues was a chap called Ron [Ronald] Bonner, and Ron Bonner had a PhD, but he was also a vice president at the same time. Ron Bonner was a student when I went to Canterbury in **<T: 60 min>** 1973, at the end of my sabbatical. Then Ron came to Trent a couple of years later, when he finished his degree, and worked here. And then went to the Ministry of Environment, then went to Rockefeller University with Frank Field, and of course, Brian Chait. [18]And Frank Field and Brian, they used to send me their electron multipliers. When the sensitivity had dropped down to about ten to the sixth, they sent them to me because I couldn't afford to buy anymore, and—

So a tremendous amount of cooperation from them. But that was Dr. Ron Bonner. And he, as I say, was retired last year also, and we are still collaborating with Ron. We have a project now on the emerald ash borer, and we are using principal component analysis, and Ron has quite some experience in this area, and so he's collaborating with us. So I've known Ron for a little over [forty] years, forty-two years.

GRAYSON: Oh, my type skills are getting down here. Okay. So this takes care of having gone abroad and coming back to Trent, and now you're really into the ion trap.

MARCH: Yes.

GRAYSON: And so you've—that's been a theme pretty much since then until now, is the ion trap.

MARCH: That was '73,'74, when we got it going. There was the time in the middle eighties when we had the ZAB-Q at Toronto, worked on that with a number of students. And then that would take us up to about 1991, and that's when Varian—of course, there was the commercialization of the ion trap. I had another student—gosh, I had a picture of this. This is not a very good photograph. Mel [Melvin] Comisarow. Does that name mean anything to you?

GRAYSON: [Yes]. Mel? Yes. He was here?

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[18] Frank H. Field, interview with Michael A. Grayson at Durham, North Carolina, 9 and 10 December 2009 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0636).

MARCH: Only for a brief visit. Mel Comisarow, and who was the big—I've forgotten the name of the big fellow that runs the NMR at Tallahassee, [Florida]. Oh, what's his name?

GRAYSON: You're not talking the high field?

MARCH: Yes.

GRAYSON: But that's in mass spec?

MARCH: Yes. Marshall.

GRAYSON: Alan Marshall.

MARCH: Marshall. Marshall and Comisarow did the first Fourier transform on ICR mass spectrum, and from frequency, and produced it as a function of mass to charge ratio. They did it by hand. And that is Mel Comisarow. This was an early conference at Trent called the Trent Conferences, which still goes. I think it's continuous since 1977 to the present day. And you can't see—this is a very poor print. But this face here, that's John Fulford, and this is a young girl called Allison McLellan, as she was before she married. And they were here at the same time. Ron Bonner had his parents here, and so he wasn't at the conference. But this is Trent University. So this—

GRAYSON: So Comisarow and Marshall did this experiment here?

MARCH: No. No. At UBC.

GRAYSON: UBC?

MARCH: Yes.

GRAYSON: Okay. That would have been 1970—

MARCH: When they did it? Oh, I don't know. Could you pass me the bottom book, and I can perhaps look it up.

GRAYSON: You would want the one at the bottom.

MARCH: Just the bottom. Yes. I'm sorry. Just push the others off. Thank you. Let me just see if I—oh, yes. **<T: 65 min>** Oh, it's going to take too much time to go through. I don't have the—the file here. I don't have the file. What is this—

GRAYSON: Well, I'm sure it's easy enough to find in the literature.

MARCH: Yes. Comisarow and Marshall, or Marshall and Comisarow. Anyway, the girl wanted to do—this is Allison McLellan, and her father still lives just up here, and she still teaches in Peterborough, and she's now Allison Armitage, has four children. I said, "Allison, what I'd like to do is we have this GC here. We can do with the ion trap electron impact mass spectrum, and we can also delay things we get as chemical ionization mass spectrum, one very rapidly after the other, and what I'd like to do is to use this gas chromatograph and to put in some simple compounds and see how they come out, and the target is to put in say four compounds, and obtain the EI [electron ionization] and CI [chemical ionization] mass spectra of each of those four compounds, separated in time. "That was her thesis problem. So she did it, and I took it to Seattle, [Washington], and I showed it, and I also had an ion trap like one of those in my pocket. Which Burnaby Munson found me showing to somebody, and he was furious.[19]

GRAYSON: Yes, yes, yes.

MARCH: You can understand why. Yes, not supposed to do it. I said, "With my home mass spectrometer. You see, I put it in my pocket. Can you do that with yours?" [laughter] Anyway, along came Paul Kelley and George Stafford.

GRAYSON: Oh, okay.

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[19] Barnaby Munson, interview with Michael Grayson at University of Delaware, Newark, Delaware, 9 April 2010 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0688).

MARCH: George Stafford, Jr. And they said, "Well, that's really pretty, doing the EI and the CI mass spectra, and you separated those. But the way you're measuring the mass spectra with a quadrupole mass filter, that's—I mean, the ion trap is great, and you need it, but the—there's got to be a better way of doing it." So this was 1979, and they went off, and of course, in 1983, announced in Washington, [District of Columbia] that they had discovered the [ion trap detector, ITD].

Which was a gas chromatograph, an ion trap—that is, a quadrupole ion trap—a computer, and a new way of ejecting the ions. It was axially—the axial—oh, dear, I've forgotten the phrase. What they did was they—oh, it's gone. They brought the ion essentially close to the center, and then increased the voltage on the device, and that moves everything to the right hand side of the [stability diagram]—all the ions are here, where this is a little one, that's one, this is two, this is three, this is four, and this is five, and so if you increase the RF [radio frequency] voltage, then they will all move to the right in this [stability] diagram, and at this point, they will leave. And they happen to leave with a lot of axial energy. This is on the axis of the trap. They'll leave with high axial energy. And they will go and hit a detector, no problem. And so all they had to do was to ramp the RF voltage and the ions would come out and generate **<T: 70 min>** a mass spectrum.

[Mass selective axial instability]. Anyway, that was it. So with a computer, of course, they were able to do the whole thing, handle the data, because you get lots of data. And that was the ITD. And then there was the ITMS (ion trap mass spectrometer), the commercial one, which they did more clever things with frequencies. When they sold the ITD, they sold it with DC [direct current] power supplies; these power supplies were never used, because the ions, the working points of the ions in the ITD always stayed on the q_z-axis.

And to get off this way or that way, this required negative DC, and this required positive DC. So when I became the research lab for Varian, we had these [DC power supplies], and so we began to explore, and so we could move ions up to here, and up to there, and down to here, and get to the boundary, and then we had a pattern for that, and so on, so all sorts of things you could do. But that became quite a powerful little instrument.

GRAYSON: [Yes]. It was very compact.

MARCH: Oh, very compact. Yes. Not much bigger than twice the size of that little cabinet there, with the things in it.

GRAYSON: [Yes]. There's one point that I happened to notice here, and we're talking about quadrupoles, but we mentioned GE, and so I thought that were you aware that GE once commercially sold the monopole?

MARCH: Sorry, did—

GRAYSON: GE once had a commercial product called a monopole?

MARCH: A monopole? Yes.

GRAYSON: [Yes]. They went with that for a few years, and I guess they figured out the market wasn't going to work out.

MARCH: No, it wasn't very good, had a very limited range.

GRAYSON: I can understand how the ions—well, what's going on inside a quad, but the quadrupole, with a monopole, you're going to limit your ability to get them—you're reflecting the fields, but the ions are going to run into the quadrupole.

MARCH: Yes, the monopole was something like—

GRAYSON: Like an L shaped thing with one single quad or a single rod.

MARCH: Like this with a single rod in here. Yes. And this was at a certain voltage, or varied voltages. What you had to do was to aim. You couldn't admit the ions here. You had to aim the ions over here. And so they were bent round, and then came out over here. And they did a little—no, they didn't. They didn't because this was—it was a monopole, but I don't think there was any RF associated with it.

GRAYSON: Oh, really?

MARCH: I think it was all DC. I may be wrong, but I don't remember seeing anything with, you know, this type of trajectory. But there may have been.

GRAYSON: Interesting. Another idea of many that didn't fly after all. So you're really into traps now, as kind of your primary research topic.

MARCH: Yes. Once I retired, I really finished with the ion trap instruments that I had, because the Water Quality Centre started. I was instrumental in starting the Water Quality Centre at Trent. We started with the Trent University Institute of Mass Spectrometry, TUIMS; TUIMS, Trent University Institute for Mass Spectrometry, and then shortly after that, perhaps three years after that, CFI started, this Canadian Foundation for Innovation. And CFI would give you forty percent of the price of a new instrument, and the Ontario government agreed it would also give forty percent, so the university or the recipients had to find twenty percent, and **<T: 75 min>** that has continued.

So with the Water Quality—with that program, this was too vague a title. So we then set up the Water Quality Centre, talking of all aspects of water, both the purification of water systems for towns and villages, water disinfection, soiled water handling, and also future problems of mercury in water, heavy metals in water, arsenic in water, sulfur in water, now nano particles. A lot of flavonoids—flavonoids, for example, make up two percent of all the organic growth each year.

GRAYSON: Really?

MARCH: And—yes. And leaves and things, when they decompose. Flavonoids get into the water, so I started out looking at flavonoids, mass spec, and NMR, flavonoids and the glycosides, some work on antibiotics. The antibiotics were interesting, because that really led to some work on mad cow disease. Keith Jennings was quite heavily involved with chasing prions in connection with mad cow disease in Britain. And they found that feeding cows parts of cows was not a good idea.

GRAYSON: [Yes]. I guess that's accepted science. I think for a while the whole idea of these tangled structures was kind of not accepted by the community for some time, if I recall correctly.

MARCH: Yes.

GRAYSON: The guy who came up with it was ridiculed for some time, especially misfolding of proteins, right? The proteins are there. They just don't fold up the way they're supposed to?

MARCH: Yes. And that led to the rise of ion mobility spectrometry. And ion mobility spectrometry is—it's something like spectrometry, but at a higher pressure. Mass spectrometry, but at a higher pressure. And with a counterdirectional DC pulse.

GRAYSON: I’m sorry?

MARCH: With an antagonistic DC pulse going through. So you have some electrodes with a hole in, and the ions could be fed through in a stream, but you could have a positive pulse being applied to each of the electrodes in turn. You get a traveling wave, and that’s the basis of the ion mobility spectrometer. At least, this is the Synergy—no, what’s it called? It’s the other one. Oh, jeez. What’s the new instrument called? Something—[. . .]

GRAYSON: FAME [Fatty Acid Methyl Esters]?

MARCH: Oh, there’s FAME. Yes. That was discovered in Ontario. It was very sad, this one. It’s really progressed. But the person who developed it and pushed it initially was a great enthusiast of riding motorbikes, and I think he had just reached an agreement with—I think it was Thermo [Electron Corporation], to take over this. Then he had an accident on his motorbike, and he’s been crippled ever since. I’ve seen him once in a wheelchair since that time. [. . .]

GRAYSON: That’s sad.

MARCH: Very, **<T: 80 min>** very sad. He lives just outside Ottawa now, in a house which can get his wheelchair all around. But this other one—

GRAYSON: The ion mobility thing, is what you’re trying to think of?

MARCH: This other mobility thing. Can you pass me volume four, which may be the bottom one again? I think I put those starting from the top. Yes.

GRAYSON: Oops, that’s five.

MARCH: Oh, that’s five. This is four at the bottom. Okay. This is the one I want. Scrivens. You know Jim [James] Scrivens?

GRAYSON: Yes, I know him.

MARCH: Somebody's stolen it. SYNAPT. SYNAPT instrument. Mike [Michael] Bowers is big on the SYNAPT instrument, looking at—

GRAYSON: Is that an acronym, or—

MARCH: No. No. It's not.

GRAYSON: SYNAPT.

MARCH: At least, it's not an obvious one. For Alzheimer's.

GRAYSON: Oh, really?

MARCH: Yes. Because it gives you some information on—

GRAYSON: The shape?

MARCH: —the shape and the volume. Yes. Now one of the SYNAPT [experimenters] did a very interesting thing. If you talk to chemists about proteins existing in charge states, we talk about native proteins and the native conformation as they might exist at physiological pH, and they're protonated, and we think that's the way, and they have particular shapes. Putting them through the SYNAPT; however, and you begin to find that for some charge states, there are two times of arrival.

GRAYSON: That suggests two different—

MARCH: Two different forms.

GRAYSON: Folding.

MARCH: Yes. Two different folding processes. Yes. And that I think is really quite fascinating.

GRAYSON: Yes. Well, and that's all because of the ability to see the shape information?

MARCH: Yes.

GRAYSON: Or distinguish between shapes.

MARCH: Yes. They're both exactly the same mass-to-charge ratio, but different shapes. And it's interesting, because I was doing an experiment once, adding something to a protein, and we could never get the protein to be fully reacted. If you have something precious and you want to make a compound from it, you add lots of the other stuff so you drive the equilibrium to the right.

GRAYSON: [Yes].

MARCH: I could never drive it exhaustively to the right, and an explanation for that would be there are two structures, one of which doesn't add on a particular ligand. So at the end of this, came the Water Quality Centre, with some new instruments. This would be a triple-stage quadrupole with a 4,000 mass range, a Q-TOF [quadrupole-time-of-flight], and then into linear traps. Linear traps get—and I missed two things in my life. [laughter] I tell people this, because it makes a bigger impression than just saying these exist. I didn't see how obvious electrospray was, even though as a youngster I used to play with my mother's spray, her perfume spray, with the little balloon, and I could do this, and I could see the mist of droplets. It was all there. All I had to do was to say, I should put in some heated nitrogen, and then the ions will be free from this thing, you see? Missed that last point. [John] Fenn beat me to it. And the other thing is that I played with [quadrupole mass filters] for years, never thought of putting a DC plate at each end. Man, I missed the boat. [laughter] They're that simple. So we have a 5500 [instrument] in the lab, which is very nice, [this is a] SCIEX linear trap instrument, **<T: 85 min>** the most sensitive we have. So I've become more interested in—gone from flavonoids to antibiotics, and now working with proteins, and insect-induced metabolite changes.

But adding ligands to the protein, we know that drugs are carried by proteins. What happens if we take a perfluorinated substance, one which I use to keep this—see this beautiful crease in my trousers? And that's partly there with a surfactant, and they're kept clean, despite the attempts of my grandchildren to mess them up, because they're treated with this surfactant. And so are the carpets, and drapes, if we had drapes, and this of course is a perfluorooctanoic acid [and perfluorooctanoic] sulfonic acid was the other one. And every American, every American has these in his blood now, or her blood.

GRAYSON: Has so much of this stuff in his body.

MARCH: Yes. Everybody. Even the deer up in the Arctic—not the deer, the bears in the Arctic have this. And so if we have a protein and we adhere a drug to it, and then we add some of this PFOS, the perfluorooctanoic sulfonic acid, it will displace the drugs.

GRAYSON: Okay. So that would be a good thing, right?

MARCH: That’s a bad thing.

GRAYSON: It’s a bad thing?

MARCH: A bad thing. If you have something in your blood which is preventing your drugs from reaching the site to which they’re intended that’s a bad thing.

GRAYSON: Okay. I was thinking it was a way to chase away drug—bad drugs, but it’s not—

MARCH: Oh, no, no, no. We’re thinking of good drugs here. Yes.

GRAYSON: Okay. So that’s not a good thing.

MARCH: You should keep bad drugs out of your system voluntarily. [laughter]

GRAYSON: Well, some people do and don’t. Yes. That seems to be something of a—what would you call it? A sleeping giant problem, this PFOS—the perfluorooctanoic acid thing?

MARCH: Yes. 3M have stopped making PFOS voluntarily. They saw the evidence, and they volunteered to stop. That unfortunately doesn’t stop countries like China and India and the Philippines making it. But I don’t think you can even buy it in the States now, and it’s very difficult to buy in Canada. Yes. And that’s in, you know, small amounts for laboratory use, it’s difficult.

GRAYSON: Well, we're learning about stuff much after the fact. I mean, we've got that whole business with the chlorinated insecticides and the polychlorinated biphenyls, and all these other compounds that looked like they were okay, or at least people didn't think about how bad they could be have come into play. I notice that you had a publication on—quite a lengthy discussion of the PCBs [polychlorinated biphenyls].

MARCH: Yes. PCBs, dioxins, and furans. We developed for Varian a tandem mass spectrometric analysis of PCBs. Well, dioxins and furans initially, and then later PCBs.

GRAYSON: They've been distributed throughout the environment in containers, for the most part, but sooner or later those containers are going to come down, and I guess there's a plan for disposing of those containers and their insides? Because—the amount that's contained is very, very much larger than the amount that's out in the environment right now, I would think, I would assume, by orders of magnitude, maybe, even.

MARCH: [Yes].

GRAYSON: But I guess people are more careful about what they put in—create and put in the environment today than they were fifty years ago.

MARCH: Oh, yes. Love Canal near Niagara Falls, was a **<T: 90 min>** great problem. I remember seeing in *Scientific American*, there was an article about the Great Lakes, and then they showed analysis of semen, human semen, from people in various towns around the Great Lakes.[20] A tremendous amount of chlorinated compounds—some brominated, but principally, at that time, chlorinated. The brominated, that is the anti-fire problems, didn't really come in until a little later. But the chlorinated ones were there. And I went to a talk at [Trent University] in Oshawa, [Ontario]—you came through Oshawa. There's a new [campus of Trent University] there. And I went to this lecture of a fellow called [John] Giesy. I had to go and see. He's got something like nine hundred sixty publications. And so we got along very well. I met him before the talk. And I asked him at the end of his talk if he thought that these halogenated compounds which have arisen in the last fifty, sixty, seventy years, does he think they are at all responsible for autism, diabetes, and/or obesity? He dodged the question. [laughter]

[20] F. Jabr, "Short-Chain Chlorinated Paraffins Draw EPA Scrutiny--After 70 Years," *Scientific American Global* May 10, 2010, accessed September 9, 2015, http://www.scientificamerican.com/article/short-chain-chlorinated-paraffins-draw-epa-scrutiny/.

GRAYSON: Well, it takes a fairly massive study to, you know, get to the bottom of that, and you can't really—if you think it's going to harm your population, that's not an ethical thing to do, you know. So it's a problem.

MARCH: Yes. Do you know, autism now is about as common as carbon-13.

GRAYSON: Oh, really?

MARCH: Yes.

GRAYSON: What, eleven percent?

MARCH: One point one percent.

GRAYSON: One point one percent.

MARCH: Yes. One in eighty-three children are autistic these days in Ontario. And, as an autistic child, very, very few of them can look after themselves or hold a job, and once they get to twenty, they have to be put into public accommodation with—so my daughter, our youngest daughter, oh, there's a picture somewhere. Our youngest daughter, there, is in charge of the Kerry's Place Autism Services for Ontario, and she has several hundred houses, each of which holds a few, and with the staff to look after them, and the government pays her company to do that. Tremendous cost.

Yes. Obesity, you can see some extraordinary pictures on Canadian and American TV, and that's getting worse throughout the world. See, in China, too. And diabetes, so they tell me, is of course very common among older people, but it's also becoming more common [in the overall population]—so we have some problems. So there's lots of work to be done.

GRAYSON: So when did you get the Water Quality Centre started?

MARCH: About 1997.

GRAYSON: Okay. So you were—when did you officially retire?

MARCH: Ninety-nine.

GRAYSON: Ninety-nine. So shortly after.

MARCH: Yes.

GRAYSON: And what was the motivation for this Water Quality Centre?

MARCH: Well, it was to provide a much more appealing title for our proposals for instrumental money.

GRAYSON: So it had a hook?

MARCH: It had a hook. Yes. We had to show that we worked together. It wasn't just for one person, not two people. It was a community or university thing which was available to people at other universities, and that's still so. And that there was some common theme to the work, so that it would be supportive of the workers. Yes.

GRAYSON: And that's supported by the province?

MARCH: The province and the federal government. The federal government is the CFI [Canadian Foundation for Innovation]. That's the Canadian part. And then Ontario is—Ontario's Research and Technology Program, which funds forty percent also.

GRAYSON: I see. So it's a joint funding activity?

MARCH: Yes. So we've just taken delivery of an **<T: 95 min>** orbitrap. A Q Exactive orbitrap, and a MALDI [matrix-assisted laser desorption/ionization] source, which is very exciting. And we have a room being renovated now to accommodate the Thermo—no, the Bruker FT-ICR [Fourier transform ion cyclotron resonance], which is coming, which has a resolution of around ten million, [and another MALDI source].

GRAYSON: That's going to be with a supercon magnet?

MARCH: Yes.

GRAYSON: It's getting harder and harder to keep those guys refrigerated.

MARCH: Yes.

GRAYSON: Helium is becoming—

MARCH: Yes, helium is becoming a problem. Yes.

GRAYSON: Very pricey proposition.

MARCH: Yes. And we have a multisector instrument for the ICP people, the people who want to look at metals. So you can look at seven isotopes of mercury at one time. You know, mercury isotopes go tra la la la la la. Well, you can look at all seven. And see how they vary in biological processes.

GRAYSON: I spent a lot of time with the Bendix time-of-flight mass spec with a mercury diffusion pump, so very familiar with the mercury isotopes. [laughter]

MARCH: Yes.

GRAYSON: But you were saying that there's a differentiation of the isotopes, that mercury, as a function of—

MARCH: Biological processes. Yes.

GRAYSON: That seems a bit strange to me.

MARCH: No, it occurs. The explanation, the most common explanation that I've heard is that [reaction rate can vary according to the magnitude of] the zero point energy, when mercury is reacting with something, it's always a situation of mercury. Let's say this is mercury. Mercury, and this is A, and there will be a moment of inertia for these two, and there's a zero point energy for this vibrator, so if we plot it like this, there's a moment—there's a zero point energy here, and that will vary with the mass of the mercury. Now it's very small.

But we know, for example, if I were doing the same thing for hydrogen in this isotope, there [are hydrogen, and there are deuterium diatomic molecules, H_2 and D_2. Of all diatomic molecules, H_2 has the greatest zero point energy; that of D_2 is markedly less, while that for HD is intermediate between H_2 and D_2. Each of H_2, HD and D_2 can exhibit differing reaction rates]. We won't bother with the tritium. But then there's appreciable difference. Here, this is say for mercury-202. I'm getting a little lost now. This is for 203. And I'm exaggerating the difference. But that is the most common explanation I have heard for the variation.

GRAYSON: [Yes]. Well, the mass difference is small—

MARCH: Yes. Well, it's half a percent, but over ten thousand years—

GRAYSON: What do you think about taking a break?

MARCH: Yes.

GRAYSON: And then we can maybe wrap up things after—let me push—

[END OF AUDIO, FILE 1.3]

GRAYSON: So I wanted to spend some time talking about this editorial job that you took on. As we discussed briefly earlier, in some cases, the editor of a book will be someone who just collects manuscripts from four or five or a dozen different people, and kind of gives them a once-over, and makes sure they're on topic, and puts them together, and sends them off to the printer. But from what I gather, your editorializing job is a little bit more complex and more complicated, more thorough than that. So you were telling me about how you and your co-editor—I guess you're co-editors, Todd and you.

MARCH: Yes.

GRAYSON: So how does—well, describe that mark-up that you use with the text when someone brings a text to you.

MARCH: Well, we published one book, or I published one book with a student, Richard Hughes, and John contributed, John Todd contributed a chapter to that.[21] That was our first book, and that was really written for graduate students. It came out in 1989. That was the year in which Wolfgang Pauli was awarded one-third of the Nobel Prize, along with Hans Dehmelt and someone else whose name I've forgotten for the moment [Norman Ramsey, Jr.]. The string-of-pearls effect. So that was for graduate students, because the work was all over the literature on the quadrupole ion trap. So we essentially pulled all of that together, gave an introduction to the theory, and put it out on the market for graduate students, and graduate students have been quite enthusiastic in the response. They've come up to me and John in conferences, and said, "You know, I have a copy of your book, and it's really good. I think I can understand it, all of it, not quite, but I'm getting close, and it's helped a lot," and so on. So that was excellent.

We updated it, bringing in the—mainly the cylindrical ion traps, which Graham had worked on, and the [2D linear ion traps]. Graham Cooks [of Purdue University]. Yes. And then the 2D linear ion traps produced by Thermo and by SCIEX. And the other books, we were asked to write, and we decided on the format of inviting people that we knew from the principal ion trap laboratories around the world, to contribute to a book. So in 1993, I think, we were invited by CRC [Chemical Rubber Company] Press [to produce a book on ion traps] and so that's what we did. We wrote to about forty laboratories. We had an order of preference, but we wrote to forty, and I think we got something like thirty-five positive responses.

The only one which I really regretted not getting was an account of the use of the quadrupole ion trap for testing [athletes' fluids] during an Olympics, and that was in France, and it was—and the French lab wasn't interested at all. So we had about thirty-five, thirty-six. Well, that was too many, really, so we were faced with a problem. And there was a switchboard operator who helped us out. We could never reach anyone [at CRC head office], and then an editor would die, another editor would be fired, another one would take a job somewhere else.

GRAYSON: This would be the editor back at the book publisher?

MARCH: At the book publisher, CRC Press, in Florida. Boca Raton, [Florida], I think it is. So it was this young lady [Nora Konopka] who helped us out. [It was quite extraordinary that the only helpful person available at CRC was the telephone operator]. So eventually with Nora's guidance, it was decided this was much too much for one volume. We would do two volumes—no, it's probably too much for two volumes. So we produced three, those three there. Those are

[21] R.E. March and R.J. Hughes with an historical review by J.F.J. Todd, *Quadrupole Storage Mass Spectrometry* (New York, New York: John Wiley, 1989).

the volumes one, two, and three.[22] **<T: 05 min>** Alas, the backs have faded with the sun, but they were published. [Nora's efficiency and confidence were discovered eventually by CRC, and she was appointed as the Editor for Electrical Engineering, Computer Engineering, and Nanotechnology some years ago. Shortly after the books were published], we had an ion trap—ASMS ion trap meeting in Sanibel, [Florida]. Thank you. In Sanibel, and we invited this young lady to come over and meet us, and we put her on a chair. She's a tiny little one. Put her on a chair, and we all cheered her. [laughter]

GRAYSON: She was the editor for these?

MARCH: She was the—no, she was the telephone operator. She was the only one we could get. [laughter] Terribly disorganized.

GRAYSON: You have a chance to change everything, so say anything you want.

MARCH: All right. Well the editors would just change because of various things. She was the link that we had. She is now an editor for CRC—and richly deserves that. I mean, she's very, very good. Anyway, Gary Glish and I were organizing this ion trap, and we put her on the chair so everyone could see her, and then sent her back home with her mother. [laughter] So that turned out to be quite interesting. We—we had a very good presentation [at that meeting] from Franzen, Jochen [Franzen of Bruker-Franzen].

[Jochen] was interested in various aspects of ion traps. We had a conference at [what is now known as Le Relais de la Benerie, but was simply 'La Benerie' when] Jean-Claude Tabet and I organized [an ion trapping conference. Jochen] was invited to attend, and he said, "I'd love to attend." He said, "Could I present my theory on these resonances?" and we said yes. He says, "How long do I have?" I said, "You can go from one meal to the other, but you cannot delay a single meal. The chef will not tolerate having his meals delayed." [laughter] All right. So he started mid-morning, and he ended sometime before supper, but we had time for lunch, and he went for about two and a half, three hours, and which he expounded the whole thing.[23] We had discussion. This was really good. And—

GRAYSON: Now this is probably a group of what, fifty people at the most?

[22]March, Raymond E., and F. J. Todd. *Practical Aspects of Ion Trap Mass Spectrometry* vol. 1-3 (Boca Raton, Florida: CRC Press, 1995).
[23] J. Franzen, R.H. Gabling, M. Schubert, J. Wang, "Nonlinear Ion Traps," in *Practical Aspects of Ion Trap Mass Spectrometry: Fundamentals,* edited by R.E. March and J.F.J. Todds, vol. 1 (Boca Raton, FL: CRC Press, 1995): 49-167.

MARCH: Yes, I would say—yes, fifty at the most. Yes, forty-five.

GRAYSON: Because I think the smaller groups, intense smaller groups, can be very productive.

MARCH: Yes.

GRAYSON: Much more so than these huge meetings.

MARCH: Yes. Oh, yes. Meetings—huge meetings, not very good. So that was very good. And then I went to—where's the place in California near the golf club?

GRAYSON: Oh, well, I've been there, but I can't remember.

MARCH: All right. It's the other place. The other meetings.

GRAYSON: You have Sanibel on the East and then they have this one on the West Coast.

MARCH: Yes. And I've forgotten.

GRAYSON: Yes. I know what it is.

MARCH: Let's just call it Palm Beach, [Florida]. It's near there. [Aha, it is Asilomar Conference Center]. So I went there [in September 1992], and I was trying to persuade George Stafford to write a book/chapter on the commercialization of the ion trap. It's a very dramatic story, because it brings in these resonances, and non-linear effects, which are inherent in a commercial trap, where we have finite electrodes, and holes in the electrodes, and so on. So it's got to come about. So there was George, with John Syka. Paul Kelley had [left the Finnigan Corporation] by that time, and, well, we must have discussed for an hour or so, and I said, "George, John, you could have had half of it done by this time, if you'd started when we first came out." I said, "I'm getting cold. It's disappointing, and I can hear the other guys drinking beer and enjoying themselves inside, and I want to go in, but I'm determined to get this thing." So I don't give up easily. So, [eventually], they agreed that George would assemble some slides, and that John would take these slides and then speak to them, and then send me the transcript.

Well, they did it. By this time, we had our house in France, and this was about 1992, 1993. So **<T: 10 min>** we're still in the stage of painting [this twelfth-century stone house and there were] still not too many carpets, [in] this big dining/living room, which [was] shaped like a subway tunnel. I sat there with my computer, and this tape recorder, listening to [John Syka's voice, John started off something very close to this: "Gee, I don't know what month it was, but I think it was perhaps early February, or was it late January? I don't know. And we decided it." Well, he rambled on like this while I tried to capture the sense of the sentence and write in on my computer], so I had to play every sentence six, seven times, [trying] to make some sense, and then quickly to write it down.

And my wife could hear [this because the recorder output echoed through our subway tunnel—after several days of this experience over the Christmas holiday] she hates his voice now. She hates it—with a passion. [laughter] She hates his voice. She met him in Baltimore, I think it was. She met him in Baltimore. "Oh, yes, John Syka." [laughter] He knows about this. But he has that Eastern drawl, which just—anyway, if you'd like to pass me the top book on this occasion.

GRAYSON: This one here?

MARCH: Yes.

GRAYSON: Number three?

MARCH: Oh, no. No. Number one.

GRAYSON: This—two, and here's one.

MARCH: There we are. Thank you. I'll give you this one back.

GRAYSON: So you're saying this attempt to transcribe his notes turned into these three books?

MARCH: No, not his notes, but this was ours. This was Franzen, non-linear ion traps, very long, but very good, and proven to be on the whole correct. And then the "Commercialization of the Quadrupole Ion Trap" by John E.P.Syka. It says, [in] small print, in the book, "From a talk, 'The Geometry of the Finnigan Ion Trap, History and Theory,' presented by the author at the

Ninth Asilomar, [California] Conference on Mass Spectrometry, September ,1992. This chapter is a historical account of the problems, etc..”[24] Yes. So somewhere it tells of the recording, the wretched thing. But it’s a wonderful—so you have science, a commercial venture, puzzling over a problem, deciding what to do, setting a limit, and then the thing coming through. And producing a thing, the mass shift, and some of these things we still argue about. But they were very, very interesting. And it was a success.

GRAYSON: But did you transcribe all of that and that’s in that chapter?

MARCH: Yes.

GRAYSON: Oh, my. You were a glutton for punishment.

MARCH: I thought it was such a great story, because it really—this is the first major, major trap that’s available to the mass spec community. ICR is too expensive. I mean, we’re going to have to pay—I think we’re paying $1.2 million for the Bruker FT-ICR. Yes. That’s the top of the range that we’re getting. Everybody can’t afford that. But this was the start of the quadrupole ion trap, the linear ion trap, the cylindrical ion trap. And without it, life would have been very much different. And it was worth telling the story, so you just stick with it. I mean, you get committed to something, to the point where if you stop, there’s too much of a loss. You’ve got to go on. So there we are. That was the beginning of this. And then we had simulations, and lots of other things. So we put together all of these I think thirty-five chapters, or thirty-four. I’ve forgotten the exact number.

GRAYSON: In three volumes.

MARCH: In three volumes, which you can handle easily. We had graduate students and postdocs contribute with their supervisor wherever possible. That’s what we asked them to do. That is, we want to be able to say that we’re training the writers of the next generation, and **<T: 15 min>** having them involved. Nobody was paid for it, but everybody got a complete set of the three books.

Yes. No money. Actually, the publisher would only pay the lead author, and the lead author, if he wanted to give something to a student, he would get no tax remission for that. It

[24] John E.P.Syka, “Commercialization of the Quadrupole Ion Trap,” chap. 4, in *Practical Aspects of Ion Trap Mass Spectrometry: Fundamentals*, edited by R.E. March and J.F.J. Todd, vol. 1 (Boca Raton, FL: CRC Press, 1995): 169-205.

didn't work. The three books worked splendidly. And we did the same thing for the next two. The difference between these two is this was ion trap mass spectrometry. That's the quadrupole ion trap, although it doesn't say. And this is for trapped ion mass spectrometry. So this brings in the linear trap, ICR trap, and the orbitrap, all up and coming.

GRAYSON: So now Todd is in the UK, right?

MARCH: Yes.

GRAYSON: So you're doing this editor collaboration at a distance?

MARCH: Yes. But when we're working, I probably get five, six emails a day from him.

GRAYSON: Okay. So it's emails that you have—

MARCH: I can email at night, you see, and tell him, "I've got a problem. Can you find this?" When I wake up in the morning, he's been awake for five hours, so he's looked something up and sent it off to memo, it works well. Much better than being in the same time zone.

GRAYSON: Yes. Wow. Interesting. That only works, too, if you've got email.

MARCH: Yes. Oh, it makes a big difference. Huge difference. Yes.

GRAYSON: But there's one thing I was going to—interested in having you describe, is how the two of you would take a manuscript and review it, and then send it back to the author, to have him address the points. You used colored markers.

MARCH: Yes. One—both edited.

GRAYSON: So you both had to read the manuscript?

MARCH: Yes.

GRAYSON: That's a lot of work.

MARCH: Yes, but we understood a lot. I mean, I know a lot about this field now, so both [of us] edited [each chapter. We] had a color code. I'm green, John is yellow. Blue means hold it, read this, this is a concern, or something like that. And there was red for something else, and magenta for something else. But—

GRAYSON: So the highlights would reflect the concerns, and he knew which author or which editor was complaining or that had the concern?

MARCH: Yes. And the third point—what was the third point? Oh, dear, dear, dear, dear. Both edited, color coded, the third point has gone entirely. Gee whiz. Oh, if I took it upstairs to my computer, it would say REM1, [JFJT1], and then REM1, JFJT2. And we might get up to RM6 and JFT9, if he makes a couple—and I have all of these on my computer, still. [laughter]

GRAYSON: So those are different versions?

MARCH: These are the versions which have gone and come back from the—

GRAYSON: So the iterative process?

MARCH: Yes. So there's the original, which would be let's say author 1, and then author 1, RM 1, author 1—2. That just tells us the sequence in which the things have been dealt with. So everything was aboveboard. There was fairness. We would take a discussion or—we didn't say, "It has to be this way." "This is what we prefer, but for this reason. Can you have a little debate? Let's have a discussion about this." Rare—I don't think we ever had to get on the phone to argue a point, only to inquire if an author had died. We would get on the phone then, and I'd say, "Oh, I thought I'd better phone in case you had passed away, and I didn't want to be sending emails to disturb your wife if you had actually gone, you see." "You think I'm dead? Why do you think I'm dead?" "Because you haven't replied, you son of a bitch." [laughter]

GRAYSON: Oh, wow. Quite a way of getting the author to move on.

MARCH: And with John, sometimes **<T: 20 min>** he would go to sleep, he'll forget, or whatever. Anyway, he doesn't respond. So I would phone him up, and I'd hear his voice, for example, and Mavis [Todd] would say, "Ray, it's two o'clock in the morning." "Oh, I'm terribly sorry. I've calculated the wrong way." I'd say, "Is John awake?" "Of course he's awake now." [laughter] It wasn't nice, but I needed a response. Come on. The ship is moving along.

GRAYSON: Yes. Well, that's a lot of work, and—that's a lot of work, absolutely. That's impressive.

MARCH: But they're good books. I can say, because all of the authors agree with what we have printed there, yes, what is printed there.

GRAYSON: Now there's also all these issues or problems dealing with the placement of figures, and getting the right figures together, and—I don't know if you have to go through the business of getting permission to reprint figures from previous things. I mean, as well as a lot of grit and grimy work. Did the CRC help you with that, or—

MARCH: Well, they were reasonable, but we had to get permission, so we asked the authors to give us information or get permissions themselves and pass them along. If they were stuck—we didn't want to give anybody a reason to hold us up.

GRAYSON: Oh, [yes]. Sure.

MARCH: The thing has got to move and keep moving. If it has some momentum, that's what [we tried to do, to maintain momentum]—if it stops, people wonder if the thing's falling apart, and that's bad.

GRAYSON: So how long did it take from start to finish?

MARCH: I think for these—about two and a half years, I'd say. I could look and find the original letter of invitation that we wrote, and if it comes out on this—I can go upstairs and look at it, to the date of publishing these things, but I would guess about two and a half years.

We had some disasters. One of the other books we had published, they published no figures, and then in another version, they published all the figures, but no captions. [Yes]. No captions. That happened even with international journals. The first time I submitted my figures electronically, they forgot to put the figures in. And so they said, "Well, we'll publish the figures, you know, together." "No, no, no." I said, "I want the whole paper done as it ought to be done." So they reprinted it.

GRAYSON: [Yes]. Well, those are weird—you wouldn't think those kind of things would happen.

MARCH: No, but Wiley. [We were very disappointed with CRC. Our volumes 1, 2 and 3 consisted of well-written interesting accounts of recent quadrupole ion trap research. The information just rolled in and we, the authors, needed help and advice as to how to cope with all of this information, and what possibilities existed for publication of all of this material. We were very disappointed with CRC for a while]. I think it had just gone to pieces.

GRAYSON: Well, I know for a fact that these editors go from one job to the next. They just don't seem to last very long. Makes you wonder why they even bother having them, you know, if they don't have a commitment to stay long enough to get something done.

MARCH: There was a good one at—oh, I wonder if you could—

GRAYSON: One of these guys?

MARCH: Yes. Throw those things off and just pass me the top one.

GRAYSON: Oh, that one?

MARCH: [Yes]. Thank you. I've forgotten his name. I don't know if it puts the editor here. It doesn't, you know? Well, it's interesting. The editor's name does not appear. James Earl Smith. **<T: 25 min>** Yes. James Earl Smith was the editor, and he was also the editor for this Barbara Finlayson-Pitts and Jim Pitts, [whom I mentioned earlier]. They did a very well-known book entitled *Atmospheric Chemistry*, and [Jim Smith] was the same editor.[25] I went to see [Jim Smith] in New York, to see if he would be at all interested in publishing, and I met him, we talked, and he was, and it came about. [It was the book by March and Hughes given in footnote 5]. But that was very good. I see here there's a fellow—I went to France—I didn't really talk about this, but I went to France on leaves, small sabbatical leaves—

[25] B.J. Pitts and J.N. Pitts. *Atmospheric Chemistry: Fundamentals and Experimental Techniques*. 1st ed. (New York, New York: Wiley, 1986).

GRAYSON: I was going to ask you about those. I noticed you went several times abroad.

MARCH: Yes. To Marseille, [France], particularly. We, [at Trent, have a new collaboration with Marseille. The laboratory that I visited was that headed initially by Jacques André and, later, by Fernande Vedel; the lab, was located in the Centre de St. Jérôme campus of the Université de Provence]. And I went back. I was an external examiner on [doctoral theses on] several occasions. I read all their papers on ion traps, and translated them, and checked the translations with the people [to make sure I had the correct sense. The doctoral examinations in France are pieces of theatre. There is often quite a large crowd of observers in the lecture theatre waiting for the group of examiners to enter the room. The examiners enter and sit on a bench or pew near the front of the hall. The candidate is invited to speak for some twenty minutes or so, and then the examiners pounce. The first examiner is the external examiner. My first small cluster of questions goes well and I just hope that my French holds up. I am more anxious during the second round of questioning because I was never sure that I had understood completely the first set of questions by the other examiners. Throughout this ordeal, I thought of the candidate's relations seated behind me. I had a distinct impression that I might feel a thrown object at any moment.

Then there was a fellow here, a young postdoc called Malek, [Alili Abdelmalek]. Now he was just known as Malek, the last name shortened. And there were a number of Arab students there. It was a great joy to get to know some of the Arab students. [This] Malek was quite well off, and his brother [owned] a restaurant in Marseille, and he gave me that little Arab teacup on the top of the [bureau. Right] hand side, teapot. On the thing. Yes. Yes. I just happened to see his name here. And there was a picture. Do you see a picture? There. There's a picture, a little painting. Yes.

GRAYSON: This one here?

MARCH: Yes.

GRAYSON: Very interesting.

MARCH: He's trying to link up quadrupole ion trap, quadrupole mass filter, a mass spectrum, MALDI. These are Rydberg states of electrons. [The Marseille group] did a lot of work on Rydberg species, crossbeam work, and this [was] done by a fellow called Georges Brincourt from Marseille. And he gave this to me just a couple of years ago, and it's a lovely little [work]—these are the trees of Provence and, what's the stuff called?

GRAYSON: Cedars? Poplars?

MARCH: No, [they are cypress trees and] the purple stuff is lavender. [The] fields of lavender in Provence, [France]. And, you know, these days you have to produce an abstract, a graphic abstract for papers. Well, John Todd and I just finished this retrospective lecture, [actually a] retrospective paper on the last fifty years of the quadrupole [ion trap], and we [submitted this charming painting by Georges Brincourt to the *International Journal of Mass Spectrometry*] as our graphical abstract.

GRAYSON: Cute.

MARCH: Got permission from Georges to—we thought it was the best—imaginative—

GRAYSON: Okay. Speaking of lavender, there was an article in *C&E News* where the European Union wants to have everything labeled with the hazards, possible hazards, and apparently, some people may be allergic or have an allergic reaction to some of the compounds in lavender, and the people who grow the lavender are in an uproar about having their natural products, you know, listed as a chemical.[26]

MARCH: Yes.

GRAYSON: And sort of a big, you know, fight between them as the way they're going to follow the law, but—and so everything's chemistry. This fellow that **<T: 30 min>** I mentioned about teaching K-through-eight kids, getting them interested in chemistry, when he gives a talk, he asks his audience of kids, where's the nearest chemical factory? And they say, oh, you know, there's one five miles down—it was Dow Chemical [Company], or a refinery. He says, "Well, there's one that closer than that. That's the guy sitting right next to you." That's the nearest chemical factory.

MARCH: Yes.

GRAYSON: You know? And unfortunately, chemistry has such a bad name that, you know, people kind of don't realize that that's so. It's all chemistry. So how many times did you go abroad? I mean, the first time, we talked about that, but you've been abroad on more—several other occasions, but all the time to France?

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[26] Alex Scott, "The Problem With Lavender Oil," *Chemical & Engineering News* 92, no. 41 (2014): 19.

MARCH: Oh, well, we had—I mean, [my wife and] I had the house [in Manas, Drôme, France for just over] twenty years, in—I was going to France, France and England, about three times a year. For a number of years. Six weeks, a month, six weeks, two weeks, three weeks. [I have probably crossed the Atlantic Ocean close to a hundred times since my first trans-Atlantic flight in 1957]. The shortest I did, the shortest I did—oh, I was going to show you the drawing of the SYNAPT.

The SYNAPT is a new instrument where they take a washer with a small hole, and then another washer with a small hole, and another, so that these washers are arranged like this, and then a small hole in here, and then you put RF onto these, that one, that one, and that one, and another one, and then these three—so this is plus RF, and this is minus RF. So now you have opposite potentials on alternating washers. I call these washers. People don't like that, but they're washers.

And this then forms part—there may be seventy of these—part of this SYNAPT apparatus. [It's called a traveling wave ion mobility-mass pectrometer [TWIM-MS] and it consists of traveling wave ion guides [TWIGS]. A SYNAPT is a concatenation of three TWIGS to create the SYNAPT high-definition mass spectrometer [HDMS]—it's going to take too much time to find it]. But this was really discovered or developed at Waters, and I was an expert for them in their patent litigation. [Together with other members of the legal team, I] had to fly to Manchester to talk with the person who was [involved in the invention of this instrument], and then fly back to Philadelphia, [Pennsylvania], and on to. Where is not Corning—Dow. Where is Dow? What's the town for Dow? [. . .] You know it?

GRAYSON: No, I can't think of it, but—

MARCH: Nope? Nope? It's an older, fairly well-settled down, very conservative town [Ah, the patent litigation was being pursued in Wilmington, Delaware]. Anyway, we had to fly [to Manchester] and back. So we got there the Sunday morning, worked the Monday and Tuesday, and flew back Tuesday afternoon.

GRAYSON: Very fun.

MARCH: Man, that's not fun. No. I was at odds with myself for a week because of that. So I traveled to Britain. Of course, I had some [sabbatical leaves] at Swansea, [United Kingdom]. The Royal Society Research Unit, which is a tremendously good idea, because it's in the lifetime of a person only. We have centers of excellence in Canada, and these are establishments. You know, they hire people, and work, and then the older ones retire or go off somewhere. But the center of excellence has to be fed, regardless of whether the people are good or bad. And they're not really as good as they started out. And they always deteriorate. But the centers—research centers of the Royal Society in Britain are created and then they die, created and then they die. So I went to [John Herbert Beynon's Research Unit in Swansea University College, now Swansea University. All of my visits were fantastic experiences, although Beynon himself was not the nicest of men].

GRAYSON: Well, he ran kind of a slave driver operation there.

MARCH: Yes. And not only arrogant, but very insulting. **<T: 35 min>** To some of his students, and so on. I wouldn't have stood for it. If he had spoken to me the way he spoke to some of the students, I would not have been there, and he knew that at the end. It was made very clear to him. So there. Where else did I go? Well, Canterbury, Swansea, Jean-Claude [Tabet] in Paris, at Pierre and Marie Curie University. And the group, [André-Vedel], and the new people now at Marseille. So we're just putting in for a new project at the moment, between ourselves doing mass spectrometry and our partners in Marseille doing NMR on this problem of the proteins and the drugs and the competition on the proteins between drugs and contaminant molecules.

There are a lot of unanswered questions in that area. But those have been my major collaborations overseas.

GRAYSON: So let's talk about funding a little bit. Where did you get all this money?

MARCH: I never get enough. [laughter] Never get—I don't get a lot, and I never get enough. Money comes from—some came from NSERC, although since I've retired, they have become not very cooperative, and so I've been writing nasty letters to them.

GRAYSON: That helps a lot.

MARCH: Well, I've— they just have a new president of NSERC who takes office on November the fifteenth, and I wrote him a letter of welcome, talking about the two solitudes, and gave him a little lecture on what's happening, so probably won't hear from him. NSERC. CFI. That's more recent [. . .]. Scholarships for graduate students come from governments, either provincial or federal governments.

GRAYSON: So you don't have to get funding—grant funds to pay their salaries? That comes independently of the—

MARCH: Yes, for some. If they do some teaching in labs, they get paid for that. Otherwise, I'd have to top them up from NSERC. Postdocs are very expensive, and I've had very few in my time. Varian, of course, I worked for about three years as Varian's research center, when they first decided to go into the ion trap business. They bought the rights from Finnigan, which became Thermo, and they bought the rights and went in, but they didn't have any expertise, so I worked with a fellow called Greg [Gregory] Wells, a physicist who was in charge of this program at Varian, Walnut Creek, [California], and he was an absolutely charming fellow, very, very capable scientist. And we had a very good time for three years. So I got a lot of money for that period, working with Varian. Yes. And that's about it.

GRAYSON: But you don't feel like you were lavishly funded through your scientific career?

MARCH: Oh, not at all. No. It was a mistake, really. Looking back, it was a mistake to try to do this type of research at a small university. I should never have tried it.

GRAYSON: And I noticed that you do have a couple of patents. Were they—or I guess they were assigned to Varian or to the school or—

MARCH: Yes, to Varian.

GRAYSON: So you did you get any recompense for those at all?

MARCH: Well, Varian bought them from me. Yes. Varian paid for the application, and then compensated the patent holders for the transfer to them. And then Varian sold them to Agilent when this business was sold to Agilent.

GRAYSON: And those are patented both in Canada and the US, or—

MARCH: US only.

GRAYSON: US only?

MARCH: Yes.

GRAYSON: Okay. All right. I mean, a lot of times patents are granted, but they don't provide any remuneration to anyone.

MARCH: Remuneration. Yes. Well, the high-resolution one still hasn't been really developed. That still awaits. I don't know—do you know about resolution? You must know about resolution. The mass divided by the width at half height.

GRAYSON: [Yes].

MARCH: Okay? There. This [peak is due to the ion M—positively or negatively charged— **<T: 40 min>** and M is the value of the mass/charge ratio of the ion; and this width] at the half height of M is delta M. And so the resolution, R, is equal to M over delta M. So as delta M—as delta M gets more and more narrow, then the resolution increases. Well, [in the course of ejecting ions mass-selectively from the ion trap we are pushing the ions out by increasing the] RF voltage amplitude, and yet we detect nothing, nothing, nothing, nothing, nothing, and the plot [shows a flat line until we reach a crucial] value of the RF voltage, and then when we increase the RF voltage one small step, just a tiny fraction of a volt, [we see a large increase to a single datum point and then the next datum point is back to the base line]. All of the ions come out in one value of the RF. And so this—

GRAYSON: How do you determine delta M? Is it—

MARCH: [The signal that we observe is] just a triangle. It's just a—

GRAYSON: [Yes], but, I mean, it's itsy-bitsy.

MARCH: How do you mean itsy-bitsy?

GRAYSON: Very small.

MARCH: Oh, it's very small. Yes. [Delta M is around 7×10^{-6}, that is approximately 10^{-5} and the mass/charge ratio (*m/z*) value of M is 503; thus $503/10^{-5}$ such that the resolution is 5×10^{7}. Note that this resolution is but five times that of the Solarix FTICR instrument described earlier and received by our WQC in 2015.] I had a slide made. Here's one. This would be six hundred and—duh duh duh, it's—I think this is *m/z* 503, and this is *m/z* 504, where *m/z* 504 is the ^{13}C

analog of *m/z* 503. And on a slide, if I was putting them on the same scale, the separation between them] would be seven meters.

GRAYSON: [Yes]. Between the peaks.

MARCH: Huge amount of empty space. But the ions have been all brought to the center [of the quadrupole ion trap under the influence of momentum-dissipating collisions with neutrals], slowly, and then they're waiting, [their trajectories are] about to become unstable as [their working points] reach the end of the stability diagram, and just one more increment of the RF, and they all have time to fly out. [All the ions have been ejected, and at the time when the RV voltage is incremented to the next step], and there's none left.

GRAYSON: They're all gone.

MARCH: So this is of course scanning slowly. So when you scan slowly, the resolution increases and increases. [Jae C.] Schwartz et al. did this first of all, and then we followed it up, and did that. That hasn't been utilized. There is a zoom in most quadrupole ion traps, but it's really quite a small effect, so that patent's still good. The payoff [is yet to come].

GRAYSON: I think I've got a lot of information about the various people that you collaborated with, and publications here. Did you mention Jennifer Brodbelt?

MARCH: Yes.

GRAYSON: Was she a postdoc, a graduate student, or a student, or what—

MARCH: When?

GRAYSON: I mean, I know she's at University of Texas, Austin now.

MARCH: This is Jennifer. I started [this meeting] about 1977 the Trent University—what was it called? Gas-Phase Ion Conference, okay? Gas-Phase Ion Conference. Gas-phase ions. And if you make a note and go to Trent University conference, mass spectrometry, Google that, and you'll be taken, and you'll see pictures, and you'll see this picture, and some others. It's still going. I started it in '77, and it's now in its—what is this, thirty-eighth, thirty-seventh—thirty-sixth year. And so I wanted—this was for Southern Ontario. But there weren't very many [active researchers in this field in Southern Ontario at that time. There was] John Stone at [Queen's University], John Holmes [University of Ottawa], myself, John Goodings and Harold Schiff [York University], one or two others, and a fellow at McMaster [University], and that was it. So I asked some Americans, I invited Chrys Wesdemiotis. That's a name you'll remember. And Bob [Robert] Dunbar. All these people I had met **<T: 45 min>** at NATO conferences. Also Cooks, Graham Cooks. If they would like to send students, [they would be very welcome], but only graduate students could give a presentation.

So don't send me a postdoc and expect to put them in. Graduate students only. And as they travel [to Peterborough, Ontario], they could all have a look at Niagara Falls, stay overnight, and we would try to arrange reasonable accommodation, and we'd have a little closing dinner, but it would be cheap, and we'd look after them. It was done on a shoestring, but they came. So I met and got to know quite well some of the graduate students of these people, and Jennifer Brodbelt was one of the graduate students, of course.

GRAYSON: From?

MARCH: From Graham's lab.

GRAYSON: From Graham's group?

MARCH: Yes. So I've known her now for thirty years, and she's not that old a person, so I've known her since she was quite young. And we've collaborated in various ways, and we wrote this paper on mass spectrometry, NMR, and chemical computation. That was the thing. And she has written I think three chapters in these books in all, and I find her very good, and I'm very supportive of her career. And she's a very hard worker. And I really appreciate what she has done. So that's how I get along with Jennifer.

GRAYSON: Yes. Now she's—

MARCH: She's a bigwig. [laughter]

GRAYSON: A bigwig. So what do you consider your most—what do you consider your most critical, important publications?

MARCH: Oh, golly. Well, I think the high mass resolution. High mass resolution, two or three with Greg Wells and Frank Londry, who was a student with me, and still works for SCIEX.[27] So there's the high mass resolution. Secondly, really, the one with Bonner, Durup, and March. That is the—what I call collisional migration.[28]

GRAYSON: This is moving ions to the center of the trap?

MARCH: Yes. We sent that paper in, and it was criticized. We responded to that, and then somebody came out with a paper saying this idea was ridiculous. They had their own interpretation of our things. And no sooner had their paper came out than [Hans G.] Dehmelt and [W.] Neuhauser and somebody else [M. Hohenstatt and P.E. Toschek] presented a beautiful paper showing a cloud of barium ions fluorescing in the center, and then lower the pressure and excite them a little, and they disappear, and then bleed in a little helium, and they come back, and there's a tiny star in the center.[29] [laughter] It was marvelous. There was no further discussion from the other people, and we won't mention who they are.

And the other one, the last one is competition for accommodation on whales. It's not entitled that, but that's—I had an argument with John Fenn. He was talking about flying elephants. And I said, "Well, flying and elephants don't relate to a protein molecule. You never really get one, neutral, and like that." **<T: 50 min>** I think it's a bad analogy. "Well, what do you think is better?" I replied, "Whales, because they're in solution, and we're going to take them and fly them out." And I have a slide of a whale leaping out of the water, you see, showing the barnacles and things attached to it. I said, "There's a competition here for drug molecules and contaminant molecules on the surface of this flying whale, going through the gas phase," you see. So that's my paper. Anyway, that came out, I think it was the end of 2012, December the thirty-first, 2013, in *IJMS*.[30] He persisted in using—well, he'd already used that in his Nobel speech, so he didn't want to go back. We were just fooling around, just having a little discussion. He was great fun, was John Fenn. Alas, the last few years were sad. I think he was mistreated and not really understood very well by his university.

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[27] F.A. Londry, G.J. Wells, and R.E. March, "High mass resolution chemical analysis with Paul traps," *Hyperfine Interaction* 81, no. 1 (1993): 179-187. F.A. Londry, G.J. Wells, and R.E. March, "Enhanced mass resolution in quadrupole ion trap," *Rapid Community Mass Spectrometry* 7 (1993): 43-45.

[28] R.F. Bonner, R.E. March, and J. Durup, "Effect of Charge Exchange Reactions on the Motion of Ions in Three-dimensional Quadrupole Electric Fields," *International Journal of Mass Spectrometry and Ion Physics* 22, no. 1-2 (1976): 17-34.

[29] W. Neuhauser, M. Hohenstatt, P.E. Toschek, H.G. Dehmelt, "Optical Sideband Cooling of Visible Atom Cloud Confined in Parabolic Well," *Physical Reviews Letters* 41, no. 4 (1978): 233-236. W. Neuhauser, M. Hohenstatt, P.E. Toschek, H.G. Dehmelt, "Visual Observation and Optical Cooling of Electrodynamically Contained Ions," *Applied Physics*, 17 (1978): 123-129.

[30] M L D'Alessandro, D.A. Ellis, J.A. Carter, N.L. Stock, and R.E. March, "Competitive Binding of Aqueous Perfluoroctanesulfonic Acid and Ibuprofen with Bovine Serum Albumin Studied by Electrospray Ionization Mass Spectrometry," *International Journal of Mass Spectrometry* 345-347 (2013): 28-36.

GRAYSON: Yes. Well, dollar signs get in the way.

MARCH: Oh, yes, alas.

GRAYSON: Yes. Well, I don't know if you have any other comments you'd like to make at this point in time. We've covered a pretty good day's worth of discussion here, with your career and its impact on the field. If you have any other words you want to—

MARCH: Have we discussed Rosetta project? Do you know Rosetta project?

GRAYSON: It sounds familiar, but I don't know if I recall exactly what that was about. Enlighten us here.

MARCH: Yes. Could you pass for me the book at the left, the white one with the blue edge, and those papers just at your left elbow? Yes. All right.

GRAYSON: Oh, I think I recall what this project's about?

MARCH: Yes. So, "An Ion Trap Too Far: The Rosetta Mission to Characterize a Comet." If you go to the webpage of Trent University and you look for news, on January the thirtieth, 2014, there's an explanation. It takes you right to a Wiley site where Wiley have put up a chapter, just one chapter, for anyone to copy and to read.[31] [. . .] And that will tell you about Rosetta comet project. And that was when the comet was woken up, and it spoke to the world. Now it took off in 2004, March 2004. [At that time, John Todd and I were completing the draft of the second edition of our quadrupole ion trap book. We approached Simeon J. Barker and his team at the Open University, Milton Keynes, United Kingdom—whom we had met at an International Mass Spectrometry Conference in Tampere, Finland, in 1997. We offered to include a detailed description of the twenty scheduled experiments to be carried out on and about a comet, 67P, in a chapter of our second edition to be published in 2005. They agreed, Chapter 9 was completed and the book was published.][32] And if the Rosetta space vehicle had crashed, nobody would ever have seen this chapter because we would never have mentioned it. I

[31] "Trent Link to the Rosetta 'Comet Chaser' Mission" *Trent University News*, January 30, 2014, accessed December 17, 2015, http://www.trentu.ca/newsevents/newsDetail.php?newsId=3681.
[32] R.E. March and J.F.J. Todd, *Quadrupole Ion Trap Mass Spectrometry*, 2nd edition, vol. 165 (Hoboken, New Jersey: John Wiley & Sons, Inc., 2005).

mean, only those who had the book would have—would have known. But it has woken up. It sent a test mass spectrum back, and it has in it a quadrupole ion trap.

GRAYSON: And Rosetta stands for the—

MARCH: It doesn't stand for anything. It's the stone.

GRAYSON: But it's a space probe to go to a comet, is what it is?

MARCH: Yes. And it is trying to understand the comet, and [it plans to determine] isotope ratios for carbon, hydrogen, oxygen, and nitrogen. And the comet is 4,600 million years old, [that is, older than the earth].

GRAYSON: How do they know that?

MARCH: I have no idea.

GRAYSON: Well, I know that they suppose that it has never come through the solar system before.

MARCH: Solar system. Yes.

GRAYSON: So from that aspect, I guess—I don't know. It's been out there for a long time.

MARCH: It's been out there for a long time, and these isotopes would not change during that time, so it takes us right back to—so it gives us a ["t" or known time] value for these isotopes, and what was the other point I was going to say? It gives us that, **<T: 55 min>** plus when I tell people about this, I say, "What do you think the shape of the comet would be?"

GRAYSON: [Yes]. That's a good question.

MARCH: And I've seen Halley's comet. I've seen Halley's comet here, [near Peterborough]. You look through field glasses, and it's round and fuzzy. And that's all I could see. It seems to have an atmosphere all around it. But we'd expect it to be spherical, perhaps, with oblation, perhaps a tail end, so it's become more elliptical, and it's flying that way. Actually, this one looks like a duck. Looks like a duck. There's a head, it comes round, and then a back. And they had to choose a landing spot. [It appears to have been formed through a collision of two comets that fused together. In any case, it was quite a surprise for Barber and his group].

GRAYSON: So we're going to land on this comet?

MARCH: November the twelfth [2014].

GRAYSON: And this is October the—

MARCH: Twenty-seventh.

GRAYSON: So two weeks?

MARCH: Sixteen days, two weeks Wednesday in fact.

GRAYSON: Wednesday. Wow.

MARCH: Two weeks on Wednesday.

GRAYSON: And it's your ion trap that's going to measuring the isotopes?

MARCH: Yes. That is the [isotopes. It is a copy of the quadrupole ion trap [QIT] that I have characterized, it is made of aluminum and is about eighty percent of the usual size of our QITs]. The proposal was formulated twenty years ago. So this part hasn't changed. But nevertheless, it's there, and it's working. I mean, it's actually sent a mass spectrum—

GRAYSON: Well, you did get the spectrum back.

MARCH: —back. Yes. And it has gas and things. These aren't—that's the thing. [Chapter 9 in our book] explains all twenty experiments [for the Rosetta project. There] are two parts to this:

there is the orbiter, which] has the big solar panels on it, and this is the lander. And so they've been together for ten and a half years, and they have sent [messages back to Earth.] It takes about fifty-four minutes to say hello and to get an answer back, fifty-four minutes, at the speed of light. And so on November 12 they're going to fire this [lander instrument package, or Philae,] down to the comet and, as it hits, it should trigger four explosions of spikes, one at each corner, which will be driven into the ice to hold [Philae safely onto the comet], and then the nine series of experiments will commence. So eleven are done with the orbiter, and nine with the lander. Presumably, most of these eleven have been done by now, because it's been flying around the comet since about August.

GRAYSON: [Yes]. Well, I'll have to stay tuned to the news, huh?

MARCH: Yes.

GRAYSON: That'll be pretty exciting.

MARCH: Yes.

GRAYSON: So then basically the data from the lander will be transmitted to the orbiter, which will then eventually be sent back to the Earth.

MARCH: Yes. Goes back to the European Space Agency [at Darmstadt, Germany].[33] And if you wanted information, the European Space Agency's Rosetta, [will take] you to a page where [there are] oodles, oodles, and oodles of information. But it's run by the European Space Agency. The people who are actually interested in the ion trap experiments per se are the group at the Open University in Britain, and—

GRAYSON: What's the name of that?

MARCH: Open University. [. . .]

GRAYSON: I mean, it's an open university?

[33] "Rosetta," European Space Agency, last accessed December 17, 2015, http://www.esa.int/Our_Activities/Space_Science/Rosetta.

MARCH: It’s an open university. Yes. It’s a new concept. I don’t think it’s [out in the open]—in practice, it’s been going [a long time], I think it’s become normalized in with the rest. Yes. It’s very difficult to stay different for long. There are penalties.

GRAYSON: Well, that’s an interesting topic on which to conclude today’s work.

MARCH: Yes. So when [the original proposal for the Rosetta project was submitted for funding, in about 1994], they had to include a list of the ages of the proposal members, because the committee wanted to know if there would be anyone left when this thing got there. [laughter] Anybody left who knew what to do with it. And alas, Colin Pillinger, who was the leader, died in **<T: 60 min>** August. It was—

GRAYSON: So he’s the leader, but is gone. He’s no longer with us?

MARCH: No. He has gone.

GRAYSON: That is an interesting request.

MARCH: And they’re going to do isotope ratios with the thing, so—

GRAYSON: That’s very nice. Very nice.

MARCH: There we are.

GRAYSON: Well, is there any other items you want to talk about?

MARCH: I don’t think so. I put these things together. I had a—there’s a book there we haven’t discussed. I had a very good student from Brazil. The idea was he’d do his research with me, and write his thesis in Portuguese, and he had a Portuguese professor who was prepared to sponsor that.

GRAYSON: [Yes]. This is a book that he published?[34]

MARCH: This is a book that he published, but we are the authors, he and I and another fellow who unfortunately died shortly after.

GRAYSON: Ah, André [Sassine].

MARCH: Andre. Yes. So I've been twice to Brazil, and I was there last December.

GRAYSON: And this is on ion traps?

MARCH: On ion traps. Yes. So it spreads the message around. I had a very good visit. Oscar [Bustillos] has the heart of a lion. He played fullback for our rugby team [in Peterborough]. We have a rugby team here. I first played—when I first came to Peterborough, I played rugby, once [upon a time].

GRAYSON: Oh, my. That's kind of like, you don't want to do that too often. [laughter]

MARCH: But I played hooker, in the middle, and I was playing for Toronto Scottish, and came here, to Peterborough. The ground was terrible. That was my first visit to Peterborough. But Oscar was a fullback, and he's smaller than I am. I mean, he's less tall, and yet he will tackle anybody. Anybody with the ball, he will tackle and bring them down. Yes. Enormous courage. Yes.

GRAYSON: Courage?

MARCH: Yes. Well he's one of the two. The other one is a friend of mine who still lives in Peterborough, and he was a pilot, and he trained on aircraft like the Harvard, and then Canada bought the—they bought jets, jets, what were they called? Began with a V. Vampires [. . .] They bought about seventy-two of these jets, the first [jet fighters ever in Canada. A Vampire jet aircraft consisted of a gas turbine, a fuel tank, and stubby wings. There was no Vampire trainer

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34 O.V. Bustillos, A. Sassine, and R.E March. *A Espectrometria De Massas Quadrupolar* (Sao Paulo: Scortecci Editora, 2005).

aircraft, unlike most all other types of aircraft that had versions that accommodated both a student pilot and an instructor. For example, the de Havilland Chipmunk that I flew as a student pilot had two seats in tandem, one after the other, the front seat for the student and the rear seat for the instructor.]

[. . .] But in [Robert Guillett's] day, you went from [a prop aircraft directly] to your first [solo flight in a Vampire. One's solo in this jet aircraft was also one's] first trip in a Vampire, and not everyone made it, but Robert went up. He said it was like being kicked in the back, and took off, and all of a sudden you found yourself, you know, at fifteen hundred feet, going like hell, and you had to turn around. And he said, "I came back, and I saw the runway, and I came down, and down, and down." And he said, "I was going to land or crash, but I wasn't going to go around again." [laughter] And he landed. I mean, tremendous courage to do that.

GRAYSON: Going to get this puppy on the ground and leave it there.

MARCH: Yes. Stay there. [laughter] But we lost a lot of fighters, a lot of pilots with that. Yes. Anyway, that's just some of the interesting people that I've met.

GRAYSON: Very good. Well shall we call it a day?

MARCH: Yes.

GRAYSON: All right. I'll push the off button here.

[END OF AUDIO, FILE 1.4]

[END OF INTERVIEW]

APPENDIX I

Letter from Raymond March to Qiang Ma

Dear Professor Qiang,

Thank you for your reply. Let us begin to examine my comments on your paper and then proceed, hopefully, to a revised manuscript.

Major comments

1. "The ion mobility results in Figure 4 of your revised manuscript show clearly that there is only one species of protonated BSA; that is, there is only one structure shown for BSA, and that structure shows some five charged states." The discovery of multiply-protonated proteins, etc., forming a series of adjacent charge states was greatly appreciated because this discovery made possible the observation of proteins using mass spectrometers having modest mass ranges. Initially, it was thought that each charge state had a unique conformation. Later, with the advent of ion mobility spectrometers, it was found that, for some proteins, e.g. liver-fatty acid binding protein, L-FABP, several charge states exist in different conformations. With an ion mobility spectrometer, it can be observed for a given charge state that each of, say, two conformations has a unique collision diameter that can be calculated from the experimental arrival time. I will attach a copy of David P. Smith, Kevin Giles, Robert H. Bateman, Sheena E. Radford, and Alison E. Ashcroft, Monitoring Copopulated Conformational States During Protein Folding Events Using Electrospray Ionization-Ion Mobility Spectrometry-Mass Spectrometry, *J. Am. Soc. Mass Spectrom*. 2007, 18, 2180–2190. See Figures 1 and 3. This paper is distinguished; it was the first recipient of the Ron Hites Award.

2. "The mass spectrometry results show clearly that the number of hydoxylated PBDE molecules associated as ligands with each of the 14+ to 18+ charge states is ≤ 2. Does this result not indicate clearly that the two ligands must occupy the two major drug-binding sites of BSA, named Sudlow's drug binding site I and II, respectively. Other species of molecules can occupy many more than two sites on BSA."

   I have obtained a copy of Ref. 32 { G. Sudlow, D.J. Birkett, D.N. Wade, The characterization of two specific binding sites on human serum albumin, Molecular Pharmacology 11 (1975) 761 824–832.} to send to you. It appeared to me that the binding of ≤ 2 hydoxylated PBDE molecules with each of the 14+ to 18+ charge states was too much of a coincidence with our observation of ≤ 2 Ibuprofen molecules. We associated the binding of 2 Ibuprofen molecules with the two Sudlow binding sites I and II. Note that we did not confirm that our two Ibuprofen molecules occupied the two Sudlow binding sites I and II.

3. The mass spectrometry results are fascinating. I wanted to relate the total intensities before and after the addition of hydroxylated PBDE molecules, so I summed the peak

heights for the BSA alone to obtain Σ = 135.5 units, while the peak heights for the BSA plus hydroxylated PBDE molecules yielded Σ = 409.5 units. From these values, I argued that the latter signals had been amplified by a factor of × 409.5/135.5 = 3.02. Upon normalizing the MS data using the factor of 3.02 and summing the ion intensities in the individual charge states, one finds that the distribution of charge state intensities for BSA alone is 14 (18^+); 71.1 (17^+); 100 (16^+); 35.8 (15^+); and 3.3 (14^+). If the one and two hydroxylated PBDE molecules have added to each charge state in a similar manner such that the number of charges on any charge state does not change due to the addition of such a molecule, then the distribution of charge state intensities, for BSA plus hydroxylated PBDE molecules, should be similar to that for BSA charge states alone. Do you agree?

4. However, when I measured (albeit somewhat crudely) the data for the BSA + ligands, I found the distribution to be 15.1 (18^+); 53.6 (17^+); 100 (16^+); 76.0 (15^+); and 24.7 (14^+). Another to look at the data is to appreciate that the loss of ions from the 17^+ state is equal to the gain in ions for the 15^+ state and, similarly, the loss of ions from the 16^+ state is equal to the gain in ions for the 14^+ state. What do these results indicate? Upon consideration of these data, plus the almost negligible signal intensity for ions of the 19^+ charge state, I am of the opinion that a large fraction of hydroxylated PBDE molecules add as anions to BSA, decreasing the charge state of the host, while a small fraction of hydroxylated PBDE molecules add as neutral species to BSA, such that the charge state is unchanged. Thus there is a mixture of reactant molecules adding to BSA."

Explanation. Upon examination of the mass spectra shown in Figure 2(a) and (b) it appeared as though more ions were observed in Figure 2(b) than in Figure 2(a) simply because the sum of the peak heights in Figure 2(b) is clearly greater than the sum of the peak heights in Figure 2(a). I argued that the total degree of ionization (or the number of charged species produced per second from the ESI capillary) will remain constant for constant experimental conditions. Thus the addition of hydroxylated PBDE molecules will not change the number of charged species produced per second compared with the number of BSA ions in the mass spectrum of BSA alone. Note that in some mass spectra, the ion current of the base peak is sometimes given in the top right hand corner; however, in Figure 2 of your manuscript, no ion current values are given.

When we examine the 16+ peak in Figure 2(a) and compare it with the total of the three 16+ peaks in Figure 2(b) it would appear that more of the 16+ BSA charge state ions are formed when the hydroxylated PBDE molecules are added. This cannot be the case, so I summed (or added together) the peak heights of the five charge states 14+ to 18+ (in Figure 2(a)) for the BSA alone and I obtained a total peak height (NOT areas) of Σ = 135.5 units. Similarly, I summed (or added together) the peak heights for the same five charge states of BSA plus hydroxylated PBDE molecules; I obtained a total peak height of Σ = 409.5 units. From these values, I argued that the Figure 2(b) signals had been amplified by a factor of × 409.5/135.5 = 3.02. Thus, if I wished to compare ion populations of the five charge states in each of Figures 2(a) and (b) either I must multiply the peak heights of the five charge states 14+ to 18+ (in Figure 2(a)) for the BSA alone by the factor of × 3.02, or divide the peak heights of the five charge states 14+ to 18+ (in Figure 2(b)). I did the latter.

Next, I normalized the MS data by setting the peak height of the base peak in Figure 2(a) equal to 100. So, to recapitulate, I measured the peak heights of the five charge states in Figure 2(a) in millimeters and found that the relative peak heights for 18+ through to 14+ were 8.5: 43: 60.5: 21.5: 2. I can normalize these values by setting the largest peak, 16+, to have a peak height of 100 units. I then found that the distribution of charge state intensities (based on peak height measurements) for BSA alone is 14 (18^+); 71.1 (17^+); 100 (16^+); 35.8 (15^+); and 3.3 (14^+). I had measured all of the peaks in Figure 2(b) and I obtained a total peak height of Σ = 409.5 units (as above). I divided the total peak height for each charge state by the factor of 3.02 to obtain the relative peak heights for 18+ through to 14+ as 7.6: 26.8: 50.3: 38.2: 12.4. Once more I can normalize these values by setting the largest peak, 16+, to have a peak height of 100 units. I then found that the distribution of charge state intensities (based on peak height measurements) for BSA + hydroxylated PBDE molecules is 15.1 (18^+); 53.6 (17^+); 100 (16^+); 76.0 (15^+); and 24.7 (14^+). I have tabulated the non-normalized values in Table 1 to show the gain/loss change for each charge state.

Table 1. Relative charge state signal intensities for BSA alone (Figure 2(a), I_0, and for BSA plus hydroxylated PBDE molecules (Figure 2(b), ($I_0' + I_L$), where I_0' is the remaining BSA and I_L is the added ligand. The difference between I_0 and ($I_0' + I_L$) is shown in the Gain/(Loss) column.

Charge state	Initial charge state intensity (Figure 2(a)), I_0 $\Sigma = 135.5$	Final charge state intensity (Figure 2(b)), ($I_0' + I_L$) $\Sigma = 135.5$	Gain/(Loss) ($I_0' + I_L$) - I_0
18+	8.5	7.6	(-0.9)
17+	43	26.8	(-16.2)
16+	60.5	50.3	(-10.2)
15+	21.5	38.2	+16.7
14+	2	12.4	+10.4

Note that the sum of initial charge state intensities (column 2) is equal to the sum of final charge state intensities (column 3). Even though the measurement of ion intensity was inferred from peak heights, with no allowance being made for overlap between ion species in Figure 2(b), such as overlap between the ‘0’ peak of the 16+ charge state and the peaks labeled ‘1’ and ‘2’ of the 16+ charge state, two conclusions can be drawn here.

There is a loss of ion intensity in the 18+, 17+, and 16+ charges states due to reaction of BSA with hydroxylated PBDE molecules, and

1. Not only is there a gain of ion intensity in the 15+ and 14+ charge states due to reaction of BSA with hydroxylated PBDE molecules, but the magnitudes of the gains in the 15+ and

14+ charge states are equal to the magnitudes of the losses in the 17+ and 16+ charges states, respectively.

From these observations, if the one and two hydroxylated PBDE molecules have added to each charge state in a similar manner such that the number of charges on any charge state does not change due to the addition of such a molecule, then the distribution of charge state intensities, for BSA plus hydroxylated PBDE molecules, should be similar to that for BSA charge states alone. Do you agree? In this case, the ligand hydroxylated PBDE molecules can be proposed either as neutral species or as deprotonated molecules that cluster with BSA simultaneously with addition of a proton from solution so that the charge of the reactant charge state remains unchanged. Both of these processes have been proposed in the literature. Upon consideration of the data in Table 1, particularly the magnitudes of the gains in the 15+ and 14+ charge states being equal to the magnitudes of the losses in the 17+ and 16+ charges states, respectively, I am of the opinion that a fraction of hydroxylated PBDE molecules add as anions to BSA, decreasing the charge state of the host, while a small fraction of hydroxylated PBDE molecules add as neutral species to BSA, such that the charge state is unchanged. Thus there is a mixture of reactant molecules adding to BSA. I then propose a model for the reaction of BSA with hydroxylated PBDE molecules as follows:

$$M^{n+} + L \rightarrow ML^{n+} \qquad (1)$$
$$M^{n+} + 2L \rightarrow ML_2^{n+} \qquad (2)$$
$$M^{n+} + L^- \rightarrow ML^{(n-1)+} \qquad (3)$$
$$M^{n+} + 2L^- \rightarrow ML^{(n-2)+} \qquad (4)$$

It is assumed that the maximum number of hydroxylated PBDE molecules forming ligands (L) with a given BSA charge state is two. M^{n+} represents any one of the five charge states observed for BSA. Up to two deprotonated hydroxylated PBDE molecules (L^-) may cluster with a BSA charge state. It is assumed further that reactions (2) and (4) occur sufficiently rapidly that it is not necessary to invoke further reactions of ML^{n+} and $ML^{(n-1)+}$ with L and L^-, respectively. In Table 2 are shown the relative intensities for each of the 15 peaks in Figure 2(b). The procedure is to discuss the fates of each of the initial charge state intensities so as to arrive at the final experimental charge state intensities calculated for Figure 2(b). Once the fates of all of the initial ion intensities have been proposed, that is, allocated to the 15 peaks in Figure 2(b), it should be possible to determine the chemical processes equivalent to these fates. Hopefully, the chemical processes defined by the allocation of the initial charge state ion intensities will correspond to those in the model proposed above.

Table 2. The ion relative intensities for each of the 15 peaks in Figure 2(b).

Charge state peak	Peak intensity	Charge state peak	Peak intensity
18_0^+	3.3	15_0^+	10.9
*18_1^+	2.6	15_1^+	15.6
18_2^+	1.7	15_2^+	11.8
17_0^+	10.4	14_0^+	3.8
17_1^+	10.4	14_1^+	4.8
17_2^+	6.1	14_2^+	3.8
16_0^+	15.9		
16_1^+	20.2		
16_2^+	14.2		

*18_1^+ represents the 18^+ charge state in Figure 2 (b) where the number 1 represents the number of hydroxylated PBDE ligands. Note that the number of ligands in Figure 2(b) can be 0, 1, or 2 only.

Table 3. Allocation of ions from Figure 2(a) to Figure 2(b).

Charge state $[I_0]$	Peak	Peak	Peak	Gain/(Loss) $(I_0' + I_L) - I_0$
18^+ [8.5]→	18_0^+ 3.3	18_1^+ 2.6	18_2^+ 1.7	-0.9
17^+ [43] →	17_0^+ - 10.4	17_1^+ 0.9 9.5	17_2^+ - 6.1	-16.2
16^+ [60.5] →	16_0^+ - 15.9	16_1^+ 9.4 10.8	16_2^+ - 14.2	-10.2
15^+ [21.5] →	15_0^+ - 10.9 -	15_1^+ 10.2 5.4 -	15_2^+ - 5.0 6.8	+16.8
14^+ [2] →	14_0^+ 2 (should be 3.8 as observed in Figure 2(b))[a]	14_1^+ - 4.8[b]	14_2^+ - 3.8[c]	+10.4

[a] There are only 2 units of 14^+ in Figure 2(a) and, in the absence of any reaction among reactants that produces 14_0^+, then there is a deficiency for 14_0^+ in Table 3. This is the only deficiency in Table 3.
[b] As there were only 2 units of 14^+ in Figure 2(a), the only source for 14_1^+ is Reaction (3), that is, $15_0^+ + L^- \rightarrow 14_1^+$. The signal intensity observed in Figure 2(b) for 14_1^+ is 4.8.

[c] Similarly, as there were only 2 units of 14^+ in Figure 2(a), the only source for 14_2^+ is Reaction (4), that is, 16_0^+ + $2L^- \rightarrow 14_2^+$. The signal intensity observed in Figure 2(b) for 14_2^+ is 3.8.

Conclusions:

Peaks 18_1^+, 17_1^+, 16_1^+, and 15_1^+ are formed by Reaction (1).
Peaks 18_2^+, 17_2^+, 16_2^+, and 15_2^+ are formed by Reaction (2).
Peaks 17_1^+, 16_1^+, and 15_1^+ are formed also by Reaction (3); peak 14_1^+ is formed only by Reaction (3).
Peaks 15_2^+ and 14_2^+ are formed by Reaction (4).

[This is the end of my letter to Dr. Qiang, I hope you might decide to use it as it is an important contribution to this field; furthermore, this letter constitutes the only specific evidence of my contribution to Qiang's publication.]

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