

CHEMICAL HERITAGE FOUNDATION

**CATHERINE FENSELAU**

Transcript of an Interview  
Conducted by

Michael A. Grayson

at

University of Maryland  
College Park, Maryland

on

13-14 April 2012

(With Subsequent Corrections and Additions)

CHEMICAL HERITAGE FOUNDATION  
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## CATHERINE FENSELAU

1939 Born in York, Nebraska, on 15 April

### Education

1961 AB, Bryn Mawr College, Chemistry  
1965 PhD, Stanford University, Organic Chemistry

### Professional Experience

1966 University of California, Berkeley, CA  
Postdoctoral Fellow

1967 NASA Space Sciences Laboratory  
Postdoctoral Fellow

1967-1987 Johns Hopkins University School of Medicine  
Instructor to Professor, Department of Pharmacology and  
Molecular Science

1980 University of Warwick, United Kingdom  
Visiting Professor

1986 Kansai University, Japan  
Visiting Professor

1991 Moscow Institute of Physics and Technology  
Exchange Lecturer

1987-1998 University of Maryland, Baltimore County  
Professor and Chair, Department of Chemistry and Biochemistry  
1995-1996 Interim Dean of the Graduate School and Associate Vice  
President for Research

1998-present University of Maryland, College Park  
Professor, Department of Chemistry and Biochemistry  
1998-2000 Chair, Department of Chemistry and Biochemistry  
2007-present Affiliate faculty, Fischell Department of Bioengineering

## Honors

1965-1966	Fellow, American Association of University Women
1970-1974	NIH Research Career Development Award
1982	ACS, Best Paper of the Year in Drug Metabolism Disposition
1985	ACS, Garvan medal
1989	Maryland Chemist Award, ACS Chesapeake Section
1991-2001	NIH Merit Award
1993	Medal of the Spectroscopy Society of Pittsburgh
1997-1998	Robert and Jane Meyerhof chair in Biochemistry
1998-2010	Board of Trustees, Maryland Science Center
1999	Eastern Analytical Symposium Award for Achievements in Analytical Chemistry
2001	Fellow, American Association for the Advancement of Science
2003	Hillebrand Prize, ACS Capitol Section
2006-present	Honorary Foreign Member of the Japanese Society for Mass Spectrometry
2006	Braude Award, ACS Chesapeake Section
2008	ACS Field and Franklin Award for Contributions in Mass Spectrometry
2009	Thomson Medal, International Mass Spectrometry Foundation
2010	Ralph Adams Award for Bioanalytical Chemistry, Pittsburgh Conference (or Spectroscopy Society of Pittsburgh)
2012	Distinguished Contribution Award, American Society for Mass Spectrometry

## ABSTRACT

**Catherine Fenselau** grew up in York, Nebraska, one of two daughters. Her mother was a violinist and a holder of master's degrees who taught at York College, thus continuing a long family tradition of educated women. Catherine's father was a businessman in York. Always interested in science, first archaeology and ultimately chemistry, she attended Bryn Mawr College. The chairman of the chemistry department, Ernst Berliner, became the first of her three mentors.

Fenselau received her PhD in organic chemistry from Stanford University, working in the lab of Carl Djerassi, who became her second mentor. Using mass spectrometry for organic research was new, so she felt she was more easily able to overcome any gender bias; her thesis was on the mechanisms of fragmentation. While in graduate school she met and married Allen Fenselau. When she went to Berkeley for her post doc, she entered Calvin Melvin's huge lab, working directly with Alma Burlingame and actually using a mass spectrometer for the first time. This instrument was the CEC 21-110, with electron ionization. She was funded by the American Association of University Women and later the National Aeronautics and Space Administration (NASA), for whom she analyzed surrogate moon rocks.

Her husband accepted a position at Johns Hopkins University School of Medicine and Fenselau also took a position there. At Hopkins she was able to study a broad range of biomedical problems, not just drugs, and her research shifted its direction more toward biochemistry, where she now feels she has ended up. Her third mentor, Paul Talalay, helped her buy her first spectrometer, the CEC 21-110 with photo plates, the machine she used for bacterial analysis and for research into anti-cancer treatments, studying drugs such as cyclophosphamide, about which she wrote one of her most-cited papers with oncologist Michael Colvin.

Fenselau accepted the chairmanship of the chemistry department at University of Maryland, Baltimore County, in part because she wanted to do more teaching. With funding from the National Institutes of Health (NIH), the Defense Advanced Research Programs Agency, and the National Science Foundation (NSF) she established a regional mass spectrometry center there and acquired several types of instruments, including a JEOL four-sector machine and eventually a MALDI Fourier transform mass spectrometer. Here she began her work analyzing whole proteins, publishing papers about using mass spectrometry to map protein topography and about HIV Gag proteins.

Taking her MALDI instrument with her, Fenselau moved to University of Maryland, College Park, for a two-year stint as chairman of the chemistry department and completing her transformation into a biochemist. She was involved in the study of anthrax—Amerithrax—promoting the rapid detection and characterization of bacteria with mass spectrometry and she established the US Human Proteomics Organization (USHUPO), becoming its first president. She continues to teach and to conduct research in proteomics and bioinformatics.

Throughout her interview Fenselau discusses fellow scientists, their contributions to mass spectrometry, and their career paths. And she talks about various mass spectrometers and their pros and cons; she says that analytical chemistry continues to be scorned, though many scientists do it, and that it prevails in the state schools. The interview concludes with her thoughts about her graduate students and her patents, emphasizing the importance of publishing, as well as her experiences in American Society for Mass Spectrometry.

## INTERVIEWER

**Michael A. Grayson** retired from the Mass Spectrometry Research Resource at Washington University in St Louis in 2006. He received his B.S. degree in physics from St. Louis University in 1963 and his M.S. in physics from the University of Missouri at Rolla in 1965. He is the author of over forty-five papers in the scientific literature dealing with mass spectrometry. 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 under O. P. Tanner. Grayson is a member of the American Society for Mass Spectrometry [ASMS], and currently is the Archivist for that Society. He has served many different positions within ASMS. He has served on the Board of Trustees of CHF and is currently a member of CHF's Heritage Council. He continues to pursue his interest in the history of mass spectrometry by recording oral histories, assisting in the collection of papers, researching the early history of the field, and preparing posters recounting historic developments in the field.



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favorite papers. James Yergey. Plamen Demirev. Competition. Work on Laetrile for Food and Drug Administration (FDA) got product removed from market. Her only paper in *Science*.

### Moving South

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Wanting to teach more, moves to University of Maryland, Baltimore County (UMBC). Begins protein work, analyzing whole proteins. Proteomics. Also was chairman of department. Freeman Hrabowski an excellent president. NSF funded JEOL four-sector machine, biggest on campus. FAB upgraded to electrospray; cost a million dollars. Japanese engineers set up in four days. Arginine. Seldom-cited paper about using mass spectrometry to map protein topography. Paper about HIV Gag proteins. Graduate students. Proteomics new buzzword; tripled ASMS membership. Success at UMBC: doubled department space; nuclear magnetic resonance developed as its strength. Students good, international, especially Chinese. Analytical chemistry becoming useful and attractive discipline.

### Further South

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Moved to University of Maryland, College Park (UMCP) as department chair. Involved in study of Amerithrax. Rapid detection of bacteria with mass spec. Department much larger; spent two years as chair, hired good faculty. School's budget, tuition, lab costs, necessary furloughs. Lab composition: all graduate students, no postdocs, mostly women. Startup package included AB Sciex quadrupole-time of flight (Q-TOF); also has Shimadzu matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF). Establishes US Human Proteomics Organization (USHUPO). Funding from Defense Advanced Research Projects Agency (DARPA): rapid characterization, not biochemistry, of bacteria. Collaboration with Demirev. Federal Bureau of Investigation (FBI) investigation of Amerithrax. Revisiting bacteria studies whenever technology improves. Using *Bacillus anthracis* non-pathogenic strain. Nathan Edwards and bioinformatics. Analytical chemistry looked-down-upon; mostly done at state schools. Patents: income from them; who gets them. Importance of publishing. Theory of viruses not yet fully tested.

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**INTERVIEWEE:** Catherine Fenselau

**INTERVIEWER:** Michael A. Grayson

**LOCATION:** University of Maryland  
College Park, Maryland

**DATE:** 13 April 2012

**GRAYSON:** [...] So, we'll go ahead and start off by saying that this is April 13<sup>th</sup>, Friday the 13<sup>th</sup>. I'm at University of Maryland, College Park, in the Biochemistry Building with Professor Catherine Fenselau. We are going to begin a little oral history interview of her career. So we usually start these wonderful things in the very beginning. Try and remember if you can that we'd like to also get the specifics about who, what, where, when, how and why, so particularly dates are nice to be able to tie things down to. I'll be probably pounding on the keyboard occasionally, because I'm creating a word list for the transcriptionist, who doesn't know all this stuff.

**FENSELAU:** Multitasking.

**GRAYSON:** Well, I don't multitask too well. So back in the beginning, it looks you grew up on the West Coast.

**FENSELAU:** No. You know, I grew up in Nebraska.

**GRAYSON:** Oh my, another Nebraska person.

**FENSELAU:** In fact, twenty-five miles from Fred McLafferty's wife, [Elizabeth (Tibby) Curley].<sup>1</sup>

**GRAYSON:** Fred...wow, that's amazing. That's...

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<sup>1</sup> Fred W. McLafferty, interview by Michael A. Grayson at Cornell University, Ithaca, New York, 22 and 23 January 2007 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0352).

**FENSELAU:** [Talking with someone in office]

**GRAYSON:** That's interesting. The Midwest seems to be a fairly good resource for people going to science.

**FENSELAU:** Or for people leaving.

**GRAYSON:** [Yes], leaving Nebraska. [Yes]. So this was on a farm or...

**FENSELAU:** No. It was a small town, about six thousand at the time, it was the county seat of an agricultural county.

**GRAYSON:** And you went to...

**FENSELAU:** Public schools.

**GRAYSON:** The school there, your high school and grade school education was in this small...

**FENSELAU:** Yes, in York, Nebraska, named after York, Pennsylvania.

**GRAYSON:** York, okay, very good.

**FENSELAU:** By the settlers who came west after the Civil War.

**GRAYSON:** And your parents were...what was their background or level of education? Were they...

**FENSELAU:** My mother's [Muriel Thomas Clarke] father [David William Thomas] emigrated from Wales, settled in [a Welsh community in] Iowa. [He married the local postmistress, Lola Wiley Thomas.] The Welsh have a millennia-long tradition of culture. My mother was educated through college, and also played the violin very well. She eventually had master's degrees in music, in Spanish, and in librarianship...

**GRAYSON:** Oh, boy.

**FENSELAU:** And she came to York to teach in the small college there, and teach violin. My father [Lee Keckley Clarke] was born in York, and he had a degree from the University of Nebraska, and they met at that time. During the Depression, when my mother got married she was told she would no longer have a salary, but she could continue to work.

**GRAYSON:** Great. So was she working...did you mention a school she was...

**FENSELAU:** Well, it was called York College.

**GRAYSON:** York College, okay.

**FENSELAU:** Yes. You know after the Civil War, colleges sprouted like apple trees all over the country.

**GRAYSON:** [Yes]. Okay. [Yes]. It's interesting there were so many land grant colleges that came into being over that period after the Civil War. So...

**FENSELAU:** Including [my present employer], by the way. University of Maryland.

**GRAYSON:** [Yes]. [Yes]. Well, Cornell [University], and they're all over the place. So I imagine then that your home life was pretty rich in <**T: 05 min**> terms of intellectual encouragement, enrichment in terms of getting your brain to function and do something besides...

**FENSELAU:** I think that's fair, sure.

**GRAYSON:** [Yes].

**FENSELAU:** There were two children, and we were both daughters. They say that fathers with no sons encourage their daughters to do some of the things boys do. So we got lots of encouragement.

**GRAYSON:** The environment around York, I guess it was primarily a farming community for the most part.

**FENSELAU:** There were about seventy-one people in my high school graduating class, but six of them went on to MD's or PhD's. So you know there was a good gene pool. After the Second World War, [more] people were given [more] opportunities for higher education.

**GRAYSON:** [Yes]. So somewhere along the way you decided of all the intellectual possibilities out there, that you thought science and/or chemistry would be something that would be fun to do or interesting, or...

**FENSELAU:** Well, certainly science. We took a lot of family trips. Every summer we went west or north. I loved the archaeology at Mesa Verde National Park. There was a lady ranger there. I really wanted to be an archeologist. She said, "Oh, you may not want to be an archeologist, because they won't let me go out in the field and dig. I have to stay in the museum and categorize." So I said, "Well, I'll find some other kind of science."

Now she was wrong, because when I got Bryn Mawr [College], I found there were women archeologists digging in Greece.

**GRAYSON:** Sure.

**FENSELAU:** But in any case...

**GRAYSON:** They wouldn't let her dig.

**FENSELAU:** They wouldn't let her dig, and then...

**GRAYSON:** Maybe there was a reason for that.

**FENSELAU:** So I looked over the rest of the sciences and thought that chemistry was the most interesting.

**GRAYSON:** So this was a fairly conscious decision.

**FENSELAU:** Yes.

**GRAYSON:** It wasn't...

**FENSELAU:** Well, you know catalyzed by Sputnik.

**GRAYSON:** Oh, yes. Okay.

**FENSELAU:** There's a whole generation of us who were encouraged and then supported by the government after Sputnik.

**GRAYSON:** [Yes], indeed. So were there any teachers in high school or any individual you can recall who put a little bit of the bug in your ear? Or did you just decide...

**FENSELAU:** I liked my driver education teacher.

**GRAYSON:** Okay.

**FENSELAU:** Well, the science folks were really trying hard, but they didn't...I mean, I came to this enthusiasm independently.

**GRAYSON:** Okay. You weren't inspired by any of them.

**FENSELAU:** They were good, but it wasn't...

**GRAYSON:** But not inspirational...



**FENSELAU:** [Yes]. I also thought I had an excellent history teacher, excellent English teacher, you know. It was, in fact, as a point in time, these were teachers— women teachers—who felt like they'd lost their potential husbands in the First World War. So they were very good teachers, overqualified, and it was just a nice time to be in a public school.

**GRAYSON:** That's an interesting phenomenon. [Wednesday], I was sitting on a session at the Chemical Heritage Foundation [CHF], where they're talking about trying to create a virtual chemistry set. So they had everyone there talking about what experience they had with chemistry sets. The president of CHF [Thomas R. Tritton] made an interesting comment. He says, "There are some people who are just dedicated to being scientists. It's in their genes. Other people get inspired." But apparently, you're one of those persons with whom that was the thing. You really wanted to get into the science.

**FENSELAU:** Some kind of science, yes. I also had a chemistry set, but I think that they didn't provide very good instructions. I can't remember ever using it. It was [the] blue [Gilbert], the one everybody had. But my father had a mysterious wooden chest in the basement that he called his chemistry set. It had lots of things in it that weren't in my FDA [Food and Drug Administration]-approved chemistry set, including a recipe to make stink bombs.

**GRAYSON:** Okay. Did he ever make any, or...

**FENSELAU:** No. I made one and took it to school.

**GRAYSON:** All right, so did this make an impression on anybody?

**FENSELAU:** It did, but they never identified the perpetrator.

**GRAYSON:** Oh, now we know. We can go back to York College...

**FENSELAU:** This is the first time—York High School—this is the first time I've talked about it.

**GRAYSON:** Quite interesting. But you weren't inspired by the chemistry set to make the stink bomb. You were inspired by the things your father had squirreled away.

**FENSELAU:** Well, that's right.

**GRAYSON:** Was he a chemist? Or...

**FENSELAU:** The homemade chemistry set was more interesting.

**GRAYSON:** I was wondering, maybe was he doing a little home brew?

**FENSELAU:** Not that I could tell from what was in the set. But that would have been from [...] when he was a youth, which would have been 1920.

**GRAYSON:** So that would have been a really very early chemistry set, yes. Well, obviously today's chemistry sets are pretty...how would you say? Tame, I think is...

**FENSELAU:** Sanitized.

**GRAYSON:** Right. So you got away with this little escapade which now we'll all know about. You'll get a chance to clean it up if you want. So then you decided that you wanted to go to college. You went to York College. Is that correct?

**FENSELAU:** [No].

**GRAYSON:** No.

**FENSELAU:** No. Well, with a mother who was a professional teacher, and Sputnik, and all of the government's interest in higher education, I was able to look further away. I glanced briefly at the University of Nebraska and decided the Greek system was too strong there, and applied to a number of the Seven Sisters colleges. A family friend who had, in fact, graduated recently from the University of Nebraska told me that if she had it to do over again, she'd go to a Seven Sisters college.

So I applied to three of those. Then I applied to Stanford [University]. So that's both an East Coast and a West Coast ambivalence. And in the end went to Bryn Mawr, just in the

Philadelphia [Pennsylvania] suburbs. Then I did get to go to Stanford [University] for graduate school.

**GRAYSON:** So were you able to be accepted in the various Seven Sisters schools that you did apply to, the different ones?

**FENSELAU:** [Yes].

**GRAYSON:** So it was a matter of your choice then.

**FENSELAU:** Yes. I can't remember which ones I applied to beside Bryn Mawr and Stanford, but those were the two I finally chose between.

**GRAYSON:** Okay. What happened during your...

**FENSELAU:** Oh, I had to take the SATs [Scholastic Aptitude Tests]. They were not widely given in Nebraska. So we actually had to drive a hundred miles into Omaha [Nebraska] to take them. My parents drove me.

**GRAYSON:** But they did have that. That was in what, probably, I'm guessing, 1957.

**FENSELAU:** Yes.

**GRAYSON:** [...] So those were in force by then, I guess, the SATs and...

**FENSELAU:** Well, for the colleges I was looking at, they were required.

**GRAYSON:** Okay, this was a requirement. So when you reached Bryn Mawr, this was, kind of, a little bit of a culture change from the Midwest?

**FENSELAU:** Sure.

**GRAYSON:** So how did you adapt to that? That was...

**FENSELAU:** Well, I loved the science, and I worked hard. I tried to figure out all those very large houses built out of elegant Wissahickon schist.

**GRAYSON:** [Yes].

**FENSELAU:** And tried to party in Philadelphia as much as I could.

**GRAYSON:** Well, that's good. But...

**FENSELAU:** Yes. I bet you have trouble spelling "Wissahickon schist."

**GRAYSON:** Well, I've got the "schist" part, but how do you spell Wicken... what?

**FENSELAU:** I'm not sure I know either. We'll have to check it out.

**GRAYSON:** I'll check it out. [...] So what kind of curriculum did they have in chemistry?

**FENSELAU:** At Bryn Mawr?

**GRAYSON:** At Bryn Mawr.

**FENSELAU:** Actually a very proud curriculum. The chairman of the department was a man named Ernst Berliner, who had been a Louis [F.] Fieser student. Louis Fieser was a famous Harvard [University] organic chemist, who taught at Bryn Mawr for a couple of years, married one of his students named Mary. Of course, Louis and Mary Fieser published a whole series of organic textbooks.<sup>2</sup>

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<sup>2</sup>Beginning with Louis F. Fieser and Mary Fieser, *Organic Chemistry*, 1st ed. Boston: D.C. Heath and Co., 1944.

**GRAYSON:** Sure. That was the Fieser & Fieser...

**FENSELAU:** Yes, the Fieser & Fieser series. So I think that he hand-picked Ernst Berliner to go to Bryn Mawr. Berliner was able to hire good faculty, not a lot of faculty. They had a number of faculty wives who were the teaching assistants. So it was very classy. They had a fair number of majors. There were probably twelve majors in my class. This was before women were widely admitted to medical school. So maybe eight of those majors wanted to be chemists, and the other four were hopeful pre-meds.

**GRAYSON:** So this Berliner fellow, he sounds like he was European. Did he come from Germany?

**FENSELAU:** Yes. You have a question here about mentors, and I've had three wonderful mentors. They were all Jewish immigrants, Jewish refugees at that.

**GRAYSON:** So did he come from Germany as a result of the tensions that were in Germany at that time?

**FENSELAU:** Yes.

**GRAYSON:** So he got out before things got nasty.

**FENSELAU:** As things got nasty.

**GRAYSON:** As things got nasty.

**FENSELAU:** [Yes].

**GRAYSON:** And Fieser facilitated him getting a position?

**FENSELAU:** Well, he did his PhD with Fieser at Harvard.

**GRAYSON:** Oh, okay.

**FENSELAU:** So he was a student of Fieser's, and I think Fieser took care of Bryn Mawr, because <T: 15 min> he taught there, and he met his wife there. So sent us a very good scholar. Berliner also married one of his students at Bryn Mawr.

**GRAYSON:** Pretty common, huh?

**FENSELAU:** Yes, I think it was. It was. Ernst stayed happily and constructively there. He was a wise man. He understood that there was value in having a record of all the women he trained and had a notebook with the locations people worked after they graduated. That was subsequently used to obtain funding from NSF [National Science Foundation] when the time was right.

**GRAYSON:** So the size of the class at Bryn Mawr was...

**FENSELAU:** I think we had a hundred seventy in my whole class, and about [twelve] of those were chemistry majors.

**GRAYSON:** So would it be considered more like a liberal arts college?

**FENSELAU:** Well, they had [geology.] They had good archeology, going back to that theme.

**GRAYSON:** Oh, really?

**FENSELAU:** And physics there was, kind of, old-fashioned, but it had very capable people doing that. I say old-fashioned because we actually did the Faraday experiment.

**GRAYSON:** Oh, wow.

**FENSELAU:** [Yes], which people don't even hear about anymore. So...

**GRAYSON:** No. So what is that?

**FENSELAU:** That's where you electrolyze a weighed amount of, I think, copper, and measure the current that had to be used to transfer that mass to some other electrode. Then you can figure out Avogadro's number.

**GRAYSON:** Oh, wow. So how close did you come or did you...

**FENSELAU:** Probably not very well, but...

**GRAYSON:** I guess it's always nice to have the experiments that they already know what the answer is. They don't depend on your coming up with the right answer.

**FENSELAU:** That's right.

**GRAYSON:** So it was reasonably, kind of, a close environment, I guess. Did you have any homesickness coming out of the Midwest?

**FENSELAU:** Oh, I surely must have missed it. But I wasn't really, like, depressed or anything. We had to travel by trains, so you know some Haverford [College] boy would take me to the train station early to get home for Christmas. Then I changed trains in Chicago and [would] go on into, actually, probably Lincoln, not to York.

Then my last year, which would have been 1961, air flight was more accessible. So I think I actually got to fly home at Christmas my senior year. But it was all exciting. I mean, I sat on my front porch that last summer—the summer after I graduated from high school—and said, “I really want to go see the rest of the world!”

**GRAYSON:** Well, I can understand.

**FENSELAU:** Yes. So Philadelphia was part of the rest of the world.

**GRAYSON:** Oh, [yes]. Well, it's a pretty big part of the rest of the world. So how was tuition there? This was a private school, right.

**FENSELAU:** Yes. My parents thought it was expensive. I had a scholarship, and I have no idea what the price...what actually the number was.

**GRAYSON:** But it was considered to be a little bit, as a private school, it was probably a little bit pricier than...

**FENSELAU:** The University of Nebraska would have been. [Yes].

**GRAYSON:** [Yes]. But because [of] the scholarship, financing wasn't an issue...

**FENSELAU:** I think because of my parents' wish to give me all the chances, all the possibilities, open all the doors that I...

**GRAYSON:** A good attitude that pervades in many families. Not as many as it should today. So that was pretty nice. You didn't have to be concerned with financial things, and...

**FENSELAU:** Right.

**GRAYSON:** So this Berliner fellow was a mentor to you at the time.

**FENSELAU:** I would call him one of my three major mentors, [yes].

**GRAYSON:** So what did he do that impressed you?

**FENSELAU:** Well, he let me work in his lab a couple of summers. I also worked with a man named Frank [B.] Mallory, who was a younger organic chemist on that faculty.

**GRAYSON:** M-A-L-L-O-R...

**FENSELAU:** Y.

**GRAYSON:** R-Y, okay.



**FENSELAU:** And learned things from both of them. But Berliner and the whole department just conveyed to us that we could. We could do it. We could do chemistry. We could have serious expectations.

**GRAYSON:** There was no negativity towards your being a woman entering a scientific field.

**FENSELAU:** Right. I mean, that's the advantage of a woman's college, right?

**GRAYSON:** Well, yes. Yes. But you know science is normally considered to be, you know...

**FENSELAU:** It was at that time...

**GRAYSON:** At that time, because I know from talking to Mildred Cohn in her oral history.<sup>3</sup> She was you know <T: 20 min> resisted every step of the way in her pursuit of...

**FENSELAU:** She was just a decade ahead of me, maybe.

**GRAYSON:** Probably. She was working for Harold [C.] Urey at Columbia in the mid-1930s.

**FENSELAU:** Oh, no, more than a decade.

**GRAYSON:** So it would almost two decades.

**FENSELAU:** [Yes]. Well, so that would be before the Second World War, and I really think that changed a lot of things in our country, plus the Sputnik.

**GRAYSON:** She also had the Jewish problem. She had a lot of resistance because of her background. But [yes], and of course, Columbia is a different place than Bryn Mawr. As you

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<sup>3</sup> Mildred Cohn, interview by Leon Gortler at the University of Pennsylvania, Philadelphia, Pennsylvania, 15 December 1987 and 6 January 1988 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0080).

say, they're interested in promoting. So that worked out pretty well. Were there any others, because Mallory and Berliner who were helping you out and giving you guidance in chemistry there?

**FENSELAU:** Well, there was an inorganic chemist named, Joe [Joseph] Varimbi a physical chemist named George [L.] Zimmerman...

[...] Then, as I said, there were a number of faculty wives who also helped with the teaching, [Dr. Frances] Berliner, [Dr. Sally] Mallory...

**GRAYSON:** So but they were like tutors or did they...

**FENSELAU:** No, laboratories.

**GRAYSON:** Laboratory.

**FENSELAU:** [Yes].

**GRAYSON:** Okay. So you had the full laboratory experience. What labs? Organic chemistry, or...

**FENSELAU:** Oh, absolutely.

**GRAYSON:** Org labs, and all that good stuff. Okay. So that was a full-blown, total immersion chemistry thing.

**FENSELAU:** [Yes]. It was a real, a real major.

**GRAYSON:** Okay. So now, I mean but did you start out going there saying, "I want to do chemistry"?

**FENSELAU:** [Yes].

**GRAYSON:** Or did you go there thinking, “Let’s look around, and I’ll decide later?”

**FENSELAU:** No. You know, you knew. You do know if you were going to major in one of the sciences, you have to start from the beginning.

**GRAYSON:** You could start early, [yes].

**FENSELAU:** [Yes]. So I went there and announced chemistry. Actually the college had a number of other requirements including proficiency in two foreign languages. I was able to take my German courses on campus, but the chemistry requirements took so much time that I needed to go to summer school to learn French. So I went to Harvard summer school. I talked my parents into letting me go to Harvard summer school to learn French.

**GRAYSON:** Learn French. So you get past that requirement.

**FENSELAU:** Yes.

**GRAYSON:** Language requirements are passé these days.

**FENSELAU:** Yes. Yes. But you know it’s been fun. I mean, they were almost immediately not relevant in science. I did read a couple of papers in German. But it’s been fun, though, to have some proficiency as a tourist.

**GRAYSON:** [Yes]. That does come in handy. I can always get by reading signage usually in Europe, but you wouldn’t want to catch me a conversation.

**FENSELAU:** [Yes]. That’s right.

**GRAYSON:** So you completed the curriculum there in pretty much the standard four years arrangement.

**FENSELAU:** [Yes].

**GRAYSON:** Were you taking typically eighteen hours?

**FENSELAU:** I think it converted to sixteen.

**GRAYSON:** Sixteen.

**FENSELAU:** [Yes]. But you know, lab courses are always more time than the credit hours.

**GRAYSON:** Oh, sure. When did you decide—or did you already know—you wanted to go on to graduate school? Was that...

**FENSELAU:** Well you know, [it was] certainly the right time, and perhaps there was more nudging there from the faculty than I realized. But I went around and talked to the faculty in the fall of my senior year about where would be good graduate schools to go. I think that was a trickier decision, because one of the schools they suggested was [University of] Minnesota, and I did not go there. But they shortly got sued for their sex discrimination record. So it wouldn't have been a pleasant place had I gone there.

I decided to try the other coast, since I'd been tempted already by the West Coast. So the Christmas of my senior year my parents sent me to California to interview at [University of California at] Berkeley, Stanford, and the new campus at UCSD [University of California at San Diego]. Then I visited an aunt in Los Angeles [California], in Pasadena [California]. It was kind of interesting because Berkeley and Stanford both accepted me, and offered me TAs.

Then when I didn't respond to the TAs at Berkeley immediately, they sent me a letter and raised the TA. But anyway, I went to Stanford, but I postdoc'd in Berkeley. I learned that they need so many TAs that they kind of treated them like cannon fodder, did at that time, and that they fully expected to fail out half of the first year class. So on the left and on the right, there were treacherous valleys that I avoided.

**GRAYSON:** Yes. Yes. [Yes]. That was, I guess it still is, one method of staffing your graduate school <T: 25 min> it seems is to take a bunch and say, "Let them..."

**FENSELAU:** Well, keep the best...

**GRAYSON:** “flail around, and the ones that don’t make it too well, then are out.” So what about...and now we’ve got Berkeley. What you did at Berkeley, but then the other school, UC...

**FENSELAU:** SD.

**GRAYSON:** In San Diego was that?

**FENSELAU:** [Yes]. That was a place fifty yards from the beach. They were just starting there. I think they took a very small class that year, so I was not accepted there.

**GRAYSON:** Okay.

**FENSELAU:** Well, you know I didn’t know them. I didn’t want to be in southern California anyway. I think it was a lot more fun to be in the San Francisco [California] area.

**GRAYSON:** Were there many other young women coming into the Stanford graduate school in chemistry?

**FENSELAU:** There were...you know, I don’t know numbers or percents, but there were three or four others in my class. So I wasn’t alone. Now Stanford was at the tipping point. It had hired W. [William] S. Johnson and Carl Djerassi and was about to hire Paul [J.] Flory and [Henry Taube and] become great, but it wasn’t quite great then, some of it.<sup>4</sup> So it was an interesting...well, it was an interesting time to be there. There were, you know, the old faculty who had been doing competent research. Then there were these new superstars layering over the old faculty. So there were more faculty tensions. But the graduate students had many opportunities.

**GRAYSON:** So there was obviously...well, I want to back up just a second before you go forward. You went into chemistry as an undergraduate degree. Did you have any vision of what you would do with it when you got out? I mean assuming...

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<sup>4</sup> Carl Djerassi, interview by Jeffrey L. Sturchio and Arnold Thackray at Stanford University, 31 July 1985 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0017); and Henry Taube, interview by Leon Gortler on the way to Grand Central Terminal, New York, New York, 19 March 1986 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0298).

**FENSELAU:** From Bryn Mawr, you mean?

**GRAYSON:** [Yes], from Bryn Mawr.

**FENSELAU:** Go to graduate school.

**GRAYSON:** Oh, so you knew you were going to graduate school, or...

**FENSELAU:** By the end of my junior year.

**GRAYSON:** By the end...

**FENSELAU:** Yes. I think my attitude—maybe not well formulated—but was it was to do as much as I could to have as well-developed a career as I was able to. Now a much younger woman in this department whose office is above me says that she knew from the beginning she wanted to be a full professor somewhere. But there are other people in my generation who, like myself, didn't approach it with that much confidence, just said I'm going to do the best I can, and that's worked out okay.

**GRAYSON:** Oh, [yes]. Well, I think that that's a good attitude to go forward with. I mean, if you give it your best shot, then...

**FENSELAU:** [Yes].

**GRAYSON:** So you finally decided to go to Stanford. It looks like a pretty good decision based on the other options that you had on the West Coast. So this would have been starting there in late 1950s.

**FENSELAU:** No, 1961...

**GRAYSON:** Early 1960s...1961, okay.

**FENSELAU:** Yes. I started at Stanford in 1961.

**GRAYSON:** So was that the era of the flower power and the hippy-chippy, or whatever?

**FENSELAU:** We were just ahead of it. I missed all the fun. [Yes]. I left Stanford in '65, and spent two years at Berkeley '65 [to] '67. Then the helicopter gassing on the Berkeley campus was after I left. The demonstration for the People's Park was after I left. [...]

**GRAYSON:** I see. You missed all the excitement.

**FENSELAU:** [Yes].

**GRAYSON:** [Yes]. My youngest son went to Berkeley. When we went out there, sometimes people referred to it as Berzerkley.

**FENSELAU:** Well, you know, I thought Berkeley was a terrific place to be a postdoc. I would not have wanted...I think it would a challenging place to be an undergraduate because there were so many opportunities. There was the Baptist preacher on the corner at noon. Then on the other block there was the Black Panther rapping. So as a postdoc, Berkeley was fun and interesting. But as an undergraduate, it might be...

**GRAYSON:** It could have been a little distracting.

**FENSELAU:** Too many distractions, is a good word.

**GRAYSON:** [Yes].

**FENSELAU:** [Yes].

**GRAYSON:** I think it still is, but not quite as much as it was then. It's a place that draws people. So you start out in Stanford, and obviously you have to pick some kind of chemistry specialty. Are you going to...

**FENSELAU:** Yes.

**GRAYSON:** Was this a choice that you had to work through or did you have some ideas right off the top?

**FENSELAU:** Well, I don't think I went there with a firm commitment to organic, and I'm not sure still that I do organic. But as we took the...what did they call those tests you take the first week <**T: 30 min**> you're there, which we probably don't do anymore?

**GRAYSON:** Oh, [yes].

**FENSELAU:** Qualifying exams.

**GRAYSON:** [Yes].

**FENSELAU:** And it became apparent that my strengths were not in physical chemistry. So I concentrated on organic.

**GRAYSON:** Yes. Well, that's not exactly a wimpy curriculum. Organic is, and it's getting less so as more chemistry's being discovered. So then that was, kind of, an early-on decision based on the fact that it looked like you were really much more qualified to succeed in the organic environment. Okay. Then so you had to do some TA work.

**FENSELAU:** Oh, that was a wonderful time! I did one semester of TAing. I feel really badly that the students here [at the University of Maryland] have to do two semesters of TAing. I did one lab. I TA'd one laboratory section. Here we work them much harder. We distract them from their research, I think. But yes, I did a little TAing.

**GRAYSON:** So just the one semester.

**FENSELAU:** [Yes].

**GRAYSON:** Okay. Probably at Berkeley you would have had to do a lot more.



**FENSELAU:** It seems that way in retrospect, yes.

**GRAYSON:** [Yes]. So was it like an organic lab?

**FENSELAU:** Yes. It was an organic lab. I remember grading homework, but I don't actually remember being in the lab with the students, but I must have been.

**GRAYSON:** Then you decided to go into organic and you're taking regular graduate curriculum, advanced courses, and you still have to get some P-chem [physical chemistry] in, right? You can't avoid P-chem.

**FENSELAU:** Sure, right, right.

**GRAYSON:** And organic chemistry, and anything on the inorganic side? Was there much interest in inorganic at...

**FENSELAU:** In inorganic?

**GRAYSON:** [Yes].

**FENSELAU:** There was very little interest in inorganic at Stanford at that time. But shortly after I left, they hired... actually, before I left they hired Henry Taube, who had really reinvented inorganic, and made it much more interesting. I really did enjoy it. I don't think I got to take his course, but I got his seminars, realized that there wasn't just memorizing phenomena anymore. There was a logic to it. [Yes].

**GRAYSON:** [Yes]. It seems like it's the poor sister of the chemistries, inorganic. But, I guess, with the solid-state sciences it's a bit more...

**FENSELAU:** Certainly strong in this department. But it merges with materials sciences.

**GRAYSON:** [Yes].

**FENSELAU:** And so the most interesting graduate course I took was one that Djerassi offered. It was called Steroid Synthesis. He was in his steroid phase, and...

**GRAYSON:** Steroid phase.

**FENSELAU:** He was always trying to be very creative in his instruction. He had each graduate student in the class write a chapter for a book.<sup>5</sup> The book was called, I think, something about steroid synthesis. He got a publisher to publish the book and gave us each a little bit of money, each of the authors. But then he spent most of the money on a small structure that we called the "round building." It was supposed to be used for group meetings, and graduate student affairs for the department.

So the whole thing was very creative, the use of the money, that format for the class. He also offered a hundred-dollar prize for the person who could name the book, which I did, I got that prize. He was often...you remember he had come out of industry. He was accustomed to financial incentives. There were some other prizes that he offered just within his own group.

One student from Brazil [Hugo J. Monteiro] who won [one of] Carl's hundred-dollar prizes, didn't cash the check. Finally Carl said, "You're messing up my checking account." And the student said, "But I'd rather have your signature on the check than the money." So I think they made a deal. He cashed the check and got the canceled check [back.]

**GRAYSON:** So he had a...what would you call it? A foreseeable future in Djerassi...

**FENSELAU:** Yes, foresight.

**GRAYSON:** [Yes]. He would be an important character and his signature would be worth something. I don't know. Is it worth more than a hundred dollars today?

**FENSELAU:** I don't know today. But he had at that point already invented the birth control pill. And he was very prominent in natural products chemistry and for some reason had a lot of affinity for Brazil. I mean, they have good natural plants to produce natural products.

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<sup>5</sup> Carl Djerassi, ed., *Steroid Reactions: An Outline for Organic Chemists Prepared by 16 Graduate Students at Stanford University*. San Francisco: Holden-Day, 1963.

So Carl <T: 35 min> had spent a lot of time in Brazil already, had a joint international program set up where postdocs went back and forth. My colleague who didn't want to cash the check was a graduate student, so Carl had a very strong presence already in Brazil. So this fellow from Brazil knew...

**GRAYSON:** So what did you name the book?

**FENSELAU:** I can't remember. I'm embarrassed. It's on my shelf. But you know it had to have certain words. It had to have steroids, synthesis, organic...

**GRAYSON:** Well that, kind of, constrains it to a large degree.

**FENSELAU:** [Yes].

**GRAYSON:** You can't be too creative with that, I don't think. [...] So he was in the habit of incentivizing the troops by offering money and things.

**FENSELAU:** It seemed that way. Yes.

**GRAYSON:** That's interesting. You say he came from industry. Do you know where he came from, or...

**FENSELAU:** Sure. He [worked at Laboratorios] Syntex [SA].

**GRAYSON:** [Yes]. But I mean...so he came after Syntex to Stanford. Or during Syntex.

**FENSELAU:** Let's see. He actually spent...I think he spent a couple of years at [Ciba.] But then he went down to Mexico to join a team of natural products chemists who were trying to recreate the recipe for converting a steroid derivative that they got out of yams to something that could be turned into hormones for the birth control pills.

They did succeed and it was...well in fact, the early part of the story is even more interesting. A fellow named [Russell E.] Marker had developed this process, who came out of Penn[sylvania] State [University], and...<sup>6</sup>

**GRAYSON:** This is the yam process?

**FENSELAU:** [Yes]. And Marker was a difficult fellow and he got mad at his little company which was called Hormona-Synthetica, or something, and just walked out. It turned out that the whole process was being carried out by uneducated folk, who probably didn't know what they were doing. They'd been taught to do this step, and didn't know why. So then, the company called in a team of experts to try to reconstruct the chemistry and tell us the process. Djerassi and some others—I think there were probably five people on that team—succeeded, and the company then was reconstituted as Syntex. There are better histories of this in several...

**GRAYSON:** Sure, [yes].

**FENSELAU:** In one of Louis Fieser's books, and in many of Djerassi's books. But [it was] reconstituted as Syntex [and] must have been registered in this country. Djerassi...the company moved to Stanford Industrial Park. Well, I'm getting ahead of myself. Djerassi decided to go back to academics and spent a couple of years at Wayne State [University].

**GRAYSON:** Okay. I remember that connection somewhere.

**FENSELAU:** That's probably when he launched the Brazil initiative, and then he was lured to Stanford. He convinced Syntex to relocate to the Stanford Industrial Park where he had the double title of Director of Research at Syntex and Professor of Chemistry at Stanford. He invented "conflict of interest." He did it very well. I mean, you know, all the questions of conflict of interest. He understood them all at that time.

So far as I was aware, the science did not go back and forth. He hired some people from his lab in the university to work at Syntex, but we were not working on projects that were of interest to Syntex. He took a half salary from Stanford, and apparently his time division was nominally fifty/fifty.

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<sup>6</sup> Russell E. Marker, interview by Jeffrey L. Sturchio at Pennsylvania State University, 17 April 1987 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0068).

**GRAYSON:** So he was conscious of trying to not mix the two together, and keep it...

**FENSELAU:** Yes. And that was way ahead of the national conversation about the conflict of interest.

**GRAYSON:** That's interesting.

**FENSELAU:** Several, several national conversations. Yes. As a lab director, I never felt like he was not there half of the time. He had group meetings once a week. I could make an appointment to see him any time I wanted to. I [didn't really] need to make an appointment, and once in a while if I came to work late, I'd find a message on my desk that said, "See me as soon as you get here."

**GRAYSON:** Okay.

**FENSELAU:** You know, which is more like, "Why aren't you here at 8:30 AM," or whatever.

**GRAYSON:** [Yes]. "Why aren't you being a graduate student?"

**FENSELAU:** Yes.

**GRAYSON:** [Yes]. So he was definitely hands-on, even though he was half time.

**FENSELAU:** [Yes].

**GRAYSON:** Okay. Stanford was getting their money's worth.

**FENSELAU:** Yes.

**GRAYSON:** Of course, I mean, he was obviously making a bundle of jack in the other half of his life...

**FENSELAU:** Well, I think he probably made <T: 40 min> his most money out of the patents. But yes, and he started several other companies while in California. High energy.

**GRAYSON:** Yes. There are people that have that ability, very creative and able to do all kinds of exciting things, and that make the rest of us look like pikers. But, so you were there five years for your...

**FENSELAU:** I did my thesis in four...

**GRAYSON:** Four, very good.

**FENSELAU:** In standard chemistry turnaround time. [Yes].

**GRAYSON:** The graduate class in chemistry was running...

**FENSELAU:** I think most people went through in four years.

**GRAYSON:** Okay. Then the number of people that came out of Stanford graduating in chemistry per year, like a dozen?

**FENSELAU:** I have no idea. You know, I mean, I didn't pay attention at that time to those interesting facts. .

**GRAYSON:** [Yes]. I was kind of curious because my son graduated from Berkeley, and we went to the ceremony. I think they graduated seventy PhD's, and five masters and three bachelors. You know it was just a totally different mix.

**FENSELAU:** Three bachelor's?

**GRAYSON:** An inversion.

**FENSELAU:** [Yes]. That's amazing.

**GRAYSON:** So I was just, kind of, curious what Stanford was doing at that time in terms of how many people...

**FENSELAU:** Well, I have the feeling there were eighteen or twenty in my graduating class. Probably fourteen or fifteen of them actually got their degrees. I don't know if it was four years or five years. But one...a man named Don [Donald F.] Hunt was in my graduate class, and...

**GRAYSON:** Oh, really. Is this the Don Hunt of Don Hunt fame?

**FENSELAU:** [Yes]. He left Stanford after one year and then finished at MIT [Massachusetts Institute of Technology].

**GRAYSON:** Oh, okay. So the West didn't agree with him, I guess. Is he an East Coast person to begin with? Do you...

**FENSELAU:** Yes. I think he's [currently]at [University of] Virginia.

**GRAYSON:** [Yes]. So Stanford is in the Bay Area, right?

**FENSELAU:** Yes. It's thirty miles south of San Francisco.

**GRAYSON:** Okay. Did you get a chance to do any of those other things that San Francisco is so well known for, you know?

**FENSELAU:** Did a lot of hiking.

**GRAYSON:** Good.

**FENSELAU:** [Yes], camping. Stanford is, you know, maybe the epicenter of Silicon Valley. These guys named [William R.] Hewlett and [David] Packard came out of the Stanford engineering department and started their company in their garage.

**GRAYSON:** Yes. Well, I wonder what they would think of the company today.

**FENSELAU:** Companies.

**GRAYSON:** [Yes], companies. [Yes], Agilent [Technologies] basically has the business they started and everything they started has been splintered up into other...

**FENSELAU:** Computer...

**GRAYSON:** You know, it used to be an outfit that you'd get good measuring equipment, frequency synthesizers, and counters and all that good stuff as well as the analytical side. But it's impossible, I think, to trace the genealogy of these companies anymore, because they keep buying each other up and trading names.

**FENSELAU:** [Yes].

**GRAYSON:** I mean, what's PerkinElmer [Inc.]?

**FENSELAU:** Yes.

**GRAYSON:** And the other...I don't know if you saw the editorial in *C&E News* [*Chemical and Engineering News*] that both PerkinElmer and Agilent didn't go to Pittcon [Pittsburgh Conference on Analytical Chemistry & Applied Spectroscopy].<sup>7</sup>

**FENSELAU:** I knew they didn't. I don't know if I learned it in *C&E News*.

**GRAYSON:** Agilent bought a booth and didn't put anyone in there. It was like a snub, stick it in your face kind of thing, you know. I don't know whether they were unhappy with the management, or what. I saw Dick [W. Richard] Howe and John Baltrus the other day at CHF. I should have asked what's going on.

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<sup>7</sup> Marc S. Reisch, "Chilly Outlook for Instruments," *Chemical and Engineering News* 90, no. 14 (2012): 32-33.



**FENSELAU:** Agilent's making a big assault on proteomics right now, on biological mass spectrometry. You know, they went dormant in mass spectrometry for what, almost a decade. But they're back with full strength with some very interesting equipment.

**GRAYSON:** So this is...I'm sorry, I didn't get the name of the...

**FENSELAU:** Agilent.

**GRAYSON:** Agilent, [yes]. [Yes]. Well, that's another story that we'll get to.

**FENSELAU:** Okay.

**GRAYSON:** Now you have a choice. Are you going to go into academia? Are you going to go into industry? Are you going to go into government? You're going to go get some guidance...

**FENSELAU:** That was number three...you know that was...I saw this on your list, and I thought I never looked at it as a choice. I only looked at academia. I think, growing up in Nebraska, I didn't ever consider the government as an employer. I mean, it's a long way from the government, and perhaps, I was always pointed by Djerassi and then by Melvin E. Calvin [Nobel Prize, Chemistry, 1961] and so on, to academics. But I was married [to Allan H. Fenselau] at the end of my graduate school, and during my postdoctoral times. So then we looked for jobs together. The two-career <T: 45 min> problem.

**GRAYSON:** That was probably one of the earlier two-career problems, situations to develop.

**FENSELAU:** Well, one of the earlier successful ones, I imagine there have always been...you know, like the Fiesers.

**GRAYSON:** I assume you did a bit of searching around the country for positions. Did you get any assistance from Calvin or Djerassi in terms of...

**FENSELAU:** Well they wrote good letters. Djerassi really handpicked Calvin for me, and handpicked me for Calvin, and made that arrangement. Though I have to tell you about a fellowship I got that really was important to my career. But the next position...you know, the first job in the university in this case, my husband looked around and applied to a number of

universities. When he would interview, he would [...] let them know at some point that he had a friend who would like to move with him.

Hopkins was sincerely interested, Hopkins Medical School. They wanted to hire Allan Fenselau because he was a good organic chemist, and at that point they were doing some experimental tinkering with their medical education and wanted, sort of, what we might call now a bioorganic chemist. You know. They also were very interested in mass spectrometry. One of the strong professors in the pharmacology department had been a postdoc with Djerassi at Wayne State and firmly believed that we should be bringing mass spectrometry into biomedical research and pharmacology, and small molecules.

I might not have been...if they'd done an independent search, I might not have gotten the job. But because the medical school wanted to hire Allan, they were very happy to consider me for the job.

**GRAYSON:** So, this was facilitated by Allan, as well as by your graduate advisors, your people at Stanford.

**FENSELAU:** [Yes]. And the Djerassi network, if you like. The fact that there was somebody already there who knew he needed some mass spectrometry.

**GRAYSON:** Now when you were at Stanford, you were doing mass spec, right?

**FENSELAU:** [Yes].

**GRAYSON:** Okay. So when was your first exposure to mass spectrometry?

**FENSELAU:** Well, that was my whole thesis project. I went there in the fall of '61 and Djerassi had been reading Klaus Biemann's papers.<sup>8</sup> Klaus really brought—in this country—brought mass spectrometry into organic applications. Then Djerassi invited him to spend a couple of months in the summer at Stanford and learned everything he could from Klaus. Bought a CEC [Consolidated Electrodynamics Corporation] instrument and, you know, and hired a European. He hired Herbert Budzikiewicz...

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<sup>8</sup> Klaus Biemann, interview by Michael A. Grayson at Alton Bay, New Hampshire, 29 August 2006 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0279).

**GRAYSON:** Yes, okay.

**FENSELAU:** Who had been trained in Austria. Djerassi thought this was important, put the pieces together from all over the world, and then started opening the field of natural products mass spectrometry. So I joined his lab at that time, and my thesis addressed mechanisms of fragmentation.

**GRAYSON:** All right. So...

**FENSELAU:** So then with Calvin, I also did mass spectrometry.

**GRAYSON:** Okay. But so this instrument appeared during your tenure as a graduate student?

**FENSELAU:** No, before I got there.

**GRAYSON:** Before you got there.

**FENSELAU:** Everything was set up...

**GRAYSON:** So it was there, Budzikiewicz was there. You put into the position of using the instrument.

**FENSELAU:** No. I never got to use the instrument...

**GRAYSON:** You never got to put your hands on it.

**FENSELAU:** This is an interesting difference between my postdoctoral work and my thesis work. Djerassi, and I think even Biemann at that time, used the tool like they would NMR [nuclear magnetic resonance]. You know, it was a tool to get measurements. Then the intellectual effort went into understanding what the spectra said. So Djerassi had maybe twenty-five to thirty people, most of them foreign postdocs. I met Japanese people, European people. Since then, imprinted by that experience, I've always thought that was a valuable feature of any laboratory. But...

**GRAYSON:** To have a worldwide distribution of the people in the lab...

**FENSELAU:** Yes, and that science is international, you know. The State Department's figured that out too. In any case, I synthesized a lot of compounds with deuterium in specified positions and sent them downstairs to have their mass <T: 50 min> spectra run. Then they came back upstairs. The spectra came back, and I would figure out if the hydrogen was transferred from the alpha, beta, or gamma position and that was my thesis, working through four or five different functional groups.

**GRAYSON:** So you never really got your hands dirty.

**FENSELAU:** Right. I never got to run the mass spectrometer. Eventually, I think Klaus's lab did evolve to be a little more interested in instrument development. When I moved to Berkeley, though, Calvin wanted me to practice for the analysis of the returned lunar samples. So I was analyzing rock extracts and things.

But Bill [William G.] Dauben was there on the faculty, a photochemist. He and I did some studies where we identified analogies between mass spectrometry and photochemistry, rearrangements, the so-called McLafferty rearrangement. It's a well-known photochemical rearrangement. Then Al [Alma L.] Burlingame, who was, kind of, one of Melvin Calvin's lieutenants.

**GRAYSON:** So Burlingame had started his career...

**FENSELAU:** At Berkeley.

**GRAYSON:** He'd gotten out of Biemann's lab, and had moved to...

**FENSELAU:** He was assistant professor at Berkeley while I was a postdoc, [yes].

**GRAYSON:** Okay.

**FENSELAU:** And Calvin had a hundred and ten people in his group. He had won the Nobel Prize by this time. He had his own building, and he was operating with five, I call [them] "lieutenants," very accomplished senior scientists in their own right, and several of them,

including Burlingame, had faculty appointments. Burlingame was running one of—as I understood it—one of Calvin’s subgroups and funded...you know, [he] was funded that way.

So I got to work with Al, and as well as with Dauben and Calvin. Burlingame was very much more instrument oriented. That’s the point I was trying to make, that whilst there was a black box in Djerassi’s lab, Al’s focus was really on...he didn’t invent instruments, but he put things together to provide new capabilities. So he had a [CEC] 21-110, which was the highest performance instrument at that time. But he became interested in computer processing of the data. You remember 21-110s. You had to read a photo plate, if you wanted a high-resolution spectrum. So that cried for automation, and Al went big time into automation. He had a small computer on site, and people to program it. We tried various ways to process our data. I don’t think we ever omitted the glass [photo] plate while I was there, but that was the objective.

**GRAYSON:** Well, photo plate...

**FENSELAU:** But I also did run my own spectra there.

**GRAYSON:** Oh, very good.

**FENSELAU:** Had to run my own spectra, so...

**GRAYSON:** Very good. So you really got hands on with the instrument.

**FENSELAU:** So my introduction to running the instrument was in Burlingame’s lab. It was the [CEC] 21-110.

**GRAYSON:** So even though you had been dealing with mass spectra, you’d never dealt with the mass spectrometer.

**FENSELAU:** Yes. Well, Djerassi was an organic chemist, and Burlingame was...

**GRAYSON:** [Yes]. That’s an interesting, kind of, a separation.

**FENSELAU:** [Yes].

**GRAYSON:** So what did you think of the 110? Let's see. You were doing organic compounds, so you were doing electron ionization with that?

**FENSELAU:** Was there anything else? [laughter]

**GRAYSON:** [Yes]. [Yes]. Well, I mean, you could do the spark source for inorganic.

**FENSELAU:** Spark source, right. No, we were doing the...

**GRAYSON:** The EI [electron ionization] source for the...

**FENSELAU:** We were working with organics.

**GRAYSON:** And using the photo plate.

**FENSELAU:** Working with these fatty acids that Calvin thought might be biomarkers in the lunar soil samples...well, they weren't fatty acids. They were alkanes, reduced fatty acids. And working with the organics from the Dauben lab that were small synthetic organics. And working with a couple of natural products that Burlingame got access to. So much of the papers, most of the papers from both labs went into *JACS* [*Journal of the American Chemical Society*], you know, because it was all new and wonderful at the time.

**GRAYSON:** [Yes]. Well, I guess, between, at that time, Biemann, and Djerassi and Calvin, was there anybody else? Maybe Fred [Fred W. McLafferty] was dabbling in things outside of the petroleum industry. I mean, it seemed like for a long period the petroleum industry really ran the...

**FENSELAU:** You know [Seymour] Meyerson and Jack [Andrew G.] Sharkey [Jr.] and...[yes].<sup>9</sup>

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<sup>9</sup> Seymour Meyerson, interview by Michael A. Grayson at Gary, Indiana, 7 March 1991 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0398).

**GRAYSON:** [Yes].

**FENSELAU:** I think Fred had...I'm not sure when Fred went to Purdue [University]. But I do know that Frank [H.] Field and [M.S.] Burnaby Munson began publishing about chemical ionization while I was still a graduate student.<sup>10</sup>

**GRAYSON:** Oh, really.

**FENSELAU:** Djerassi, in his characteristic manner, got them out to learn what they had to teach <T: 55 min>. So, I heard about that pretty early.

**GRAYSON:** That's interesting, though. I mean, these are...well, of course, Djerassi came from an industrial background. So he probably didn't have any qualms about bringing people from industry in to talk.

**FENSELAU:** Right, right. And as you point out, half the field was in industry anyway...

**GRAYSON:** [Yes], but bringing the guys from Humble Oil & Refining...

**FENSELAU:** Chemical ionization is chemical ionization.

**GRAYSON:** But it's interesting because when talking to those gentlemen during these interviews, they pointed out how much those industries actually brought in very high-powered academics to talk to their people, something that's not done today, at least to my knowledge. Particularly, in the petroleum industry, but they brought in [Herbert C.] Brown who came and talked to Sy [Seymour] Meyerson's people, when he was up at Standard Oil of Ohio, and all this kind of [thing].<sup>11</sup> There was really this great exchange. It's just an amazing intellectual concept of what happened then and doesn't happen today in industry. So there was, kind of, a back and forth between them. Djerassi was going to bring people from industry who had something valuable to talk to the academics, and vice versa.

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<sup>10</sup> Frank H. Field, interview by Michael A. Grayson in Durham, North Carolina, 9-10 December 2009 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0636); and Burnaby Munson, interview by Michael A. Grayson at the University of Delaware, Newark, Delaware, 9 April 2010 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0688).

<sup>11</sup> Herbert C. Brown, interview by James J. Bohning at Purdue University, 11 November 1994 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0117).

**FENSELAU:** I have no idea if Djerassi consulted for anybody besides Syntex, because as I said, he was a professor in my presence and not a...

**GRAYSON:** [Yes]. [Yes], interesting. So actually did he bring out both...

**FENSELAU:** No. He brought Frank.

**GRAYSON:** Frank out to talk about...Frank could have talked about it in Baytown, they could have heard him. That huge booming voice, I don't think I'll ever forget that.

**FENSELAU:** He was a smart guy. You know Djerassi knew a smart...respected that.

**GRAYSON:** [Yes], [yes]. So that was pretty neat. So let's see. You got through the graduate school curriculum in four years, and that was a successful thing. You'd gotten married and you just did some postdoc at Berkeley, is that...

**FENSELAU:** [Yes].

**GRAYSON:** Okay.

**FENSELAU:** With Calvin and Burlingame.

**GRAYSON:** Okay. That was a dual career type thing, then. Did that work out?

**FENSELAU:** [Yes]. Well, that worked out partly because Djerassi made sure it did. I mean, Allan had, as an organic chemist, becoming a bioorganic chemist, [gone] to work with Daniel [E.] Koshland [Jr.]—was a postdoc with Dan Koshland—who was in some way associated with the Levi Strauss Company, a San Francisco family. Then Djerassi spoke to or became aware that Calvin could use a mass spectroscopist and made that happen.

But Calvin wasn't willing to give me a salary. I don't know if that's because he didn't have the money, or because that was his standard approach to postdocs. You had to bring your own money. So many people from Europe, for example, did come with government funding. So



it was very, very critical—and you have this question in your outline somewhere—to my career that I was able to get a modest funding for that postdoc, the first postdoctoral year. That came from the American Association of University Women. They had a small fund, I think it's a much, much larger fund at this point for supporting female—not just scientists and maybe not even mainly scientists—but scholars. So...

**GRAYSON:** So I mean were you aware of this organization before you came to the point where you wanted some money...

**FENSELAU:** No. I think my mother's best friend from college was very active in the national structure of the American Association of University Women, and was keeping track of me, and said, "Why don't you think about applying to this fund?" And I did get it. I may have been one of the first scientists they funded. That got me into...you know, I could go to Berkeley then. Then Calvin liked my ideas, then funded me the second year from his NASA [National Aeronautics and Space Administration] grant.

**GRAYSON:** So you had a guardian angel there to help you out.

**FENSELAU:** Well, I don't know. Or just a connection, or you know, if it hadn't been that one, then it probably would have been something else, but that's the one that came through.

**GRAYSON:** Is that organization still in operation?

**FENSELAU:** Oh, yes.

**GRAYSON:** Today.

**FENSELAU:** [Yes]. AAUW.

**GRAYSON:** AAUW, okay.

**FENSELAU:** Yes. They do a voter...anyway, I think they do voter information. They still have this fund for scholarships for female scholars, fellowships for female scholars.

**GRAYSON:** So that got you into Melvin Calvin's lab. That's kind of a tough act, though. I mean, you had to come with your own funding. That's...

**FENSELAU:** Well, I think I was a big boy, right? <T: 60 min> And I think many of his postdocs did. Many postdocs did at that time.

**GRAYSON:** Of course, I mean, you know, it's also worthwhile to you and your career to be working for a guy like that. So you know, I mean you can figure out how to do it one way or the other, borrow some money.

**FENSELAU:** Right, right. Well, and it was also a good experience to be...I mean, I worked not only with Calvin, in fact, more with Burlingame, but that was also a valuable experience.

**GRAYSON:** So Burlingame was probably not too far into his career at the time that you arrived.

**FENSELAU:** I think he was like two years older than me at the time, [yes].

**GRAYSON:** You arrived on the scene, and so I guess...

**FENSELAU:** He didn't stay at Berkeley, as you probably know.

**GRAYSON:** [Yes]. Was Burlingame the mass spec group person who, kind of, got it going in Calvin's group?

**FENSELAU:** [Yes].

**GRAYSON:** So Calvin didn't have any mass spec expertise or equipment prior to that...

**FENSELAU:** Nobody. I mean, it was pretty rare in those days. Biemann's group, which included Al, were seeding the country and Djerassi sent out a number of people to start mass spectrometry, as well.

**GRAYSON:** So that was a big project for Al to go ahead and get that operation functional.

**FENSELAU:** But he had a big budget. He bought all these toys. It was nice equipment. Put it together. I think he must have been happy in the science...

**GRAYSON:** Oh, [yes]. That would have been a very nice position to be in, to have the funds to buy the equipment that you needed and...

**FENSELAU:** Play with it.

**GRAYSON:** And play with it. Well, I assume that it also produced results...

**FENSELAU:** I don't mean to say that he played with it, but I mean he wasn't mission-driven as he might have been, if he worked at Dow [Chemical Company].

**GRAYSON:** [Yes]. Oh, [yes]. But, I mean, he was a person who appreciated the power of the tools, and wanted to use them, play in the sense that he wanted to make them work to their ultimate and get a lot of...I mean, Al's a very serious scientist for sure. I mean, scientists enjoy things.

**FENSELAU:** [Yes]. Yes. Again, preparing to analyze the lunar soil samples. That was a very...my father, of course, thinks I left too early, moved on to my Hopkins job too early.

**GRAYSON:** Ah, okay.

**FENSELAU:** Should have...

**GRAYSON:** So, you had...

**FENSELAU:** It was five or six more years, before...

**GRAYSON:** Before the lunar samples came back...

**FENSELAU:** [Yes]. Ten years, maybe.

**GRAYSON:** [Yes]. I don't remember. [Yes], it was a while. But, I mean, you couldn't wait forever...

**FENSELAU:** That's right. And Berkeley was exploding with the social unrest.

**GRAYSON:** So you stayed there for two years.

**FENSELAU:** Yes

**GRAYSON:** One year you had the AAUW...

**FENSELAU:** Support...

**GRAYSON:** Help you out. The second year, Calvin came in and decided, "Well, I think we can go ahead and [...] fund this person." That's nice.

**FENSELAU:** Sure.

**GRAYSON:** But then, at the end of the two years, you wanted to move onto something besides being...

**FENSELAU:** A real job. [Yes].

**GRAYSON:** [Yes]. I mean postdocs are still, kind of, graduate student-ish.

**FENSELAU:** I like to tell my postdocs that [it's] the nicest time in your scientific career, because they're not responsible for raising the money. But they're also not studying for their cumulative exams or something. So they can just do science.

**GRAYSON:** [Yes]. Yes, the money-raising part, indeed. So now you've got a pretty good set of credentials and you want to get a real job.

**FENSELAU:** Yes.

**GRAYSON:** You've got people that are going to support you with good letters of recommendation. So...

**FENSELAU:** Well, this is the point at which Allan started the two-career search. I would then follow up on his leads, and Hopkins Medical School came through. So I like to say I was the first trained mass spectroscopist to be hired by a U.S. medical school.

**GRAYSON:** Okay.

**FENSELAU:** There are a couple of qualifiers in there, because I don't know what was happening in Europe. I can say U.S. The other qualifier is "trained," because there had been some very interesting isotope tracer work done at Columbia [University College of Physicians and Surgeons] by a man who wasn't [formally] trained [...] in mass spectrometry. In fact, [David Rittenberg] was Richard [M.] Caprioli's thesis director. So...

**GRAYSON:** So what, so now you were doing some work at Columbia?

**FENSELAU:** No. I was at Hopkins.

**GRAYSON:** You were at Hopkins.

**FENSELAU:** But Columbia Medical School...

**GRAYSON:** Oh, [yes].

**FENSELAU:** I was saying why I say first "trained" mass spectroscopist in a US medical school, because there was work done by folks who hadn't been formally trained. But it was a new field, and [if] you <T: 65 min> were there at the time...so it had to be populated by people who weren't trained.

**GRAYSON:** [Yes]. It was you, kind of, got thrown into it, and...

**FENSELAU:** Yes. Of course, it was like computer science as a new field, it wasn't so particular about who it hired. Sy Meyerson was always proud that he was not a PhD And so it was in some ways easier for a woman to come into—this is one of your questions in your outline—as computer science was in its first decade. There was nobody who knew how to do it, so they took people who could teach themselves how to do it.

**GRAYSON:** [Yes]. Try to apply as much logic as you had, and your ability to comprehend the arcane behavior of simple computer language.

**FENSELAU:** [Yes]. But anyway, then from Klaus' lab...well, okay. From my colleagues graduating from Djerassi's lab, Bob Shapiro, Robert [H.] Shapiro, went to the University of Colorado at Boulder. He started the journal *Organic Mass Spectrometry*. I started the journal *Biomedical Mass Spectrometry* a couple of years later. From Klaus' lab, Sandy [Sanford] Markey went to the University of Colorado Medical Center. He and I probably started the same year, so maybe I should claim I was one of the first two formally trained mass spectroscopists hired in a medical school.

[J.] Throck Watson, a couple of years later, went to Vanderbilt's Medical School. And [James] McCloskey a couple of years later, started his career at Utah.<sup>12</sup> You've just been talking to him.

**GRAYSON:** [Yes].

**FENSELAU:** And Throck and possibly Jim were delayed a little bit by Army service. You know more about Jim right now than I do, because of your...so there was suddenly this diaspora or distribution of trained people across the country.

**GRAYSON:** Kind of an explosion.

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<sup>12</sup> J. Throck Watson, interview by Michael A. Grayson at Watson's home in East Lansing, Michigan, 27-28 October 2013 (Philadelphia: Chemical Heritage Foundation, in process); and James A. McCloskey, Jr., interview by Michael A. Grayson at the McCloskeys' home, Helotes, Texas, 19-20 March 2012 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0702).

**FENSELAU:** And many of us went into medical schools, because many of the medical schools saw the need, had different funding mechanisms than proper chemistry departments.

**GRAYSON:** So, [yes]. That's an interesting thing I hadn't thought about is so many people did go to medical schools or get involved in bringing mass spectrometry to medicine...

**FENSELAU:** Well, biomedical...

**GRAYSON:** Bio. So what, why, who? I mean, these medical schools were getting turned on to this by someone, or what's the background?

**FENSELAU:** [Yes]. I don't know why. [...] In my case, the pharmacology department wanted the support for drug development, organic synthesis again, we're talking about. But then they gave me the charge when they hired me to exploit mass spectrometry across the spectrum of biomedical research, which was a great job description to be given.

Throck Watson was hired to do one very specific thing, to use mass spectrometry to quantitate [prostaglandin metabolites] for a senior faculty member at Vanderbilt. So he had a very tight leash compared to me. I'm not sure about Sandy Markey, what was expected of him at the University of Colorado. But he shortly moved to NIH [National Institutes of Health] for...

**GRAYSON:** [Yes], Colorado...do you know who he went and worked for at Colorado?

**FENSELAU:** I don't know if he was in the psychiatry department or the pharmacology department. But Throck and I were in pharmacology departments, which is small molecules...

**GRAYSON:** [Yes]. [Yes]. Well, I mean small molecules would have been the starting point...

**FENSELAU:** Sure. Couldn't do any...heck, could only work with volatile things in those days.

**GRAYSON:** [Yes], gas phase ions. Make it a gas phase ion, come on.

**FENSELAU:** You know, get into the gas phase!

**GRAYSON:** [Yes], please make a gas phase ion. [Yes]. That ultimate requirement that I think a lot of people, even I think at one time, Fred McLafferty felt that limiting requirement and the fact that the only method of ionization was, at the time was electron ionization or electron impact, felt that mass spec was going to run into a wall and that was the end of it. You know, he took that position on the East Coast with Dow Research after he left Michigan with Dow, because he just felt that mass spec was...there wasn't much future in it.

**FENSELAU:** Okay. That's interesting...

**GRAYSON:** And then he went to the East Coast and <T: 70 min> ran their research operation. Of course, when he got back into academia, he got back into mass spec big time.

**FENSELAU:** Well, he of course focused on resolution when he started at Purdue. But that was still all electron impact.

**GRAYSON:** Oh, [yes].

**FENSELAU:** [Yes]. Well, you and I would know, if we plotted publications, we'd probably see a plateau, until we started looking at plasma desorption and—oh, that other thing—field desorption..

**GRAYSON:** [Yes]. Well, we went to the meetings and people were trying other ionization things, I remember. Of course, there's a lot of fundamental people doing fundamentals on photo ionization trying to get...

**FENSELAU:** Which is still interesting...

**GRAYSON:** [Yes], trying to get the energy for the ionization process refined to the last decimal point...

**FENSELAU:** [Yes].

**GRAYSON:** But still, I don't think people were doing these things, but not so much with the idea to try and develop a new ionization method, but just to, kind of, see what you can do with



it. Field ionization was an interesting technique, which I think was very technique-y. My recollection is that people either succeeded or didn't succeed, and...

**FENSELAU:** Yes, it was hard. It was hard. When [Hans-Rolf Schulten] went around the world and introduced it, he forgot to tell us there were a lot of extra ions above the MH<sup>+</sup> ion. In fact, if he had, we would have understood it better and maybe things would have evolved faster. But they didn't talk about MNa<sup>+</sup> for a while.

**GRAYSON:** Yes. Okay. So you're finally settling down at Johns Hopkins...

**FENSELAU:** [Yes].

**GRAYSON:** And you're given the charter, pretty broad charter...

**FENSELAU:** Great charter.

**GRAYSON:** Do they have any equipment when you got there?

**FENSELAU:** When it was decided that I would go, the powerful chair of biochemistry named Al [Albert L.] Lehninger, who has written a very successful biochemistry book, and a powerful chair of pharmacology named Paul Talalay wrote proposals asking for an instrument.<sup>13</sup> I don't know if they called it shared instrument in those days, but asking for an instrument. They sent the proposal to NIH, they sent the proposal to NSF and listed me as the competent person, and they were both awarded. We took the NSF one [because it was a little larger.]

**GRAYSON:** [Yes].

**FENSELAU:** So by the time I...well, that's not quite true. I spent a year there without an instrument, because CEC practically made it to order in those days. So even if you had the money it was a long wait.

**GRAYSON:** Oh, [yes]. So you were charged with selecting an instrument.

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<sup>13</sup> Albert L. Lehninger, *Biochemistry* New York, NY; Worth Publishers, 1970.

**FENSELAU:** [Yes]. I guess I got to, although I'm not even sure there was much choice. I mean if you...you know the MS9 wasn't quite competitive yet at that point. But I did get to become very good friends with my local [AEI (Associated Electrical Industries)] salesman.

**GRAYSON:** A number of meals...

**FENSELAU:** Dinners, yes.

**GRAYSON:** Dinners and whatnot. [Yes]. So then you wanted to go with...well, I guess 103 [CEC 21-103C single focusing mass spectrometer] was passé for what you wanted to do.

**FENSELAU:** Well, we thought that the higher resolution might be useful with biological applications. I guess that the argument was sufficiently made to the funding agencies that that was the case. So they gave us the money to buy a 21-110 with a photo plate, and all that stuff. [...] By then, Fred had moved to Purdue, and I went out and spent a week in the darkroom with one of Fred's students learning to, again, develop photo plates, and though I'd had some of that experience at Berkeley, still it was not enough.

We set it up and started to use it. Still had a glass bulb for the petroleum industry on the thing. I let each of my postdocs break the vacuum once, the way we all did. [laughter]

**GRAYSON:** Oh, yes. So when you went...

**FENSELAU:** The big advance between when I was at Stanford and when I was finally at Hopkins was that we no longer recorded our spectra on photo paper. We recorded them on the oscilloscope, light-sensitive paper. So when I talk about photo plates, it was the plates that had to be developed, but not the...

**GRAYSON:** [Yes]. [Yes] <T: 75 min>. Now, that was the age where you had the black sleeve and you stuck in the thing and went into the darkroom and you had...

**FENSELAU:** [Yes]. . Well, that's how it was...

**GRAYSON:** Twelve feet of paper trying to get into this weird...

**FENSELAU:** Squashed...

**GRAYSON:** Shaped thing, and...

**FENSELAU:** [Yes].

**GRAYSON:** So now, did you have any teaching responsibilities?

**FENSELAU:** Very little. That's the thing about medical schools. I did teach. I gave some lectures to the medical students. By now, we're talking about the end of the 1960s, and the students were rowdy everywhere. That was a great experience. So the very bright boys would sit in the back row and read *The New York Times*, not just during my lectures, during all their lectures.

And then I also taught a series in the...by then, we had a bioorganic chemistry course, primarily for postdocs and graduate students, and I gave a series of lectures [on a] particular family of enzymes there. So there was this [model, which] still is the pattern of teaching in medical schools—of plugging in modules in several courses, but not putting together a whole course.

**GRAYSON:** So you're having a fairly small-sized class for these.

**FENSELAU:** Well, the medical class was a hundred.

**GRAYSON:** Oh, okay. So a big-sized class.

**FENSELAU:** The bioorganic class was often thirty to forty people. I think the students came from the Arts and Science Campus to take that course.

**GRAYSON:** Were these undergraduate or graduate...

**FENSELAU:** No, they would have been all graduate students.

**GRAYSON:** And were these people then going on for MD's primarily?

**FENSELAU:** No. This was a course that was suitable for graduate students.

**GRAYSON:** So they're trying to give them some background in the bio...

**FENSELAU:** [Yes], because biochemistry as a field really came into maturity during my career. So at the beginning of my career, biochemistry had probably gotten...well, it had gotten past the description of the vitamins which is how it started. But it was still trying to become based in the science, in the more solid science of chemistry, less descriptive and more kinetics, thermodynamics, and principles of organic. So we were teaching biochemistry students about organic chemistry and organics, and organic graduate students about biochemistry.

**GRAYSON:** Okay. So it...

**FENSELAU:** It happened to be in the medical school, because there were a group of people there who had already made the transition, which was including me, by that time.

**GRAYSON:** [Yes]. So even though your primary responsibility was to deal with this mass spec...

**FENSELAU:** Was research, [yes].

**GRAYSON:** Research, you were given some teaching responsibility.

**FENSELAU:** Sure. I was training people in the lab too. I think from, maybe not the first eight or nine months, but from then on, I had postdocs or graduate students in the lab.

**GRAYSON:** So your equipment showed up about a year after you...

**FENSELAU:** Well, maybe it just seemed like a year. No. I think it was a year. It was a year, [yes]. You know they trucked it from California, when they finally got it made. The truck driver would call us every night and tell us what his progress was. It was very intense. Then it arrived

on December 23<sup>rd</sup>, and the truck driver was a Canadian who wanted to get home for Christmas. So he was in a big hurry to unload it, and drove his truck on to the sidewalk—the loading dock wasn't appropriate—but drove his truck on the sidewalk and crushed the sidewalk. The chair of pharmacology, who was a physician and the third of these emigrant mentors that I should mention, told the trucker driver, he knew how to cure all his aches and pains, and gave him a bottle of whiskey to carry him north into Canada.

**GRAYSON:** Not sure you want to have a truck driver drinking...

**FENSELAU:** Well, you know, so these days we wouldn't dare do it, would we? So the third mentor I should mention is the chairman of pharmacology at Hopkins who hired me. His name is Paul Talalay. He is from... [...] I believe that he was probably more Russian; Berliner was German. Djerassi was Austrian/Bulgarian.

**GRAYSON:** [Yes].

**FENSELAU:** Talalay was Russian. But they all came for the same reasons [around] same time, good for our country. He had spent several years in England on his way west, and <T: 80 min> spoke English with a British accent, and had married an English woman. Gave me lots of coaching, mentoring on science, and how to present myself in public. You know, told me not to wear green shoes one time. Medical school's much more family-like, it was at that time, than the chemistry departments at Stanford or Berkeley.

So Talalay and Lehninger got the first instrument. Talalay supported me on a department grant that he had for a couple of years, and also really coached me a lot, as I say on getting started. His program project grant from NIH was reviewed after I'd been there two years, and Klaus Biemann was on the review committee. Klaus Biemann said that mass spectrometry was going very well, and they ought to let me write my own grant. So they did, and I got it. So I really owe Klaus a big thank-you for pointing out that I didn't have to be just part of the team, I could also be independent.

**GRAYSON:** So he was in the business of being consulted about grant applications...

**FENSELAU:** Well [...] NIH would send out five people, I suppose, to look at how the money was being spent, what was being produced, what science has come out of it. Klaus was one of them. [Yes].

**GRAYSON:** Now did he have any knowledge of you from...

**FENSELAU:** From ASMS [American Society for Mass Spectrometry], probably...

**GRAYSON:** ASMS primarily...

**FENSELAU:** Yes. So Klaus had directed his...you know, his focus was on natural products, and [his student] McCloskey took the nucleotides. I guess Bob [Robert C.] Murphy took the lipids and somebody else, a man named Don [C.] DeJongh took the carbohydrates. But anyway, nobody worked in drug metabolites or in pharmacology in Klaus' lab. So he complimented me after he heard me talk and said, "This is something new. This is nice, new stuff," although Klaus would never say "stuff."

So I don't know, six years later I [...] went on an NIH team to review how Klaus was spending his money. That was the point which he was hiring Cathy [Catherine E.] Costello. He'd had a fellow named Charles [E.] Hignite as his—I use the term "lab lieutenant"—director of the facility or manager of the facility. He was going to pay Cathy less than he'd paid Dr. Hignite.

So [during] the site visit I said, "There's no reason to pay the woman less. You have to pay her the same." [...] In order to accommodate that, we asked NIH to increase his budget by the three hundred dollars, or whatever it was. So in some way I was able to return the courtesy to Klaus.

**GRAYSON:** [Yes]. That's interesting. I'm not familiar with this Hignite fellow. I guess he was, like you say, a lab lieutenant. Did he publish much with Klaus? Or...

**FENSELAU:** Probably, but this is so, not only long ago, but at that time you probably weren't following biology...

**GRAYSON:** No. [Yes]. But I mean...

**FENSELAU:** I don't know where he went. He got a good job.

**GRAYSON:** [Yes].

**FENSELAU:** Probably in industry. He probably went to industry.

**GRAYSON:** Of course, ASMS meetings at that time, were of such a size that you know...

**FENSELAU:** How could you miss him, [yes]?

**GRAYSON:** You knew pretty much everybody. Yes, those were the days.

**FENSELAU:** Those were the nice days.

**GRAYSON:** [Yes]. I'm not sure about those hospitality suites that they had infinitely long, for hours...

**FENSELAU:** [Yes]. [Yes]. Well, they did away with that—wisely, I think.

**GRAYSON:** [Yes]. It goes with that. So this guy was successful in dumping the instrument before, so he got back to Canada for Christmas...

**FENSELAU:** I guess. We got it unloaded and into the building. He went on to Montreal [Canada]. Then, of course, after the first of the year, the CEC engineers came and installed it. Very exciting.

**GRAYSON:** Yes. Installations of these instruments have their own lives. Some of them are just super nice, and others are super not nice.

**FENSELAU:** This was a super nice installation. The uncertainty I had was that it was going to be installed on a second floor. But it turned out the building was stable enough. And the elevators were far enough way and it wasn't earthquake prone, so it worked out fine.

**GRAYSON:** [Yes]. Normally people like to stick these things in the basement, but it was...

**FENSELAU:** Well and now, Bob [Robert J. Cotter is running] the mass spec lab at Hopkins pharmacology, and it's in the basement <**T: 85 min**>. So it's as you say...

**GRAYSON:** Put them as low as possible.

**FENSELAU:** Well in that case, it's because that's the least disputed space. We could have more space in the basement without having to fight about it.

**GRAYSON:** [Yes]. Having it on the second floor, you could have windows...

**FENSELAU:** [Yes], that's right.

**GRAYSON:** Which is nice.

**FENSELAU:** Yes, it's absolutely...

**GRAYSON:** But being in a basement, the window thing's not much of an option.

**FENSELAU:** Yes.

**GRAYSON:** So now you're using this equipment in its EI mode with electrical detection? Or were you still doing photo plates, or...you could probably do either one, I imagine...

**FENSELAU:** Mostly...yes. We could do either one. And, of, course whenever you have the option, one of them becomes the default mode, a little more popular.

**GRAYSON:** [Yes].

**FENSELAU:** So, of course, the oscillographic recorder was the method we used most of the time.

**GRAYSON:** But your photo plate was a nice integrating detector. I mean, that was the primary advantage to the photo plate was all the ions got collected; you know, with electrical detection...



**FENSELAU:** So we set up a small darkroom and, you know, did that seriously for a couple of years.

**GRAYSON:** I mean, there's always that, kind of like you're betting it's going to work, because you don't see anything. You don't see anything until after you take the plate in the darkroom and develop it.

**FENSELAU:** That's right.

**GRAYSON:** Did you ever end up with plates that were...

**FENSELAU:** You know, I don't remember...

**GRAYSON:** You know, no spectra or anything?

**FENSELAU:** I don't remember there being a big disappointment like that. I mean, the plates were treacherous for a lot of reasons. [Yes]. So we did eventually move beyond the plates.

**GRAYSON:** Well, it had its place in the scheme of things. It was an important tool, like you say, for super sensitive work, it's an integrating detector. So...

**FENSELAU:** Yes.

**GRAYSON:** You get the advantage of collecting all the ions from all the peaks, which there's something to be said for that.

**FENSELAU:** [Yes].

**GRAYSON:** There used to be...I remember this huge battle between Biemann and the electrical detection boys at AEI [Associated Electrical Industries], or it wasn't...was it AEI by then? I think...

**FENSELAU:** I think it was...

**GRAYSON:** Was it Metropolitan-Vickers or whatever. But at any rate, they were... obviously, the MS9 was electrical detection, and CEC was pushing photo plates at this one time. I think there was this huge debate at one of the ASMS meetings where each was trying to show that his method was better than the other's in terms of detection sensitivity and all these other things.

**FENSELAU:** Sure, well, Klaus was pretty conservative about those things. I mean, I can remember him having heated discussions about other issues in later years. So...

**GRAYSON:** Well, I mean, also he was a very strong believer in his way was the way.

**FENSELAU:** I guess, that's what I mean by conservative...

**GRAYSON:** Okay.

**FENSELAU:** [Yes].

**GRAYSON:** I guess that carries over from his European style, ancestry, although he left the European science scene because he didn't want to do the long slave labor, period of *Habilitation* before he could become his own man. But when he got here, I guess, he still had some of those European tendencies. I'm the boss. I'm the big man. But I mean, he was. He certainly did an awful lot for mass spectrometry and bringing it...

**FENSELAU:** [Yes], if only because he trained a lot of people...

**GRAYSON:** He trained a lot of people, and he moved it beyond the confines of the petroleum industry.

**FENSELAU:** Yes.

**GRAYSON:** As far as you could take it, given the ionization techniques that he had available. You know, because, of course, his synthetic chemistry background was critical for that as well.

**FENSELAU:** [Yes], [yes].

**GRAYSON:** In terms of making it work. So now that you've got this wonderful piece of equipment, what are you going to do with it?

**FENSELAU:** Well, you asked me about my favorite publications, and [few] of them come off of this piece of equipment. We did try many things for many people. I learned very quickly that I was going to be frustrated with biochemistry because there are a lot of phosphates attached, a lot of big molecules that wouldn't vaporize. We introduced lyophilized rat heart [into the instrument.] I mean, people just brought me these crazy ideas in retrospect, but at that point, we weren't sure what would happen.

We introduced bacteria, whole bacteria, into mass spectrometer with that instrument. As you know, that's been a theme of mine for a long time. So I guess one of my papers I'm proudest of would be from that series of bacterial analysis.

**GRAYSON:** But that was a little bit later in your career, wasn't it?

**FENSELAU:** No, in 1975 that first paper was published.<sup>14</sup> That was done on the 110 <**T: 90 min**> with electron impact. We had to heat the bacteria. The volatile molecules were what we saw. They weren't proteins.

**GRAYSON:** [Yes]. I need to pull up something here...

**FENSELAU:** But then, very quickly though, advancement came. I think by about '72, or '73 the oncology unit had bought me a GC-MS [gas chromatograph-mass spectrometer.] So I was already moving to an interfaced instrument.

**GRAYSON:** Okay.

**FENSELAU:** And a second one in the lab.

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<sup>14</sup> John P. Anhalt and Catherine Fenselau, "Identification of Bacteria Using Mass Spectrometry." *Analytical Chemistry* 47, no. 2 (1975): 219-225.

**GRAYSON:** So this GC-MS instrument was ...whose was it?

**FENSELAU:** Well, it was mine, but...

**GRAYSON:** But, I mean, who manufactured it?

**FENSELAU:** Oh, I'm sorry. It was CEC, but [soon] it was DuPont [E.I. du Pont de Nemours and Company].

**GRAYSON:** Oh, okay.

**FENSELAU:** Remember DuPont bought CEC. It was a DuPont [491.]

**GRAYSON:** Was that the cycloidal puppy?

**FENSELAU:** No. This was a sector. It was a small sector.

**GRAYSON:** Small sector.

**FENSELAU:** [Yes]. I actually had a conversation with Bob [my husband, Robert J. Cotter] about this, this morning, about whether it was 391, or a 491. But I think it was a 491. The interface for GC had the new Biemann-Watson interface in this instrument. So, you know, it was state-of-the-art even though it was still GC and worked [only] for organic compounds. We could sort of enrich them and move them on into the mass spectrometer.

**GRAYSON:** So you say the oncology people got you this instrument?

**FENSELAU:** Well, it was bought with money for an oncology collaboration.

**GRAYSON:** Okay.

**FENSELAU:** One of my major collaborators was an oncologist, whom I always viewed as a closet chemist. He was quite a good chemist, you know. But he was an MD, and he...

**GRAYSON:** I like that, "closet chemist."

**FENSELAU:** [O.] Michael Colvin. And some of my most highly cited papers were coauthored with Colvin, characterizing the metabolites of the still widely used anti-cancer drug, cyclophosphamide. So we actually worked out the first structures of [some of] the human metabolites of cyclophosphamide, [including] one which is toxic, [and] one that's therapeutic. It's a very...it's amazing that [cyclophosphamide] got on the market and is still used because the balance between the toxicity and therapeutic effect is fine, thin.

Anyway, we had this [491] with a GC and a Biemann-Watson interface. Then I had the good judgment to buy an INCOS automated device for selected ion monitoring. Did you ever hear of Don [E.] Hagge at INCOS?

**GRAYSON:** Oh, my. There's a name that's coming out of the background. How did he spell that? Don...

**FENSELAU:** H-A-G-G-E was his name. He founded...now we're beginning to talk about computers, right?

**GRAYSON:** [Yes], [yes].

**FENSELAU:** He was from the Berkeley scene, had a PhD I don't know in what; [physics], perhaps. One of the computer automation devices he developed, invented, would control mass spectrometer scanning so that you could look at one [ion at a time.] It's the old uranium story, only easier.

**GRAYSON:** [Yes].

**FENSELAU:** So the selected or multiple ion monitoring would skip between one mass and another without too much loss in sampling time. His company was called INCOS Science U.S. He was in [that] business for about a year, and I don't know if I was his only customer. I never heard of anybody else buying [from] him, except Finnigan [Instrument Corporation] bought [his company.]

**GRAYSON:** Right.

**FENSELAU:** Finnigan bought the company. Then, of course, it was no longer available for sector instruments. It was great for...

**GRAYSON:** Quads.

**FENSELAU:** Ion traps, quads, right, quadrupoles.

**GRAYSON:** So was it the ASMS connection that got you hooked up with INCOS?

**FENSELAU:** Probably. I probably heard him talk at ASMS, [yes].

**GRAYSON:** [Yes]. And you saw that there was a utility for having that type of a...

**FENSELAU:** In blood metabolism studies. They wanted blood levels, you know. These oncologists <T: 95 min> wanted to know how much of this toxic metabolite was in the blood or the urine.

**GRAYSON:** [Yes], [yes].

**FENSELAU:** So this gave us sensitivity because we didn't waste our time going through uninteresting parts of the spectrum.

**GRAYSON:** Sure...

**FENSELAU:** I have a picture of that device. You would laugh. It's a...

**GRAYSON:** Pictures are good.

**FENSELAU:** Okay, for the...

**GRAYSON:** [Yes].

**FENSELAU:** Okay. Photos...

**GRAYSON:** These are developments that, kind of, were a little bit of a flash, but they were critical because they got people's attention and redirected their...

**FENSELAU:** Well, Thermo [Fisher Scientific] has always—in the bio applications business—Thermo has always had the edge in computer automation. That's because they bought Don Hagge's company and Don Hagge's expertise for a while. So it really did advance...he advanced the field. [...] The contract by which he sold the company to Thermo bound him to them for a couple of years. Then he went off and invented bar-code reading for grocery store checkout.

**GRAYSON:** There you go.

**FENSELAU:** Which was a much better idea.

**GRAYSON:** Well, I'm sure he probably got more money out of that.

**FENSELAU:** [Yes], got more money out of it.

**GRAYSON:** Now you have to check out your own groceries.

**FENSELAU:** Which I still don't like to do, but yes. So that was one of the things we put together at Hopkins, [with] Don.

**GRAYSON:** So now you've got this DuPont GC-MS instrument. They didn't really have a data system.

**FENSELAU:** Right.

**GRAYSON:** Then you bought the INCOS, the Don Hagge's version of INCOS with...

**FENSELAU:** Which still gave me a strip chart readout, but it was of a single ion, a single ion intensity as a function of time, GC time.

**GRAYSON:** So it would look at selected ions.

**FENSELAU:** [Yes].

**GRAYSON:** How many could you select? Do you recall?

**FENSELAU:** I used four in some of my publications. I'm not sure that was the maximum, but...

**GRAYSON:** This would have been in the 19...late, or early 1970s, mid 1970s.

**FENSELAU:** Yes. Sorry.

**GRAYSON:** These aren't supposed to be linear things.

**FENSELAU:** That's okay. I didn't...my notes are not linear. Okay, so probably '75 was when we started doing that work. And Ian Jardine was on your list of interest, was one of the first people in my lab to exploit the multiple ion monitoring device; [in] a popular, a well-referenced paper on quantitation of metabolites in cancer patient urine and blood.<sup>15</sup>

**GRAYSON:** Now so you had the big 110. I'm getting the impression that you were obviously being given samples that were really not really...

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<sup>15</sup> I. Jardine, C. Fenselau, M. Appler, M. N. Kan, R. B. Brundrett, and M. Colvin, "Quantitation by Gas Chromatography-Chemical Ionization Mass Spectrometry of Cyclophosphamide, Phosphoramidate Mustard, and Nornitrogen Mustard in the Plasma and Urine of Patients Receiving Cyclophosphamide Therapy." *Cancer Research* 38, no. 2 (1978): 408-415.



**FENSELAU:** Direct probe.

**GRAYSON:** Appropriate to use...

**FENSELAU:** [Yes]. So...

**GRAYSON:** They weren't really in a form from which you could derive much useful information. I mean, is that not a fair assessment of the kind of thing...

**FENSELAU:** Well, if we wanted a structure or a molecular weight, the direct probe on the 110 was very good. If we wanted quantitation, the best data would be a GC peak that you could integrate or LC peak, in these days. The 110 didn't ever get interfaced to a LC or GC, rather...well, it probably did, but not in my lab. And the instruments are getting smaller, you know. This [GC-MS was] not even as big as this table. So we were evolving toward interfaced instruments, GC-MS in this case.

**GRAYSON:** Now you're going back to what you would call nominal mass...

**FENSELAU:** Yes. We we're talking about...

**GRAYSON:** Power type instruments...

**FENSELAU:** Right.

**GRAYSON:** [Yes].

**FENSELAU:** But this particular drug contained chlorines, so we had the double-check of the chlorine isotope ratio. So I monitored two ions at once for the molecular ions.

**GRAYSON:** That was good.

**FENSELAU:** Yes

**GRAYSON:** This provided a resource that was valuable to the oncologist?

**FENSELAU:** [Yes]. [The GC-MS] was fun to do new things on, fun for me to do new measurements on.

**GRAYSON:** So they appreciated, your collaborator...

**FENSELAU:** Well, it was really valuable to the pharmacologist, because there are all kinds of oncologists. This fellow was interested in drugs.

**GRAYSON:** I'm just thinking that the value of that activity and that analytical approach was probably considered more successful than say the 110, the value <T: 100 min> of what came out of the 110 in terms of...because, I mean, the samples you got for the 110 were, kind of, not as well behaved.

**FENSELAU:** Well, yes. I guess that's correct. I mean, I should look at the papers I published from the 110 to see what kind of samples were [used]. You will recognize that with a gas chromatograph, this one, this instrument had even more severe limitations on volatility than the direct probe on the 110. So the steroid guys who'd been pushing their wanting a mass spectroscopist was part of the reason I got the job. We always did their work on the 110.

**GRAYSON:** Ah, okay.

**FENSELAU:** There was a lot of synthesis. It wasn't human samples as we're now moving to human samples with integrated, with GC. -MS. But GC's got more limitations, so this [...] cancer drug had to be permethylated to fly at that point.

**GRAYSON:** [Yes]. [Yes]. That was a very common approach to do some kind of derivatization in order to get it to fly, and those were serious chemical issues, if you weren't into organic chemistry that much. I mean, I think it limited a lot of people in the application because they didn't have even the minor expertise of how to do some of these things.

**FENSELAU:** So I looked for...well, first I had to find out what pharmacology was, because if I wanted to get tenure in this department, you know. So I went to the first Gordon Conference that was organized on pharmacology. I got enough assessment of what it was, and then

proceeded to work toward tenure. I looked for drug metabolites whose analysis was not easy, you know, so I would be moving more now toward [new] bioanalytical thinking.

Certainly this cancer drug, which had no UV chromophore, could not be detected coming out of any kind of chromatographic separation until we used the mass spectrometer to detect it. Another class of drug metabolites, which was very hard to analyze at that time were [glucuronides]...the liver hooks a lot of drugs up to a sugar called glucuronic acid. That makes it possible to excrete them into urine or through the urine.

So this is a major part of metabolism. People were usually hydrolyzing [the conjugate] with acid or something, or an enzyme [removed] the sugar from the drug. But sometimes it's good to know how much of the drug is actually attached to the sugar, where it's attached, and that's the kind of stuff mass spectrometry can tell you. So we did some of the initial work on the 110. They were pretty tricky. We had to derivatize those as well, to make a sugar...

**GRAYSON:** Oh, [yes].

**FENSELAU:** A glucuronic acid fly. Then we were able to do a lot more of that work, again as derivatives on the GC-MS. Then you can get into business. You can start looking at urine samples and things with a good separation technique. So we opened up the analysis of glucuronic acids using both the 110 and the GC-MS. The reason I say this is because you're asking me what we did with the 110. But it was [...] more productive with the separation system in front of the mass spectrometer. We also found we needed standards. So we developed an immobilized enzyme method to synthesize glucuronides, which was new at that time, and a new way of doing things. Again, [we're] talking about the value of [my] organic background. I mean, this is enzymes, but we're also talking about bioorganic [chemistry.] So this [was a] new way to make the standard glucuronides and then, new ways to analyze standard glucuronides. And I went around and talked to every drug company in the country about all of this, because they needed these techniques.

**GRAYSON:** So the research project into glucuronides represented a whole new area of the application of mass spectrometry in the biochemical environment. Of course now, your organic chemistry is now getting kind of transformed into a bioorganic...

**FENSELAU:** Yes.

**GRAYSON:** And you're starting to teach people. So when you teach it, you learn it.

**FENSELAU:** Yes. Yes. Well, I had a colleague down the hall [Indu Parikh], who was immobilizing proteins on agarose beads. He wasn't immobilizing glucuronide transferase. But we learn from <T: 105 min> [our] environment always. So our first paper is, in fact, coauthored with him.<sup>16</sup>

**GRAYSON:** So there's a lot of learning chemistry involved as needed to do the mass spec, and also to understand the bioorganic process that's going on and...

**FENSELAU:** Sure, and to open areas of research that were mine that would meet the requirements of my career.

**GRAYSON:** So you're looking at tenure.

**FENSELAU:** [Yes]. Or an increased salary, or whatever. Six of one, [half dozen of the other.] [laughter]

**GRAYSON:** Yes. The eternal goal of the academic.

**FENSELAU:** Yes.

**GRAYSON:** But, I mean, this approach is part of your trajectory towards that. It's a conscious plan on your part to do that kind of thing. If you need a break or anything...

**FENSELAU:** No. I'm good.

**GRAYSON:** Want me to take this...I can turn it off. [Recorder switched off] [Yes]. We're back on...

**FENSELAU:** Is this the time for me to tell you for a minute about salaries at Hopkins?

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<sup>16</sup> Indu Parikh, Donald W. MacGlashan, and Catherine Fenselau, "Immobilized Glucuronosyltransferase for the Synthesis of Conjugates." *Journal of Medicinal Chemistry* 19, no. 2 (1976): 296-299

**GRAYSON:** Sure. That would be great.

**FENSELAU:** So I was delighted to get a job and, they paid me the same salary Calvin had paid me as a postdoc. They were annoyed that it was so high.

**GRAYSON:** So the postdoc salary was pretty...

**FENSELAU:** I didn't think so, but I mean...you know.

**GRAYSON:** Most postdoc salaries aren't that high.

**FENSELAU:** But it was possibly a West Coast/East Coast thing.

**GRAYSON:** [Yes].

**FENSELAU:** Transition. But so, they paid me that. Then after [President] Lyndon [B.] Johnson signed [Executive Order 11375], and we had to start admitting women to law school and medical school and [were] supposed to have equal salaries, first of all a lot of my classmates from Bryn Mawr suddenly went to law school, were able to go to law school.<sup>17</sup> A few of them had been able to get into medical school.

Anyway, so the Hopkins' dean set up a committee to look at faculty salaries, and they put me on that committee. The salaries were presented to us without names, but we were given the gender.

**GRAYSON:** You were not or you were?

**FENSELAU:** We were given gender.

**GRAYSON:** You were given gender.

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<sup>17</sup> Lyndon B. Johnson, "Executive Order 11375: Amending Executive Order No. 11246, Relating to Equal Employment Opportunity," October 13, 1967. Online by Gerhard Peters and John T. Woolley, *The American Presidency Project*, accessed 2 April 2015, <http://www.presidency.ucsb.edu/ws/?pid=60553>.

**FENSELAU:** And, of course, most of the women were lower than most of the men. There was one man, however, one point in the chart that was really out of line for a male in the department of medicine. So we asked about that, and, again, without being given his name, we were told that he was married to the richest woman in Texas. So they were naughty. So we said you can't do that.

**GRAYSON:** [Yes]. What's that have to do with the guy's salary?

**FENSELAU:** [Yes]. The guy's...blah, blah, blah. So anyway, they didn't address my salary with me in the room, but at the end of that year, without comment, I got a 25 percent raise. I knew then that I'd been among the underpaid women. But I was loving the job, so I wasn't really complaining. But it's...

**GRAYSON:** That's interesting.

**FENSELAU:** Yes.

**GRAYSON:** Really is interesting.

**FENSELAU:** It is interesting. [Yes].

**GRAYSON:** That was in 19...

**FENSELAU:** Well, I can't remember the date I was on the committee, but I think Lyndon Johnson signed [the executive order] in 1967. [...] So this would have been in the '70s, anyway.

**GRAYSON:** That's not a problem. I'll just make a note in here to find it...

**FENSELAU:** [Yes]. It may be that there was a gap, because I think Johnson was president in the 1960s, I may be wrong. But anyway, it was finally working its way through the courts and being implemented in medical schools.

**GRAYSON:** [Yes]. That is really amazing. I like that.

**FENSELAU:** I can bracket it from my point of view, because this man that I liked so much as chair, was only chair for four or five years after I was hired. So it's in my first five years. [Yes]. So it was real, you know. But anyway, so I took the money and ran.

**GRAYSON:** [Yes]. [Yes]. So you were quite successful then. I mean, were you back in the position of having to go back for more grants?

**FENSELAU:** Sure. Well Klaus, as I said, told the university that it would be appropriate for me to submit my own grant. I was successfully funded. Then I was off that team grant. I mean, I liked the team grant, but anyway, I had my own grants for a long time...

**GRAYSON:** Were these going to NIH or NSF?

**FENSELAU:** NIH, mostly, [yes]. We bought the 21-110 with the NSF grant...

**GRAYSON:** NSF money, [yes].

**FENSELAU:** Eventually, I had large NSF money again. But for the period we're talking about now, it was NIH. I've had that same grant for my whole career. So it's <T: 110 min> you know, year thirty-two or something...

**GRAYSON:** [Yes], [yes]. That's nice. Did NSF have any grief about the fact that you were using...

**FENSELAU:** NSF equipment...

**GRAYSON:** NSF equipment...

**FENSELAU:** You know their equipment grants end after a year.

**GRAYSON:** Oh, after a year...

**FENSELAU:** They don't keep track of it or feel any ownership after that. So no, we gave them a good report at the end of the year, and that was it. But then, we had the responsibility to keep it running.

**GRAYSON:** Oh, [yes].

**FENSELAU:** So we needed some other source. We needed some sources of income.

**GRAYSON:** Were you picking up graduate students immediately upon getting on the ground?

**FENSELAU:** You know, much as I admire Paul Talalay for his professional mentoring, he did not think it was appropriate to train graduate students in the pharmacology department. So we didn't. So I had a lot of good postdocs. Then, only when Talalay turned the chairmanship over to someone else, then that man, the new chair [J. Thomas August], initiated a graduate training program.

**GRAYSON:** Okay. So that would have been a couple of years after you...

**FENSELAU:** [Yes]. I think I probably had three graduate students the whole time I was at Hopkins. One of them has done very well since, and we can talk about him later. But I got into real graduate business when I moved to the state schools.

**GRAYSON:** [Yes]. Did you go back for more instrument grants? I guess the GC-MS was part of an instrument grant. Or...

**FENSELAU:** You know this is so funny. I was trying to remember how that instrument was funded. I really do think that the oncology department paid for that. Perhaps paid for with patient funds, but then I did go again and again, mostly to NIH for a while, for instrumentation.

My next big instrument was probably the MS50. That was NSF again, [who] purchased [the] instrument. By that time, we had a new chair. The new chair...you told me to mention difficult experiences. The new chair was a virologist, a molecular biologist, really didn't understand chemistry, really wasn't sure he wanted it in his department. So the chemists did not thrive. So the mass spectroscopist got sent to the basement. I rebounded by getting a regional instrumentation center from NSF.



**GRAYSON:** Okay.

**FENSELAU:** This is the same time Mike [Michael L.] Gross got [funded]. His and mine were the first two mass spec centers, and maybe the only two mass spec centers NSF funded.

**GRAYSON:** [Yes].

**FENSELAU:** We both bought [Kratos] MS50s. That distressed the new VG [Instruments Inc.] company.

**GRAYSON:** [Yes]. There was a point that I wanted to explore and I'm...

**FENSELAU:** Sorry.

**GRAYSON:** And it's slipped out of my brain. Oh. One of the things that I was aware of at Washington University is that when it comes to buying equipment, there's a lot of money comes out of the medical school slush fund or pot of money, or whatever. So Mike Gross's approach is to, you know kind of get a good deal on the instrument then, sweeten that with...he was able to pull in money from the medical school. There's a lot of money, or they do a lot of instrument funding with your own money. Not using it to buy a complete instrument, but to add to the purchase. I was wondering if that kind of thing happened...

**FENSELAU:** Well, remember that when Mike and I got our NSF regional instrumentation center, he was at the University of Nebraska.

**GRAYSON:** Right.

**FENSELAU:** And Hopkins was...much sharper businessmen. I won't say better, but I never had matching funds from Hopkins.

**GRAYSON:** Ah, okay.

**FENSELAU:** The first time I had matching funds was here.

**GRAYSON:** Okay, at [University of] Maryland.

**FENSELAU:** [Yes]. And it was very effective, as Mike knows.

**GRAYSON:** [Yes]. Well, I mean, at Wash U in St. Louis [Missouri], that's the way almost all of the equipment is funded, is through...

**FENSELAU:** A grant with a little piece from the university.

**GRAYSON:** [Yes].

**FENSELAU:** To sweeten the pot.

**GRAYSON:** Significant help, to show that the university is committed to helping the thing along. So I think that probably helps the granting agency in terms of...

**FENSELAU:** But anyway, this MS50 was not, and that was not my experience at Hopkins, nor is it Bob's experience at Hopkins.

**GRAYSON:** Okay.

**FENSELAU:** So I'm very mystified about this instrument appearing from oncology, according to my notes, from oncology.

**GRAYSON:** Where did it come from? Well, maybe you need to go back and research that, and find out. Obviously, it was an instrument that you used, and somebody had to pay for it.

**FENSELAU:** [Yes]. But there was so little fuss that, you know, for me anyway, in <T: 115 min> getting that one. So we moved on to the basement with the MS50.

**GRAYSON:** So did that mean moving...well, did you get rid of the 110?

**FENSELAU:** Yes.

**GRAYSON:** You retired it.

**FENSELAU:** We actually...we gave it to another lab.

**GRAYSON:** Okay. How long did you actually use it?

**FENSELAU:** Okay. So probably at least ten years.

**GRAYSON:** Okay. So it had a useful life.

**FENSELAU:** [Yes], a good run. But by then detection technology [had evolved,] and we were beginning to get automated computational data processing. But it was a beautiful piece of stainless steel and the kind of thing physical chemists love.

**GRAYSON:** It had a nice appearance. The thing I liked about it was, and I mean it wasn't something that impacted my existence, but when you know that you can pull the modules forward and lay them down...

**FENSELAU:** Oh, [yes]. Oh, [yes].

**GRAYSON:** To get into the electronics, I mean, whoever designed that instrument layout was smart in terms of the fact that, hey, we're going to have to maintain this thing someday. So let's make it real easy to get to, instead of burying it inside.

**FENSELAU:** Right. They're so compact now that...

**GRAYSON:** And I thought it was a brilliant idea. I don't think anybody's ever done anything like it since.

**FENSELAU:** That's a very interesting point.

**GRAYSON:** [Yes]. It was nice that way, and it never really impacted my life, but I just was impressed by the fact that it was such an easy instrument to get into when you had to replace...well, you didn't replace...I guess you could replace transistors in that instrument, but not anymore. You replace circuit boards...

**FENSELAU:** There might have been even some tubes in that instrument.

**GRAYSON:** I think probably there were, in particular on the high voltage side. You know, you must have certainly had tubes.

**FENSELAU:** [Yes].

**GRAYSON:** Yes. Did you ever get bit by that machine?

**FENSELAU:** I was almost disappointed I didn't, because you know there was that old club, the pride of being scarred, and Budzikiewicz had his scar from hitting a high voltage source in Europe. But fortunately, that club has died out. So I never got...

**GRAYSON:** That's probably just as well.

**FENSELAU:** Shocked.

**GRAYSON:** But you did break vacuum on it.

**FENSELAU:** Yes. All that glassware at the inlet side. [Yes].

**GRAYSON:** [Yes]. Those were interesting pieces of equipment, for sure. So you got rid of the 110, and were you able to keep your GC-MS equipment, or...

**FENSELAU:** I think we didn't. We didn't move it either. We moved on to an LC-MS.

**GRAYSON:** And down to the basement.

**FENSELAU:** [Yes].

**GRAYSON:** Because of politics, mostly, right? I mean, the new chair didn't think he wanted the...

**FENSELAU:** He wanted to put a molecular biologist in our second floor space, our space with windows. [Yes]. So that would have been about 1979, '78, '79. Again, it took a while for the MS50 to arrive after we ordered it [from Kratos.]

**GRAYSON:** Oh, [yes]. [Yes].

**FENSELAU:** Also made to order, and I think they flew it across the ocean.

**GRAYSON:** [Yes]. Now did you go to the UK [United Kingdom] to look at the equipment?

**FENSELAU:** Bob [Cotter] went.

**GRAYSON:** Bob went, okay.

**FENSELAU:** By that time...we staffed the NSF regional instrumentation center together, because you remember at Nebraska, they had Charlie [Charles L.] Wilkins, [Gerry] Meisels even Jean [H.] Futrell.<sup>18</sup>

**GRAYSON:** [Yes].

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<sup>18</sup> Jean Futrell, interview by Michael A. Grayson at Richland, Washington, 28 and 20 October 2012 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0706).

**FENSELAU:** So you needed more than one person, and he came onboard at that time. He got to go to England.

**GRAYSON:** Those were fun trips.

**FENSELAU:** Well, yes and no. You know Manchester [United Kingdom].

**GRAYSON:** Yes, right. So, but basically he went to check out the gear. And was there competition, any serious competition? Was CEC trying to...

**FENSELAU:** CEC had been bought by DuPont, and DuPont went out of the business by then.

**GRAYSON:** That had become, kind of, a strange thing.

**FENSELAU:** They closed. A fellow named Ed [Edward] Chait tried to make a success of mass spectrometry for DuPont. They had such a high profit margin requirement. They wanted 15 percent profit, and if you only got 13 percent, they'd close you down. But anyway, they shut it down, so the choices then were, you know, Finnigan was making quadrupoles and...

**GRAYSON:** Right.

**FENSELAU:** The high resolution and high mass instruments were made by the English companies. I don't even know what JEOL [Japan Electron Optics Laboratory Company, Ltd.] was making then.

**GRAYSON:** Well, there was also MAT [Mess und Analysentechnik] in Germany.

**FENSELAU:** Ah, MAT.

**GRAYSON:** [...] I don't know what they had at that period. But I think they probably had something, trying to get competitive in the high resolving power side.

**FENSELAU:** I can't remember that they ever had something. So Hank [Henry M.] Fales had an MS9 [at NIH] <T: 120 min>, and we got this [next generation instrument.] His was from AEI [Associated Electrical Industries]... [yes], okay. Right. I don't remember anybody besides VG as being in the competition for that selection.

**GRAYSON:** Okay. So it was not so much a competition as "This is what we need, can you do it?"

**FENSELAU:** [Yes]. AEI had split by then into Kratos and VG. We bought the Kratos MS50.

**GRAYSON:** All right. [Yes].

**FENSELAU:** You know, Brian [N.] Green had left and Syd [Sydney] Evans stayed.

**GRAYSON:** [Yes]. That whole...

**FENSELAU:** Yes, too many good engineers. So the competition was between the two English companies. We bought the MS9, and Mike bought the MS9, and...

**GRAYSON:** Okay, all right. So these...

**FENSELAU:** I'm sorry. MS50. MS50...

**GRAYSON:** [Yes]. So [yes], all right. So VG had come into existence out of the AEI shop.

**FENSELAU:** Yes.

**GRAYSON:** And that was the competition. Okay. Okay. [Yes]. Oh, yes. [Yes], Brian Green is an interesting fellow. I really have always enjoyed meeting up with him. He's still smoking away and puttering away.

**FENSELAU:** He's one of that 1 percent that...

**GRAYSON:** [Yes].

**FENSELAU:** Yes. He's [now] a "Sir," isn't he?

**GRAYSON:** I don't know.

**FENSELAU:** Didn't he get the Order of the British Empire?

**GRAYSON:** I don't know. It could well be. I should know. You know, I went to the U.K. to interview John [H.] Beynon and Keith [R.] Jennings.<sup>19</sup> I really wish I had had the foresight to go ahead and talk to Brian Green while I was there, and also Bob [Robert] Bateman. Bob Bateman's retired apparently. So all of those guys are really sharp people, really amazing, sharp people.

But so I don't know, you want to take a break, and get ready for lunch? One way or the other.

**FENSELAU:** Sure. We should eat, even if my guest doesn't show up.

[END OF AUDIO, FILE 1.1]

**GRAYSON:** There we are recording again. I didn't get names of your parents. That's, kind of, a good piece of information to have.

**FENSELAU:** Okay. Well, we can do that by email, but Muriel Thomas Clarke. Thomas was her Welsh maiden name. And Lee Keckley Clarke. His grandfather [Charles R. Keckley] and great grandfather [William H. Keckley] fought for the Union Army in the Civil War.

**GRAYSON:** Okay. Oh, boy.

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<sup>19</sup> John H. Beynon, interview by Michael A. Grayson at Swansea, Wales, United Kingdom, 22 April 2008 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0420); and Keith R. Jennings, interview by Michael A. Grayson at Leamington Spa, Warwickshire, United Kingdom, 24-25 April 2008 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0419).



**FENSELAU:** That's how they came to homestead in Nebraska.

**GRAYSON:** I see. Yes. Interesting how those historical events affect lives in a large way. They homesteaded in Nebraska. They were from...

**FENSELAU:** [Ohio.] .]

**GRAYSON:** Were they second generation? First generation?

**FENSELAU:** No. Somebody was in the country in 1620.

**GRAYSON:** Oh, okay. [Yes], right.

**FENSELAU:** But every generation seemed to move west. So the pair who joined the Union Army were living in [Ohio or] Indiana at the time.

**GRAYSON:** Okay. Indiana was one of those states that was, kind of, neither here nor there, wasn't it? With regard to the...

**FENSELAU:** It was technically Union, but...

**GRAYSON:** But it was...

**FENSELAU:** [...] But that's like Maryland. Maryland was technically Confederate, but the population really had two views.

**GRAYSON:** [Yes]. Well, Missouri was the same.

**FENSELAU:** Oh, [yes].

**GRAYSON:** I think all the border states were, kind of, in a bit of a bind. The Missouri Historical Society's running a big thing about the Civil War and Missouri now, hundred-fiftieth anniversary, pointing out how the two different sides semi-coexisted and shot at each other, [...] and caused all kinds of problems for each other.

**FENSELAU:** [Yes].

**GRAYSON:** So you finally had been kicked into the basement because your department head doesn't think much of chemistry...

**FENSELAU:** Thinks less of chemistry, [yes]...

**GRAYSON:** In general. The mass spectrometry was even less to be thought of, I guess.

**FENSELAU:** We were beginning to be useful though, so maybe, you know, it could be called biochemistry. [Yes]. As we went to the basement we got this NSF regional instrumentation award and that saw us in good stead for...

**GRAYSON:** Did that have the same kind of requirements that the NIH-type award has where you have to provide service, run samples for other...

**FENSELAU:** And do core research...

**GRAYSON:** Academic, and do core research and publish papers, et cetera, et cetera. So the same general...

**FENSELAU:** Similar. I'm sure that the folks from NIH would tell us what the differences are, but [yes]...

**GRAYSON:** [Yes].

**FENSELAU:** It provided for major equipment which we probably wouldn't have gotten otherwise.

**GRAYSON:** Now this equipment didn't have a GC [gas chromatograph] with it, the new 50?

**FENSELAU:** The MS50 did not. One time, just as we paid Don Hagge to put an INCOS unit on our GC-MS, we paid Marvin [L.] Vestal to come and interface thermospray to the MS50.<sup>20</sup> That actually didn't work out too well. I think it was a little early in his thermospray inventions.

**GRAYSON:** It seems like Marvin appears in many places.

**FENSELAU:** [Yes]. He's a traveling instrumentalist.

**GRAYSON:** Yes, definitely. So then you stuck with what, CI, chemical ionization and EI?

**FENSELAU:** It had FAB [fast atom bombardment]. And FD [field desorption]. It came with FD, but after we had it a year or something, fast atom bombardment, the company was selling that. They delivered us the first one. We did some really interesting things with it. [...] Your outline says, "What are your favorite papers?" One of them was a paper in *JACS* 1981, where we published spectra of nucleotides that were alkylated with the anticancer drug that we're interested in.<sup>21</sup> It's a good alkylating agent.

**GRAYSON:** So that was...

**FENSELAU:** They were definitely not volatile, you know.

**GRAYSON:** [Yes].

**FENSELAU:** I mean phosphates on the nucleotides and phosphates on the cancer drug...

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<sup>20</sup> Marvin L. Vestal, interview by Michael A. Grayson at the Orange County Convention Center, Orlando, Florida, 3 March 2010 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0680)

<sup>21</sup> Vanessa T. Vu, Catherine C. Fenselau, and O. Michael Colvin, "Identification of Three Alkylated Nucleotide Adducts from the Reaction of Guanosine 5'-monophosphate with Phosphoramidate Mustard." *Journal of the American Chemical Society* 103, no. 24 (1981): 7362-7364.

**GRAYSON:** Well FAB, I think, really made a serious impact at that time, because it really worked for all those compounds and nothing that normally, nothing else worked for.

**FENSELAU:** [Yes]. It was much more reliable than plasma desorption or field desorption, but <T: 05 min> it just didn't have the...when electrospray came along, electrospray had more sensitivity, or was implemented with more sensitivity.<sup>22</sup>

**GRAYSON:** Did you get into any negative ion work?

**FENSELAU:** We probably have published some negative ion papers. But somehow the laws of physics seem to be violated, that these instruments don't transmit negative ions as well as they do positive ions.

**GRAYSON:** In theory, it shouldn't be that big of a difference, right.

**FENSELAU:** Yes.

**GRAYSON:** I mean, an ion is charged, but you've got to reverse everything. It never does seem to work as well as the other way around. So you really probably hopped on to FAB pretty quickly, I guess.

**FENSELAU:** Yes. This was the first structure elucidation published with FAB. This is 19[81].<sup>23</sup>

**GRAYSON:** [...] 1981. [Yes]. Okay. [...] So that was...

**FENSELAU:** Was a goody.

**GRAYSON:** That was a goody from the viewpoint that it kind of got a lot of attention?

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<sup>22</sup>Catherine Fenselau and Robert J. Cotter, "Chemical Aspects of Fast Atom Bombardment." *Chemical Reviews* 87 (1987): 501-512.

<sup>23</sup>Vanessa T. Vu, Catherine C. Fenselau, and O. Michael Colvin, "Identification of Three Alkylated Nucleotide Adducts from the Reaction of Guanosine 5'-monophosphate with Phosphoramidate Mustard."

**FENSELAU:** You know, it's well referenced. It's not one of my highest referenced papers, but it got a lot of attention from the FAB community.

**GRAYSON:** [Yes].

**FENSELAU:** There were a lot of people interested in alkylated nucleotides and a lot of people interested in this cancer drug, so it had attention from a variety of communities.

**GRAYSON:** So that was probably one of the first things you did with FAB.

**FENSELAU:** Yes.

**GRAYSON:** Now there's all this business with liquid SIMS [secondary ion mass spectrometry], and this kind of squirting match between the people who said that it already existed well before the organic chemists came along, and all that good stuff.

**FENSELAU:** I'm willing to agree with that.

**GRAYSON:** Okay. I guess [Michael] Barber and that group were the first ones to actually show that you could use it for organic chemistry.

**FENSELAU:** You know, he published a paper in [*Journal of the Chemical Society, Chemical Communications*.]<sup>24</sup> There's a paper right beside it from a physical chemist at the same chemistry department [John Vickerman], doing the same thing with liquid SIMS, I think.<sup>25</sup> But anyway, it sounds to me like they might even have worked together to evolve the idea of it, but then they fell out and published it separately.

**GRAYSON:** That's interesting.

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<sup>24</sup> Michael Barber, Robert S. Bordoli, R. Donald Sedgwick, and Andrew N. Tyler, "Fast Atom Bombardment of Solids (FAB): A New Ion Source for Mass Spectrometry," *Journal of the Chemical Society, Chemical Communications* 1981: 325-327.

<sup>25</sup> David J. Surman and John C. Vickerman, "Fast Atom Bombardment Quadrupole Mass Spectrometry," *Journal of the Chemical Society, Chemical Communications* 1981: 324-325.

**FENSELAU:** The physical chemist is still...well, Michael Barber died, you know, and the physical chemist is still active in research. He does a lot of imaging studies with SIMS. [...]

**GRAYSON:** [Yes], why not, kind of, explore that idea that you...it would be interesting from a historical viewpoint to...

**FENSELAU:** Well, the two papers are there. I'm not...I mean, I don't know.

**GRAYSON:** Well, sure...

**FENSELAU:** I didn't know [Surman or Vickerman] at all.

**GRAYSON:** I can go to that literature, because I can access that and find the papers. But I remember there's a certain amount of "you guys have reinvented the wheel" thing. You know.

**FENSELAU:** But those guys commercialized it, and thus, you didn't have to be a physical chemist to have access to it, too.

**GRAYSON:** It seemed to work so simply. I guess, of course, there was all this business of trying to develop different matrices. I think glycerol was probably...everybody just picked up on that, I imagine and used that...

**FENSELAU:** [Yes].

**GRAYSON:** Pretty much. But...

**FENSELAU:** You know the...VG. Now we are talking about two English companies that also brought it out almost simultaneously...commercialized it almost simultaneously. I think that...I guess, maybe both companies didn't want to give away the glycerol secret. You know, here we have our magic fluid. We'll put in your sample and it'll work. So the first time that the technician in my lab at Hopkins, a man named Gordon Hansen, looked at the spectrum, he said, "Oh, that's glycerol." So that was a secret that was hard to keep.

**GRAYSON:** [Yes]. So if you knew a little bit about mass spec, then it was very easy to sort it out.

**FENSELAU:** Yes.

**GRAYSON:** [Yes]. Then I think mass calibration could be a bit challenging sometimes with FAB, as I recall. Actually, no, you put the salts on there and that worked pretty well, depending on the mass range, if you were pushing things <**T: 10 min**> mass...

**FENSELAU:** Yes. It's true that you had to do a different calibration...

**GRAYSON:** How high in mass read did you take your FAB thing? Did you really get up into the higher mass ranges?

**FENSELAU:** We were very proud of our insulin spectrum, [mass ~5775 Da.]<sup>26</sup>

**GRAYSON:** Oh, wow. Okay.

**FENSELAU:** And I'm trying to think if we didn't do some proinsulin, which is nine [thousand Da.] But we wanted it with unit resolution, so the insulin spectrum is resolved, and the heavier proinsulin is a blob.

**GRAYSON:** So that would have been in 19...

**FENSELAU:** The early 1980s. [It was 1982.]

**GRAYSON:** Early 1980s. Wow, okay.

**FENSELAU:** I once gave a talk and [showed] a collection of everybody's insulin spectra. You know Michael Barber published one. We published one. Howard [R.] Morris published one. The

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<sup>26</sup> Catherine Fenselau, J. Yergey and D. Heller, "Particle Induced Desorption and the Analysis of Large Molecules," *International Journal of Mass Spectrometry and Ion Physics* 53 (1983): 5-20.

best one probably was from an instrument in Japan. They called it the Grand Mass Spectrometer. It had a very large radius of curvature...

**GRAYSON:** It was a magnetic sector guy?

**FENSELAU:** [Yes]. It took probably half a cup of sample but it did resolve. It did give very good resolution.

**GRAYSON:** Neat. Interesting. Yes. Well, this is something that does come in handy to have it. But that was pretty impressive to have unit mass resolution at the...

**FENSELAU:** We thought so.

**GRAYSON:** [Yes], at that point in time. That was with the MS50.

**FENSELAU:** Yes.

**GRAYSON:** Now how was getting that machine [to perform]? You know, they had these high resolving power specifications. Were they attainable or were they just like...

**FENSELAU:** Yes. You know, that was a really well-made instrument. It met specs with no problem. It did take some weeks to get it set up and pumped down, and the ion trajectory established. But there weren't any setbacks, and it did meet specs.

**GRAYSON:** So once it was installed, and spec'd up, then that was...it stayed there.

**FENSELAU:** Yes. In contrast to the four-day installation of our four-sector JEOL [Ltd.] system, ten years later [...].

**GRAYSON:** [Yes]. Well, that's important. The thing that's kind of strange about that instrument, the 50, is the ion source physical location has to be fixed rather carefully. I mean, that's [an important] part of the optics.



**FENSELAU:** [Yes].

**GRAYSON:** I mean, the VG machine had this kind of self-referencing arrangement, and the source was on the spring. When you put it in, it kind of got referenced...

**FENSELAU:** Positioned itself...

**GRAYSON:** [Yes], but the 50 was on the flange, hard on the flange, so that flange had to be very precisely aligned.

**FENSELAU:** Is that why I had so much old gold ['O' rings] in my...

**GRAYSON:** Yes.

**FENSELAU:** At my desk.

**GRAYSON:** That's pretty valuable gold...

**FENSELAU:** Yes. Actually, I recently traded my gold ['O' rings] in for a computer for the lab.

**GRAYSON:** Oh, well, hey. You know this is a good time to do it.

**FENSELAU:** Yes.

**GRAYSON:** Yes. That's an interesting concept. So, I mean, you ended up having to do the routine baking and all that kind of good stuff that comes with the instrument in terms of keeping it clean for resolving power purposes, and...

**FENSELAU:** Well, [yes]. I mean, we treated it as it was supposed to be treated. But at that point, with NSF funding, I was running it less, was less close to it. So this is like the first instrument I didn't have my hands on very much. So a guy named Gordon Hansen and a guy named David [N.] Heller were the folks who were closest to the instrument.

**GRAYSON:** Okay. So they kept it up to snuff.

**FENSELAU:** Yes.

**GRAYSON:** [Yes]. So you actually did a lot of probe samples.

**FENSELAU:** Yes. The exciting biological polymers, you know, that we'd never been able to do before.

**GRAYSON:** [Yes]. So the GC, it never was put in the GC-MS mode, modified the...

**FENSELAU:** It didn't even come with a GC.

**GRAYSON:** [Yes].

**FENSELAU:** But the LC that we tried to work out with Marvin, the thermospray just wasn't working, so we didn't go ahead with that. So instead we got, again, a second instrument, an interfaced LC-MS with thermospray.

**GRAYSON:** [Yes]. That would have been a pretty exciting time to be having an instrument that could do those kinds of things with the direct probe and biological samples, which were almost impossible to do...

**FENSELAU:** Well, and I guess ...the theme for our NSF facility was pushing the mass range. So that instrument allowed us to deliver.

**GRAYSON:** Yes. [Yes].

**FENSELAU:** One of the papers—you asked me about what papers I liked—there was the paper in *Analytical Chemistry* in 1983, where we envisioned the kind of isotope clusters that we

might get with proteins that weigh a hundred thousand or ten thousand.<sup>27</sup> So we really were laying the groundwork for working <T:15 min> with heavier samples.

**GRAYSON:** So this was the [...] theoretical description of how the isotopic pattern would shift as you got into higher masses and the carbon-13 peak would start to take off with...

**FENSELAU:** Right. Couldn't see the carbon-12 anymore.

**GRAYSON:** [Yes].

**FENSELAU:** Then we did a couple of other papers that worried about how the world would change at high mass, even though we didn't have electrospray yet. One of them was the speed of fragmentation. We managed to find experimental conditions with actually using plasma desorption on time of flight as well as [laser desorption on one of Bob Cotter's customized TOF instruments] to show that the heavier molecules decomposed more slowly.

**GRAYSON:** Because there were more degrees of freedom to distribute energy.

**FENSELAU:** [Yes], I think so. [Yes]. I don't know if that surprises anybody now, but it was a very nice experimental...you know, got a three-point curve. That one was *Analytical Chemistry* 1987.<sup>28</sup>

**GRAYSON:** So did you do that work with [James] Yergey on the [...] isotopic distribution...

**FENSELAU:** [Yes]. He wrote a little program that allowed us to generate those.

**GRAYSON:** [Yes].

**FENSELAU:** I mean, he was a very good postdoc for other reasons too.

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<sup>27</sup> James Yergey, David Heller, Gordon Hansen, Robert J. Cotter, and Catherine Fenselau, "Isotopic Distributions in Mass Spectra of Large Molecules." *Analytical Chemistry* 55, no. 2 (1983): 353-356.

<sup>28</sup> Plamen Demirev, James K. Olthoff, Catherine Fenselau, and Robert J. Cotter, "High-mass Ion Fragmentation as a Function of Time and Mass." *Analytical Chemistry* 59, no. 15 (1987): 1951-1954.

**GRAYSON:** So he was a postdoc at that time...

**FENSELAU:** [Yes].

**GRAYSON:** In your shop...

**FENSELAU:** This is Jim, not Al [Alfred L. Yergey].

**GRAYSON:** Oh, Jim.

**FENSELAU:** This is Al's brother, Jim.

**GRAYSON:** I see. Okay. Well, I didn't even know about brother Jim. All I know about is Al. No, this is good to know.

**FENSELAU:** Brother Jim works for Merck [Company] in Canada. He's probably not doing mass spectrometry, but he's probably in charge of some analytical unit.

**GRAYSON:** I see, okay.

**FENSELAU:** He's even more affable than Al.

**GRAYSON:** Okay. So it was 1987 that the other work was done with plasma desorption, did you say? Or...

**FENSELAU:** Well, it was done with several ionization techniques, but the first name on that one could be [Plamen A.] Demirev.

**GRAYSON:** [Yes].

**FENSELAU:** 1987 *Analytical Chemistry*.

**GRAYSON:** “High mass fragmentations and function of time...”

**FENSELAU:** [Yes].

**GRAYSON:** [Yes].

**FENSELAU:** So those were papers that even though we weren't getting much above ten thousand, let's say, those papers were laying the intellectual foundation. We also published, not necessarily one of my favorite papers, but published the idea of doing a survey scan to find out where on the large mass range the molecular ion was, and then could go back and elaborate on that.<sup>29</sup> That's [now] a standard [approach] used in high mass...in top-down protein analysis. So we were thinking hard about it, and encouraging the rest of the community to think hard about it.

**GRAYSON:** So these ended up being papers as well at ASMS meetings and...

**FENSELAU:** Oh, I'm sure. Everything...yes, absolutely. I don't have those references, but we know how to get them.

**GRAYSON:** Oh, [yes]. So it's a very exciting time, I guess, being able to do things that...and I guess you got a lot of people, other people in the community, doing it as well...

**FENSELAU:** Sure.

**GRAYSON:** FAB. But each...so you had each kind of carved out a little bit of a biochemical...

**FENSELAU:** I don't know. There was a lot of competition too.

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<sup>29</sup>R.J. Cotter, B.S. Larsen, D.N. Heller, Joseph E. Campana and Catherine Fenselau, “Wide Mass Range Scanning for the Fast Atom Bombardment Mass Spectrometry of Very Large Compounds,” *Analytical Chemistry*57(1985): 1479-1480.

**GRAYSON:** There was.

**FENSELAU:** Sure. Burlingame had very similar equipment. Then a guy at Illinois, Ken [Kenneth L.] Rinehart...

**GRAYSON:** [Yes], Rinehart.

**FENSELAU:** And [Rinehart] probably was more in the natural products business, but he liked to show off his FAB source. So that was fun, you know.

**GRAYSON:** But I mean you all were doing FAB, but you were not competing in the part of biochemicals that you were looking at, were you? Or...

**FENSELAU:** I'd say, I don't know about competing, but several of us were addressing proteins.

**GRAYSON:** Okay.

**FENSELAU:** Howard Morris was addressing proteins in England. So there were...you know that makes it go faster if there's more than one...

**GRAYSON:** Oh, [yes]. [Yes]. Well, that's the thing I was, kind of, curious about, McCloskey, he was kind of out there in the nucleoside world pretty much by himself.

**FENSELAU:** [Yes]. I think that's my opinion, yes.

**GRAYSON:** [Yes].

**FENSELAU:** And doing work that seemed very esoteric at the time with RNA methylation than, of course, then when people figured out that RNA was folded and that a lot of the modifications directed and stabilize the folding, then [Jim's work] was suddenly very important.

**GRAYSON:** [Yes]. Well, I mean, they were funding it. He told me that they actually had to...you know, looked at his work and says, “Well, I’ve got to move you from this pot to another pot.” But they didn’t say, well...

**FENSELAU:** [Yes].

**GRAYSON:** In other words, there was a, “We can’t fund you, but here’s a place that can...”

**FENSELAU:** That’s right.

**GRAYSON:** Rather than saying, “We can’t fund you and go away.”

**FENSELAU:** [Yes] <T: 20 min>.

**GRAYSON:** So obviously their work was important...

**FENSELAU:** Somebody thought it was important.

**GRAYSON:** That they saw to it that he got his research shifted. So then, when did you...I mean, proteomics seems to be one of the big buzzwords of the modern age, which is 2012. I’m curious when you started to get into the proteins and...

**FENSELAU:** Really not until I moved to UMBC [University of Maryland, Baltimore County], and we were interested in weighing proteins. But in terms of sequencing and doing that kind of...

**GRAYSON:** Okay...

**FENSELAU:** Looking at post-translation modifications.

**GRAYSON:** So the protein weight did what for you?

**FENSELAU:** Well, it proved that we could, for one thing. We looked at some insulins from different species. I guess, if we could see a different mass that that might, used in conjunction with classical sequencing, tell us what the differences were between species. So we were really [putting] more emphasis on methods development at Hopkins, on how to work with a large ion rather than applying it.

**GRAYSON:** There's this whole issue with larger ions making less of a signal when they get to the detector, was that...

**FENSELAU:** Sure. So we do post-acceleration.

**GRAYSON:** So once they get there, you give them a little kick, extra kick to...

**FENSELAU:** [Yes]. In fact, probably the reason that [Koichi] Tanaka got the Nobel Prize [Chemistry, 2002] was because he designed his instrument to analyze [and detect] heavy ions. Although he used a funny matrix, a kind of powdered metal, he had post-acceleration. He had a longer flight tube, whatever was needed to confirm that he had desorbed these proteins and protein clusters. [...]

**GRAYSON:** Okay. So that was a definite requirement that you ran up against pretty much immediately is, so you can get the mass spectrometer to separate these things and get them out there. But without...

**FENSELAU:** Still have to detect them, [yes].

**GRAYSON:** Still have the detector issue. It has to be souped-up in order to handle these larger compounds. That was an important development and it did come out of the instrumental manufacturer types?

**FENSELAU:** Well, you know Tanaka's at Shimadzu [Corporation]. I don't know if he was the only one who did it, and probably somebody would tell me that the Atomic Energy Commission did it during the Second World War. I mean, nothing seems to ever be totally new in physics.

**GRAYSON:** Somebody got there sooner.



**FENSELAU:** But they weren't using it to analyze whole proteins.

**GRAYSON:** Right.

**FENSELAU:** [Yes].

**GRAYSON:** So you moved into the protein business, you say, when you moved to...

**FENSELAU:** My next campus, right.

**GRAYSON:** Next campus.

**FENSELAU:** I ought to tell you, if I may, two more things about Hopkins, going back a little bit.

**GRAYSON:** [Yes], that's fine.

**FENSELAU:** The papers of which I'm most proud [from Hopkins] were...I guess I've got two on the list here. Well, we just talked about the high mass work, but two others. I told you we were developing methods to synthesize and characterize these glucuronide conjugates of drugs. There was a problem the FDA was having with a natural product that was [patented as a glucuronide and] proposed to be an anticancer agent. It was called Laetrile. It was uncertain what it actually was, and it was also uncertain it actually had any effect on the disease.

But in any case, [we had developed a method to synthesize glucuronides, and the FDA brought us a great opportunity to use that method. They were evaluating a commercial preparation from Mexico that was being promoted as an anti-cancer agent. The question we asked in collaboration was if the chemical sold as Laetrile<sup>TM</sup> was the glucuronide described in the patent. We synthesized the glucuronide of mandelonitrile and compared its mass spectrum, gas chromatogram (the samples were derivatized) and NMR with several of the commercial samples. The latter were found to contain the diglycosides amygdalin and neoamygdalin. This analysis was carried out on our new GC-MS.]

So we helped the FDA and the courts define what <**T: 25 min**> the commercial substance was, and it was taken off the market. I think they also were able to show that it had no effect on cancer.

**GRAYSON:** So the commercial product was an attempt to synthesize what was happening with this natural product?

**FENSELAU:** The commercial product was probably a fake. Just out and out a fake.

**GRAYSON:** It was just...wow.

**FENSELAU:** That was published in *Science* in 1977.<sup>30</sup> So it definitely goes into the Hopkins' folder. My only paper in *Science*.

**GRAYSON:** Well, one doesn't get there that easily.

**FENSELAU:** I don't try very often, [either]. Then the other [paper] I wanted to mention to you from Hopkins. I don't even know whose name is first [on the *Science* paper.] There were so many names on that paper. The other thing I wanted to mention from [my] Hopkins time was that all of this work with the real cancer drug, cyclophosphamide, was published in several papers. Some of them had Ian Jardine's name on them. The one that I liked the best was the one that's called "A human metabolite of cyclophosphamide," and that was in *Cancer Research* in 1973.<sup>31</sup>

**GRAYSON:** Wow, that's going back a ways.

**FENSELAU:** Well, that was done with that GC-MS that we talked about, you know, and permethylation and all that stuff. Horrible, all the...

**GRAYSON:** "Biologically active metabolite in cyclophosphamide..."

**FENSELAU:** [Yes]. 1973, is that...

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<sup>30</sup> Catherine Fenselau, Sharon Pallante, Robert P. Batzinger, Walter R. Benson, Robert P. Barron, Eric B. Sheinin, and Millard Maienthal, "Mandelonitrile beta-glucuronide: Synthesis and Characterization." *Science* 198, no. 4317 (1977): 625-627.

<sup>31</sup> Michael Colvin, Charles A. Padgett, and Catherine Fenselau, "A Biologically Active Metabolite of Cyclophosphamide." *Cancer Research* 33, no. 4 (1973): 915-918.

**GRAYSON:** [Yes], 1973 with Colvin?

**FENSELAU:** [Yes]. He was the oncologist.

**GRAYSON:** [Yes], okay. That was in *Cancer Research*.

**FENSELAU:** The closet chemist...yes. Then you've got the *Science* one in 1977.

**GRAYSON:** [Yes].

**FENSELAU:** Okay, so that brings me...those are the comments I wanted to make...

**GRAYSON:** So these are all related to cancer research, right. The important ones at Hopkins...

**FENSELAU:** The last two I mentioned were. But the other set that were related to how to analyze proteins, basically. Okay, so...

**GRAYSON:** Okay. What brought you to...

**FENSELAU:** UMBC.

**GRAYSON:** Your tenure at...

**FENSELAU:** Hopkins...

**GRAYSON:** Oh, okay. Well, you were in the tenure track?

**FENSELAU:** I got tenure in 1984.

**GRAYSON:** In...okay. So you ended up being tenured.

**FENSELAU:** [Yes]. I told you already that Hopkins is very good with their money, so when [Bob and] I got the big [center] grant from [NSF], it helped [me] to get tenure. In 1988, I moved to a University of Maryland campus, but not this campus, one called Baltimore County. It's halfway between [College Park, Maryland] and Baltimore. I had decided that I wanted to be more active in teaching than I could be in the medical school. I also felt that I was never going to get a chance to try being a chair of a department, because the chairs in that medical school are for life. I noticed in my department they tended to be MD's.

**GRAYSON:** Surprise.

**FENSELAU:** So I moved to try my wings in another pond, if I could mix my metaphors. That was UMBC...and I had a very interesting time there. UMBC is a campus founded in the 1960s, when there was this glut of college students and a lot of state systems built additional campuses. It had the permission to grant PhD's, but it hadn't built much of a research program. Had a very good president at that time, named Michael [K.] Hooker, who went on to be the chancellor of the University of Massachusetts system, and also eventually the—I'm not sure about these, if it's president or chancellor—but at University of North Carolina, Chapel Hill.

He hired an assistant provost...he hired someone into the administration whose job it was to increase the enrollment of African-American students in that campus, and that man's name is Freeman [A.] Hrabowski. . Freeman Hrabowski has been the president of that campus now for nearly twenty years. He succeeded Hooker, when Hooker left.

**GRAYSON:** So that's R something?

**FENSELAU:** H-R-A-B-O-W-S-K-I. As he said, "The plantation owner was Polish." But you understand "free man"...

**GRAYSON:** [Yes], [yes].

**FENSELAU:** That was his first name.

**GRAYSON:** [Yes].

**FENSELAU:** Freeman is a very educated person. I think he probably had a bachelor's in math, and a PhD in education. He's still there. They're very fortunate to <T: 30 min> have had his hand, you know, one hand and a good hand, on the helm for a long time. It was fun working with Freeman. He started a really successful program for educating high achieving African[-American] men. He meant high achieving in science and math, engineering. I got to be [part of] the founding faculty of that program. Then when he started getting federal money, they told him he [couldn't] limit it. He couldn't exclude women, and then, they said he couldn't...

**GRAYSON:** Couldn't exclude women.

**FENSELAU:** Couldn't have it just black. So anyway, it's still a very good program, and it still has that focus. At that campus, I went there as chair of the department, and...

**GRAYSON:** So that was your beginning position at the campus...

**FENSELAU:** Yes. Then I was an interim dean of the graduate school for, I don't know, eighteen months. [That job] let me sit on the president's council meetings. So I learned a lot about running universities. There I also did some really interesting research, which I want to tell you about, but just looking [at my notes]...so anyway, Talalay was my last mentor. I don't count these other guys and gals as mentors.

**GRAYSON:** Well, you're pretty well on your own by that time...

**FENSELAU:** Yes. I guess that's correct. So the papers I would mention there are [...] well, we had a four-sector. We had the JEOL four sector...

**GRAYSON:** This is at...

**FENSELAU:** As I was moving, I applied to NSF for...okay. Sorry, I have to start all over again. We had the NSF regional instrumentation center at Hopkins.

**GRAYSON:** Okay.

**FENSELAU:** Which Bob wanted to inherit or take...not inherit, but he wanted to take over completely and I wanted, of course, to have something, a similar sized operation at UMBC. So I

applied to NSF for support like that at the new place. They gave it to us, and we bought a four-sector instrument. When I went there, I had the biggest [and only] mass spectrometer on campus.

**GRAYSON:** Biggest piece of equipment...

**FENSELAU:** Big frog in a little pond, [yes]. But the four-sector's a fabulous instrument, really was.

**GRAYSON:** This was a JEOL machine...

**FENSELAU:** The JEOL four-sector was a fabulous instrument. I don't know that the VG ever worked very well. But...

**GRAYSON:** [Yes]. I don't know if it did, either...

**FENSELAU:** Was it your experience [also?] [When] I won an award from the International Mass Spectrometry Society, shared it with Cathy Costello and Peter Roepstorff from Denmark, we all were supposed to give ten-minute histories of our lives. We all three ended with a picture of a four-sector JEOL. It was astonishing. It was such a big...it was thrilling to have that instrument. Now, you know, nobody uses sectors very much anymore. It was a FAB instrument, but we got it upgraded to electrospray.

**GRAYSON:** So how much did that kind of equipment cost?

**FENSELAU:** It was a million dollars.

**GRAYSON:** A million.

**FENSELAU:** In that day.

**GRAYSON:** Okay.

**FENSELAU:** The box arrived, and four Japanese engineers got [there] and put it together in four days.

**GRAYSON:** Did they fly it in from Japan?

**FENSELAU:** I think it came by ship. But it was just so well-engineered that there was no problem with alignment, and...

**GRAYSON:** Wow, four-sector's you've got to have some problems.

**FENSELAU:** Well, yes. But they were pumping down and seeing ion current in four days, and you know, they may have tuned it after that, but they were out of the lab in a week. So we used it and loved it, and several of the names you want me to comment on sometime were people who used that instrument to full advantage.

So one of the best things we did there was to measure the proton affinity of arginine. The physical chemists at NIST [National Institute of Standards and Technology] and so on had measured the proton affinities of some of the amino acids, most of the amino acids, but arginine is too basic for the reference compounds that were available and the methods that were available. So we used this method where you have two molecules sharing a proton and [when the complex is energized] the one that's more basic leaves with the proton. I went to the international meeting in Amsterdam [The Netherlands] in whatever year that would have been, probably 1991. Among other things, I met the Russian, Victor [L. Tal'roze]. It was finally a time that the Americans and Russians could talk to each other...

**GRAYSON:** [Yes] <T: 35 min>.

**FENSELAU:** [...] But more importantly, I saw a poster [...] that had a compound on it with a proton affinity very carefully measured that was more basic than arginine. And we actually could [buy] the compound. Came home, ordered it, did the charge competition experiment and published it. Now the physical chemists thought this wasn't the perfect method, but it's the only method [so far].

**GRAYSON:** [Yes]. Well.

**FENSELAU:** It's the only value still in the literature!

**GRAYSON:** [Yes]. So this was a case where a poster session was very...

**FENSELAU:** Tal'roze.

**GRAYSON:** Oh, okay.

**FENSELAU:** Okay. [Yes], [it was in] the poster session that I stumbled onto that poster.

**GRAYSON:** [Yes]. Well, I mean that's what the hope is with idea information exchanges in a conference. You know, if one good idea comes out of it, then...I'm sure there are a lot of good ideas coming out, if you could go around and took them all up. So that was a pretty cool, kind of, deal.

**FENSELAU:** Yes. It was an exciting time. Some of the other things we did...well, when we got electrospray, we could do a lot of things. We looked at...

**GRAYSON:** So you didn't get electrospray until moved to the UMBC.

**FENSELAU:** Right. Well, no, is that true?

**GRAYSON:** Well, you had the thermospray back in...but that didn't fly very well.

**FENSELAU:** So I moved there in '88. That was the first instrument I had it on. [...]

**GRAYSON:** [Yes]. Well, electrospray didn't really get to be popular until...

**FENSELAU:** Ninety...

**GRAYSON:** [Yes], late '80s, early '90s.



**FENSELAU:** So I think that instrument was delivered with FAB. Then we used it that way for a couple of years, but we got the electrospray, and again, JEOL did a very nice job of engineering it.

Okay. So the other kinds of things...so I really did a lot of work with proteins, not yet proteomics, but protein studies at UMBC.

**GRAYSON:** Okay.

**FENSELAU:** And arginine basicity was part of what you needed to know to do peptide work, at least. We did publish an experiment which is not referenced much, but I believe is the first experiment using mass spectrometry to map protein folding, protein topography. I did it with a [biophysical] chemist [Robert F. Steiner] and we used acetylation, which is not, like, as subtle as an HD exchange.

But anyway, we published that paper in *Analytical Biochemistry*, in 1991.<sup>32</sup> I think it's an important paper that people have missed or not referenced anyway. I think it was the first paper that reported using mass spectrometry to study protein topography.

**GRAYSON:** So what protein? Were you looking at some particular ones, or just...

**FENSELAU:** No. It was a binding pair. You've got the *vitae* that tells us...

**GRAYSON:** It was, what, 19...

**FENSELAU:** It's one of Mike Gross's favorite proteins actually. But he was interested in it for different...he was...

**GRAYSON:** We're doing 1991?

**FENSELAU:** [Yes]. The first [author] might have been Murphy. But it's in *Analytical Biochemistry*.

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<sup>32</sup> Robert F. Steiner, Sharon Albaugh, Catherine Fenselau, Constance Murphy, and Martha Vestling, "A Mass Spectrometry Method for Mapping the Interface Topography of Interacting Proteins, Illustrated by the Melittin-calmodulin System." *Analytical Biochemistry* 196, no. 1 (1991): 120-125.

**GRAYSON:** First author...for '91, first author is Bryant. Bryant, Fenselau, Hua? [...] O'Dell, Orlando, Rose...

**FENSELAU:** No. No. That was not it.

**GRAYSON:** Shore, Simpson, Steiner, Unger...

**FENSELAU:** R.F. Steiner, that was it.

**GRAYSON:** Steiner.

**FENSELAU:** Okay. Steiner...

**GRAYSON:** "Mass spectrometry methods for the interface topography interacting proteins..."

**FENSELAU:** Yes. So we used a melittin-calmodulin pair. You know, calmodulin rearranges itself when it binds melittin.

**GRAYSON:** [Yes].

**FENSELAU:** And about the same time, Mike Gross was interested in counting the calciums of calmodulin.

**GRAYSON:** Right, [yes].

**FENSELAU:** And it turns out, you know, calmodulin had been heavily studied by the physical chemists in the preceding decade, but anyway. So that's one I'm proud of, even though it's not highly referenced.

**GRAYSON:** So you were able to investigate folding...

**FENSELAU:** The structure of the folded protein. Folding has a kinetic implication. We just looked at it after it bound the small molecule, the peptide and saw that its three-dimensional structure was different than when the small molecule wasn't bound.

**GRAYSON:** Okay. And how did you know that?

**FENSELAU:** Because we alkylated it. We alkylated all the accessible lysines...

**GRAYSON:** Okay <T: 40 min>...

**FENSELAU:** And the number of accessible...and then, denatured it and cleaved it with trypsin, and looked at each peptide to see if it carried an acetyl group. The number of lysines that were acetylated was different in the free calmodulin and the complexed calmodulin. And we argued that when it was complexed that some of those lysine sites were protected.

**GRAYSON:** Were protected in the fold, in the formation of the protein...

**FENSELAU:** Complex.

**GRAYSON:** Structure as a result of the wrapping around the calmodulin.

**FENSELAU:** Mm-mm. Well, the calmodulin wrapping around that [peptide.]

**GRAYSON:** Ah, okay. Yes.

**FENSELAU:** [Yes].

**GRAYSON:** Got it backwards.

**FENSELAU:** So...yes. That's the strategy that's now done with hydrogen-deuterium exchange and other alkylation reactions.

**GRAYSON:** [Yes].

**FENSELAU:** So I like that one, but I don't think a lot of people saw it. That was just before good [searchable] indexing, you know...

**GRAYSON:** [Yes]. Well, it's in *Analytical Biochemistry*, so...

**FENSELAU:** And that's not a...[yes].

**GRAYSON:** Is that not a...

**FENSELAU:** It's not a protein journal that...

**GRAYSON:** [Yes], [yes].

**FENSELAU:** So, okay. Then I guess the other one I wanted...I should mention from that time period is a collaboration with some folks from the Frederick Cancer [Research and Development] Center, which was rapidly, at that time, turning into an HIV research center. They brought us a gene product from HIV, which they had in culture under appropriate safety conditions.

They wanted us to...it was known that there were [multiple] proteins, [...] a finite number in the virus. And that these all were cut out of just a much smaller number of long proteins that were the direct gene products. So we looked at the [Gag] gene product and could say which of the proteins, the smaller proteins were cut from it, and where the cleavages occurred.

**GRAYSON:** Okay.

**FENSELAU:** That one's actually very highly referenced. That's *Journal of Virology*, 1992, and that particular gene product is called Gag.<sup>33</sup> Don't ask me why.

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<sup>33</sup> Louis E. Henderson, M. A. Bowers, RC D. Sowder, S. A. Serabyn, D. G. Johnson, J. W. Bess, L. O. Arthur, D. K. Bryant, and C. Fenselau, "Gag Proteins of the Highly Replicative MN Strain of Human Immunodeficiency Virus Type 1: Posttranslational Modifications, Proteolytic Processings, and Complete Amino Acid Sequences." *Journal of Virology* 66, no. 4 (1992): 1856-1865.

**GRAYSON:** “Gag proteins with a high replicative MN strain human immunodeficiency virus Type I posttranslational modifications...”

**FENSELAU:** It has all those big words in it.

**GRAYSON:** Yes, *Journal of Virology*. [...]

**FENSELAU:** But anyway, so that was what we did. Then there were lots more [studies made] with the superb capabilities of that system and electrospray. We looked at carbohydrates. We did just a number of other things. That was a very productive period. That was a period when I really started having graduate students.

**GRAYSON:** So in this work where you were doing kind of a ‘medium-size’-down [as opposed to a top-down] type approach. You were doing some digestion...

**FENSELAU:** I think probably we did a...well, we weighed them, sure. But we did most of it, what we called “bottom-up.” You know.

**GRAYSON:** Okay. [Yes].

**FENSELAU:** But it wasn’t really proteomics yet. You know, it’s the structures of several proteins. Proteomics is high throughput...

**GRAYSON:** [Yes]. That was one of the things I was going to ask you. What is your definition of proteomics?

**FENSELAU:** Okay. It’s automated analysis of...automated or high throughput analysis of complex protein mixtures.

**GRAYSON:** Complex protein mixtures that are pertinent to a cell?

**FENSELAU:** Well, you know the protein mixture can come from cells. It can come from a whole animal. You can grind up a spider or something. It can come from a subcellular organelle. You could just isolate nuclei and look at the proteins in the nuclei.

**GRAYSON:** So it can be anything you want, but you're trying to find out about all the proteins that are in...

**FENSELAU:** At once, in one experiment. Yes.

**GRAYSON:** In one experiment.

**FENSELAU:** Maybe you never find out about all of them, but many of them, [yes].

**GRAYSON:** You want to find out as many as you can.

**FENSELAU:** In one...yes. In a single...

**GRAYSON:** And you're in a hurry.

**FENSELAU:** That's high throughput. People used to spend a whole PhD thesis purifying one protein. Then, hopefully, they could have time to get it sequenced by the chemical methods that required <T: 45 min> a milligram of material. Mostly we now, still look at peptides, but by [comparing] the peptides with the genome sequence.

So they have a collection of all of the possible protein sequences. We can characterize a peptide [sequence], look for it in the [proteins] from all of the genome, all across the genome, and perhaps know thereby what protein we're working with. Then you can ask some more definitive questions, like what's the posttranslational modification.

But anyway, you can define your proteome as an animal cell. You could look at the heart, [as an] organ, or some cellular organelle like the nucleus. Also, you have to define your proteome in time, because it's different for a young person and an old person. It's different for a well person and a sick person. If you think about the monarch butterfly and the monarch caterpillar, same genome, different proteins, different form and function. So time is a variable in defining the protein mixture too.

**GRAYSON:** Interesting.

**FENSELAU:** Yes.

**GRAYSON:** So then that's the big buzz thing in mass spec today is the proteome...

**FENSELAU:** That's what has tripled the attendance at ASMS.

**GRAYSON:** [Yes]. It's turned it into a biology meeting.

**FENSELAU:** Full of European [scientists].

**GRAYSON:** [Yes]. [Yes], and a lot of people I've never seen before.

**FENSELAU:** [Young scientists from Europe.] Yes.

**GRAYSON:** So this JEOL machine, when you put it on the ground, it started delivering results.

**FENSELAU:** Yes.

**GRAYSON:** You didn't have to mess around.

**FENSELAU:** Right.

**GRAYSON:** And you got graduate students.

**FENSELAU:** Well, but the postdocs were still very productive. Yes.

**GRAYSON:** [Yes]. But I mean you really...you were starting to now really...

**FENSELAU:** Could train people.

**GRAYSON:** Train graduate students, which is something you didn't have that much of an opportunity to do...

**FENSELAU:** In the medical school.

**GRAYSON:** Now the school that you were at, this in-between place was, kind of, small, wasn't it? I mean...

**FENSELAU:** It still is. It has about ten thousand undergraduates and graduate students total.

**GRAYSON:** Oh, okay.

**FENSELAU:** It's a really difficult size, because in the...well, it's not two thousand where there are certain expectations, and it's not twenty thousand where there's a lot more budget. But Freeman seems to be keeping it going.

**GRAYSON:** You had a pretty successful tenure there.

**FENSELAU:** [Yes], I thought so. [Yes]. As the chair, I was able to double the size of the department space. My one disappointment was that I was never able to increase the number of the faculty. They still haven't increased it. You know, I've been here twelve years now and UMBC still has the same number of chemistry faculty.

**GRAYSON:** So how big was that group of faculty when you were there.

**FENSELAU:** Oh, it's eighteen.

**GRAYSON:** Okay.

**FENSELAU:** Which is just under critical mass, most people think.



**GRAYSON:** Obviously, the department had a specialization, or more of a flavor?

**FENSELAU:** Well, you know, you have to teach everything. So you have to have physical chemists, inorganic chemists, organics, and biochemists, so we had all of that staff.

**GRAYSON:** [Yes]. But like you say, with eighteen, you know, it's not quite the critical mass to be able to make a big dent in any particular area, is it?

**FENSELAU:** So to my surprise, the strength that developed there while I was chair was in NMR.

**GRAYSON:** Oh, wow.

**FENSELAU:** Yes. And maybe some people would say we had strength in mass spectrometry too. But we hired a young man to teach inorganic chemistry and he started looking at peptides, proteins that bind metals, and started doing that by NMR. , though I don't think that was in his background much. He also, he found the money to have synthesized a long peptide that was the model for one of the important HIV proteins, and showed that structure in NMR binding zinc ions and that really launched his career. Now he's been a Howard Hughes Fellow...

**GRAYSON:** Oh, boy.

**FENSELAU:** You know, which is good for him. His name is Mike [Michael F.] Summers. So that was another good thing that happened while I was there, in addition to my own success.

**GRAYSON:** Is that S-U or S-O?

**FENSELAU:** I think it's S-U-M-M-E-R-S. [We also were able to hire a senior carbohydrate chemist who uses NMR very productively, C. Allen Bush.]

**GRAYSON:** Okay. Were you the chair during your whole time there?

**FENSELAU:** Yes. I was...you know, while I was the acting dean of the graduate school, I was not the chair. But I came back to it.

**GRAYSON:** So what kinds of issues did you have to deal with? I know when I was in the U.K...I think you're probably aware of this, is that a lot of the chemistry <T: 50 min> departments in the U.K. are being kind of...

**FENSELAU:** Downsized?

**GRAYSON:** Downsized.

**FENSELAU:** Sized out...out sized.

**GRAYSON:** [Yes], they were right-sized or wrong-sized.

**FENSELAU:** [Yes]. Well, as I said, I was disappointed that we never could increase our faculty enrollment. The hardest...I think the hardest issues for me were the tenure decisions. There were a couple of split decisions. You know, some where people were denied tenure, and that's always hard to tell someone, tough to tell someone.

**GRAYSON:** [Yes].

**FENSELAU:** Otherwise, we had some good faculty, good researchers, good teachers there. I had a really good administrator who'd been one of my lab technicians at Hopkins, a woman named Sharon [Pallante] Morell. She [moved with me] and managed a lot of the room assignments, you know, and counting the students in the classes, and [scheduling.]

**GRAYSON:** So when you have these issues with tenure, I mean, there was obviously some turnover in the faculty I assume, while you were there.

**FENSELAU:** Yes, and we could replace the ones that left. [Yes].

**GRAYSON:** [Yes]. So generally speaking, what happens if...there's like a period of a year or so after they're not given tenure...

**FENSELAU:** After they're told that they are not going to get tenure.

**GRAYSON:** Have an opportunity to look for...

**FENSELAU:** Look for another job...[yes]. And several of the...maybe they went mostly into industry. This has been a pretty good area to work in, because there's employers of many kinds [in Maryland.]

**GRAYSON:** [Yes].

**FENSELAU:** From this department a number of people who haven't gotten tenure have gone to work as NIH program officers. [This reminds us that it is good to be] nice to [everyone] at all times.

**GRAYSON:** That's not such a nice place for them to be. You could have some issues there, I can see.

**FENSELAU:** [Yes].

**GRAYSON:** Scary, scary stuff. [Yes]. That would be an interesting situation that some of your previous students are now out there deciding whether you should be funded.

**FENSELAU:** Yes. I'm sure this happens to people. They have to work [with] somebody.

**GRAYSON:** [Yes]. [Yes]. Well, a lot of people don't like to deal with this department chair thing. They see it as, kind of, a super pain in the can. But you didn't...you saw it as some more opportunity to try and shape...

**FENSELAU:** I wanted to try something else. Remember, I'd been in the medical school for a long time, so I wanted to be back in education and have some other career experiences. Somebody wrote that we should change our jobs in some way or another, every ten years. So you can get a new instrument, but that's not quite as good as...so I had the full support of the president and a very good assistant, my previous technician. So it was okay.

**GRAYSON:** So did you get good references from Johns Hopkins when you left there? I mean, were you on good terms with the people there?

**FENSELAU:** Oh, I have no idea that they asked anybody.

**GRAYSON:** Oh, okay.

**FENSELAU:** Ah, here we go.

[END OF AUDIO, FILE 1.2]

**GRAYSON:** [...] So is there anything you want to say about...

**FENSELAU:** UMBC...

**GRAYSON:** Johns Hopkins.

**FENSELAU:** Oh, Johns Hopkins.

**GRAYSON:** [Yes], because you've had a successful career there in terms of tenure, but you wanted to do something besides being kind of like a second fiddle operator in the med school.

**FENSELAU:** So I wanted to say that [...] I was the first female who became full professor in preclinical science [at Hopkins.]

**GRAYSON:** Okay.

**FENSELAU:** The medical school had been founded by a group of wealthy Quaker women who—or at least funded in large part—by a group of women who required from the beginning that they admit women. So they always had women students and that eventually evolved into some female physicians and medical faculty. [Among] the preclinical faculty, which was the

research faculty, I was the first one who made full professor. That's one of the things I wanted to say.

**GRAYSON:** Okay. I was just curious, if you know anything about the "Johns." I'm sure it's known somewhere, why it's "Johns" Hopkins and not "John."

**FENSELAU:** Johns was his mother's maiden name or something. It was a family name.

**GRAYSON:** Ah, okay. So it's two family names together.

**FENSELAU:** [Yes]. [Yes]. He never married, and supposedly, was a great good friend of his cousin, female cousin, but they weren't allowed to marry by the family. So he gave his money to Baltimore charity.

**GRAYSON:** Oh, there you go. Okay. And it became Johns Hopkins.

**FENSELAU:** [Yes].

**GRAYSON:** Oh, I see. So this intermediate step to getting [to the University of Maryland at College Park] was this kind of a new school, was that really, basically created in the 1960s.

**FENSELAU:** Yes.

**GRAYSON:** And but you were able to bring funds, research equipment, and troops there, even as a new institution. I mean, did that represent a bit of a hindrance for people who were...or was your reputation so well established by then, that people say, "Well, you know, it doesn't matter where she is; I'll go there."

**FENSELAU:** I like to think it was the latter case. I know that at least two of my graduate students did come there to work in my lab. Plus, [UMBC was] getting some very good students through the 1990s. And all of the country started getting more foreign students. So I didn't feel bad about the student quality there.

**GRAYSON:** So starting...this is pretty high-tech business in a brand new shop. This is not the kind of thing that I would normally expect or that people would see as being feasible. You know, but I mean out of that, maybe I'm confused.

**FENSELAU:** Well, I told you about the NMR entrepreneur, as well, who has done very well there. They hired some other, another [one or] two NMR people there. So the place was evolving with a lot of high powered analytical equipment, instrumentation.

**GRAYSON:** So the whole idea of doing analytical chemistry was okay, with the operation there. It wasn't...

**FENSELAU:** Yes.

**GRAYSON:** You know, some schools don't see analytical chemistry as a proper discipline.

**FENSELAU:** Well, the current chair there is an analytical chemist.

**GRAYSON:** Okay.

**FENSELAU:** So I guess they were...[yes], the state schools of course, have been more interested in analytical chemistry than the private universities. State schools have figured out that analytical chemists are attractive to industry, and even start new companies, and just are generally useful to the local economy. So [my current] department has a reasonable number of analytical chemists.

**GRAYSON:** You did mention a topic that is of interest, I think, in a broad educational sense, and that is the influx of foreign students into the educational system in this country. Do you have a sense of when you began to see more...I mean, primarily I assume Japanese...

**FENSELAU:** Chinese...

**GRAYSON:** Chinese...

**FENSELAU:** Well, I mentioned that Djerassi's lab was filled with European postdocs, and South American postdocs, and Asian, foreign postdocs...now that's postdoc, not students. Probably, I was sheltered in the medical school because I wasn't too well in touch with graduate training. But when I moved to UMBC, University of Maryland Baltimore County, we were getting awfully good Chinese students. That would have been in '88, and they were just opening up. They were granting [exit] visas on merit, which I don't think is necessarily the case at the moment <**T: 05 min**>.

One of the students in my lab, well actually a postdoc in my lab [Xueheng Cheng] had placed first in a national competition to be supported by the government to study abroad. He'd gotten his PhD at Harvard with a man named Joe [Joseph J.] Grabowski, who now is at the University of Pittsburgh. Joe had for some reason sent him to me to postdoc. He was, in fact, scary bright, the kind of guy who forgets to look at the stop light as he walks into traffic [thinking.] But...

**GRAYSON:** Okay. Not good for his longevity, but...

**FENSELAU:** [Yes]. Then, after he left my lab, he became an employee at Abbott [Laboratories], and [developed] a big Fourier transform laboratory there. Now, he's working in a Chinese startup, a high tech venture capital company.

**GRAYSON:** Do you notice that there's a continued increase in the Chinese presence, particularly in the graduate schools?

**FENSELAU:** I think we've leveled off here, so I had the ten years there, and now the ten years here. I think we've leveled off, and we've also come to understand that the quality is as variable as [with] our own students. Of course, the engineering school has a tremendous number of Indian [applicants who] would like to come and study. So to a certain extent, it's discipline-oriented as well. We're fortunate to have good Chinese students. Engineers are fortunate to have good Indian students.

**GRAYSON:** [Yes]. There is that kind of dichotomy. When I was at University of Missouri at Rolla [Missouri], there was a ton of Indian engineering students. That was primary...it used to be Missouri School of Mines. There was a ton of engineering Indian students, but you know, which I guess that's some kind of a traditional, educational division, and Indians go for engineering here, and the Chinese come for the sciences.

**FENSELAU:** [Yes]. I don't understand those trends, but we also have some good Turkish students in this department. I learned recently that we have a number of undergraduates from

Japan and that these are often children of families whose fathers were located here for three years or five years on business, and they want to come back to the United States for undergraduate degrees.

**GRAYSON:** Did you notice as a consequence of 9/11 that there was a problem with students, dropping down in the number?

**FENSELAU:** Yes. Oh, [yes]. They couldn't get into the country for the first year after that. But the university presidents made a big fuss with the government about that visa issue.

**GRAYSON:** Have you noticed that there's a trend, a difference between the earlier period, when the foreign students were coming to this country, as they were staying here to work, as opposed to going back to their home country?

**FENSELAU:** My experience, they're still mostly staying. I've had, I don't know, a half dozen Chinese students earn their PhD [with me] and they're all working in this country still, most of them working in companies, which is a gift to the country. There are a couple of them working, who have managed to get jobs at NIH and the FDA.

But one Chinese student [Dr. Yan Li] who got her PhD from another faculty member in this department, postdoc'd at Hopkins and then has recently gone back, and is an assistant professor somewhere [Peking University] , you know. So there are some who go home.

**GRAYSON:** Well, that was a point that was raised by the medal recipient last night in her speech to the reception, or to the group there, that we're letting too much of that foreign talent come here for education and going back to their home countries, rather than keeping them here.

**FENSELAU:** But that may vary, again, by discipline. I don't think it's chemistry, though.

**GRAYSON:** Your sense is that the chemist discipline tends to stay here then. Okay.

Well, I think, if Hopkins is wrapped up, you actually then had this very conscious decision that you wanted to move onto something more challenging. I mean, this opportunity at Maryland, was that something that you were aware of?

**FENSELAU:** You mean this campus or the intermediate one?



**GRAYSON:** Well, your intermediate campus.

**FENSELAU:** Oh, [yes]. One of the faculty members there sent me a note saying they were looking for a chair.

**GRAYSON:** Okay.

**FENSELAU:** And that was...

**GRAYSON:** And they knew that you were wanting to do something on those lines?

**FENSELAU:** No. Not that I...I don't think so. I never...

**GRAYSON:** Expressed an interest in...

**FENSELAU:** I never squeaked, never complained. But my children were of an age where I could take a little <T: 10 min> longer [time] to get to school, if there was a crisis. So it was a good time, and I jumped at the opportunity.

**GRAYSON:** Did you still maintain your home in Baltimore then?

**FENSELAU:** Yes.

**GRAYSON:** So you've really, basically, lived in Baltimore this whole time.

**FENSELAU:** . Yes.

**GRAYSON:** Moving further south...

**FENSELAU:** Right. I'm trying to work on the faculty of every school in the state that gives a PhD [laughter] Hopkins and the two Maryland campuses, and I've also been adjunct faculty member at the Maryland Medical School. So I've been at four of the PhD granting institutions.

**GRAYSON:** Interesting.

**FENSELAU:** Without changing house.

**GRAYSON:** Well, that's a trick, good trick. Well, it's pretty dense here, the population. Things aren't that far from one another. So do you want to start a little bit on what happened when you moved from the UMBC campus to here?

**FENSELAU:** Sure. Sure, my children got into school, and I could do a longer commute, and I thought that this would... I would enjoy being in a slightly larger—well, way larger—campus.

**GRAYSON:** So what, probably four, five times larger?

**FENSELAU:** Well, if that was ten thousand, this one's probably thirty. Combination of undergraduate and graduate, maybe thirty-five...[yes].

**GRAYSON:** Okay. Good size.

**FENSELAU:** [Yes]. So we made the move, and reestablished. I had to leave the four-sector, but four-sector days were passing.

**GRAYSON:** [Yes]. And so basically, did you ever bring equipment with you?

**FENSELAU:** Just HPLCs.

**GRAYSON:** Okay, but not really big guns.

**FENSELAU:** Not a mass spectrometer.

**GRAYSON:** [Yes], okay. But as you say, at that point, the four-sectors were becoming dinosaurs, or they're kind of dinosaurs in a way to begin with.

**FENSELAU:** Yes. [When I left, UMBC] hired Dan [Daniele] Fabris, who is one of the names you want me to talk about, as a visiting assistant professor, then as a real assistant, a tenure track assistant professor. Of course, he mostly used [only] two of the four-sectors...

**GRAYSON:** Okay.

**FENSELAU:** Because he could have good sensitivity for FAB with the two.

**GRAYSON:** Okay, sure. So this was still at UMBC.

**FENSELAU:** UMBC, [yes].

**GRAYSON:** [Yes], okay. Then he used it as a single mass spectrometer, [yes].

**FENSELAU:** Yes.

**GRAYSON:** It's always good for that.

**FENSELAU:** Sure.

**GRAYSON:** [Yes]. So then when you come here, what position did you come with, as a...

**FENSELAU:** I was chair here for a couple of years.

**GRAYSON:** So you came here as chair.

**FENSELAU:** [Yes]. And then, professor also for...

**GRAYSON:** Now [...] I noticed that [the Department is now] Chemistry & Biochemistry.

**FENSELAU:** Yes.

**GRAYSON:** So somewhere along the way, bio...it used to be all chemistry.

**FENSELAU:** Yes. Actually, the UBMC is also chemistry and biochemistry. There was some point in...gee whiz, maybe the early 1980s, where practically every East Coast university chemistry department added biochemistry to its name. Also in that time period, Harvard renamed its chemistry department, "Chemistry Applied to Biology." So you know it was the fashion. I think that's the time that UCLA [University of California at Los Angeles] became chemistry and biochemistry...

**GRAYSON:** So do these schools have biology departments?

**FENSELAU:** [Yes], but biochemistry...biology is not biochemistry.

**GRAYSON:** True, but I mean I wondered what the biology departments thought of this. Or did they think anything?

**FENSELAU:** Oh, [yes]. I don't know.

**GRAYSON:** Or did it matter what they thought.

**FENSELAU:** I don't know. It's probable that it reflected the real evolution of chemistry, that we were finding that we could address problems in biology.

**GRAYSON:** [Yes], from a chemical basis.

**FENSELAU:** [Yes].

**GRAYSON:** Which is in the end, really I think, a serious requirement for making serious progress in understanding what's going on. So you came here, it was already a chemistry, biochemistry operation at the time that you came here.

**FENSELAU:** [Yes].

**GRAYSON:** And how do you feel about your career, now? Are you more of a chemist or a biochemist, or mass spectroscopist, or chair department?

**FENSELAU:** Well, I'm not the chair, that's a good thing. This much larger department did take a lot more attention to be chair of it. At that point, I got very involved in...well, because of 9/11 and those anthrax mailings, the so-called Amerithrax. I got involved in the Amerithrax investigation. I had been talking to a lot of people about rapid detection of bacteria, so I just had a lot of national service at that point.

But so what am I right now? I like to think I'm a biochemist. I've learned a lot about <T: 15 min> proteins, a lot of protein chemistry; the biochemists may think I'm a bio-analytical chemist. The analytical chemists accept me. [Those were analytical] people you were just with at the seminar. But one thing I'm pretty sure, I'm not an organic [chemist] anymore, because those folks have a very strongly evolved culture and their teaching is pretty uniform all over the country. I've never taught organic.

**GRAYSON:** Probably something that you don't regret.

**FENSELAU:** That's right, it's kind of...

**GRAYSON:** But that's basically your starting point in the chemistry crew, it was Djerassi and those people who's...well, you got to name his book using the word "organic" and "synthesis" and "steroid"...

**FENSELAU:** That's right, in some order, one order or another.

**GRAYSON:** Still need to find out the name of the book that won you a hundred dollars. So you did actually [come] here as a chair of the Chemistry and Biochemistry Department for starters. This is doubling up the size of the operation. I mean, you had about eighteen people in the faculty...

**FENSELAU:** And this is forty-five or so...

**GRAYSON:** Okay. And, I mean, that doubling is really more like quadrupling the amount of work. It probably goes up exponentially with size because of all the other good things that are going on.

**FENSELAU:** Sure. [Yes].

**GRAYSON:** So when you got here, what was the feeling? What was, kind of, the sense of the chemistry department's forte, of biochemistry, biochemistry?

**FENSELAU:** I suppose I thought that organic chemistry was the strongest here, as it is still in many departments around the country. It is still very strong here. The current chair is, I think, an organometallic [scientist.]

**GRAYSON:** So how long was your tenure as chair here?

**FENSELAU:** I did two years.

**GRAYSON:** Two years, so that was, kind of, a conventional tour of duty.

**FENSELAU:** Rotation, [yes].

**GRAYSON:** [Yes], rotation type thing. Did you do anything dramatic during those two years? Or did you...

**FENSELAU:** I was not able to double the size of the space of this department. We did some good hiring. We hired in the biophysical chemistry area, and there is a pretty strong group of biophysical chemists, which includes NMR and x-ray, that has grown up since I've been here, in the time I've been here.

**GRAYSON:** Was there...since you came here, some of the buildings look newer than others. I assume...

**FENSELAU:** Yes.

**GRAYSON:** There's been some expansion of the physical plant.

**FENSELAU:** Yes. Well, that's right, this wing is built in the '70s, I think, and it's been well maintained. But there's a new wing that's only six or eight years old that has really nice, even nicer, labs. Of course, the trouble with any state construction is they always use concrete blocks and don't bother about the wallboard to cover them up. And we do still have at least one wing which does not have adequate air conditioning or adequate heating. So it's tough, but we always continue to work on getting that renovated if not torn down.

**GRAYSON:** Well, that's a project.

**FENSELAU:** [Yes].

**GRAYSON:** So I guess the state is the major source of funds for keeping the university, essentially running?

**FENSELAU:** I don't...you know, I think probably, again, most [state] universities have state support of about a third of their budget. The tuition is another third. Then, the overhead on external funding is the final...or donations, which we're doing a little better on here.

**GRAYSON:** Are you familiar with the tuition now, is there...

**FENSELAU:** What are we here? Oh, dear, no. I'm not. I do know that the present governor has not allowed tuition to change for three or four years.

**GRAYSON:** Well, that's good. I assume that out-of-state students are...

**FENSELAU:** Are charged a little more... yes.

**GRAYSON:** [Yes]. That's an issue, I know in Missouri now it seems that they're wanting more support coming from the students in terms of tuition.

**FENSELAU:** [Yes]. And fees.

**GRAYSON:** [Yes], and fees, right. So that's always...it's like the taxes you pay when you rent a hotel room, you know. It's an extra 20 percent.

**FENSELAU:** [Yes], which...the [total] price is not as advertised. So our administration actually has figured out that science training costs more, particularly laboratory costs. Of course, it costs more. They're actually...they've floated the idea of charging science and engineering students a higher tuition. The students all objected, but I don't think that decision's been made one way or the other. But that's an interesting space for financial analysis.

**GRAYSON:** [Yes].

**FENSELAU:** An interesting avenue to take <T: 20 min>.

**GRAYSON:** Well, but I mean don't they also, at least in terms of graduate section, bring in more money in terms of students doing TA work.

**FENSELAU:** Overhead on our grants would be...

**GRAYSON:** [Yes].

**FENSELAU:** We have more grants. [Yes].

**GRAYSON:** So it seems like there's maybe a tradeoff there that's fair, and just leave it the way it is.

**FENSELAU:** Which is probably what will happen.



**GRAYSON:** Well, at least that would be nice. But [yes], I don't know. Has this money crunch for the last couple of years, been felt? Can you feel it here?

**FENSELAU:** We had furloughs for two years...

**GRAYSON:** Furloughs? Wow.

**FENSELAU:** [Yes]. And this year, we're not having furloughs.

**GRAYSON:** So is this like giving a month away, or...

**FENSELAU:** [Yes]. It actually depended on what your salary was, how many free days you worked.

**GRAYSON:** Free days.

**FENSELAU:** How many days you worked for free. You know, because I'm not going to stay home just because they're not paying me.

**GRAYSON:** Sure, [yes]. That's interesting, because that happened for...my one son works for a company that used to be Motorola [Freescale], and they furloughed people, I think, one week every quarter. But under those circumstances, for the way they had it worked out, for some reason they were not allowed to work on anything when they were not...

**FENSELAU:** Yes, in a company, you're probably not allowed on the grounds.

**GRAYSON:** [Yes]. So he couldn't do anything, and you couldn't get paid...

**FENSELAU:** [Yes].

**GRAYSON:** For not doing his things. So...

**FENSELAU:** Well, [yes]. You know, if we're training graduate students, we really want to be here.

**GRAYSON:** [Yes]. So you started with graduate students at UMBC, right?

**FENSELAU:** [Yes]. Well, I had a couple. I had three, maybe, at Hopkins.

**GRAYSON:** Okay. Then at UMBC, you were really more into the graduate student thing.

**FENSELAU:** Yes.

**GRAYSON:** So you were turning out...I mean, you had so many per year, you think, I mean that you were graduating after a while. Or did...

**FENSELAU:** Well, honestly, I have never looked at it that way. The data's at hand, but I don't know the answer to that.

**GRAYSON:** [Yes], [yes].

**FENSELAU:** And here, in the last five years, I've had all graduate students and no postdocs.

**GRAYSON:** That's interesting.

**FENSELAU:** Yes. You know, but I've also reduced the size of my group, so that we're six. You know, I used to think twelve was a good number. But twelve's a good number only if you have a couple of postdocs.

**GRAYSON:** [Yes]. [Yes]. Well, that's one of the things my son at Tulane [University] is struggling with, what's a good number for...you know. It's an interesting problem. You've got to get it right, and...

**FENSELAU:** Well, I told you Djerassi had twenty-five to thirty and they were almost all postdocs.

**GRAYSON:** [Yes]. Those are self-directed or to a large degree. And you said Melvin Calvin had an even bigger stable.

**FENSELAU:** Yes. But he had permanent faculty members as his sub-team leaders.

**GRAYSON:** Yes. Some guys can do that.

**FENSELAU:** [Yes].

**GRAYSON:** So when did you come here to this campus?

**FENSELAU:** I came here in '98. So I've been here, you know, fourteen years now.

**GRAYSON:** Okay.

**FENSELAU:** Almost fourteen years.

**GRAYSON:** [Yes]. After your two year...I mean, were you able to actually deal with graduate students while you were chair?

**FENSELAU:** Well, I had some graduate students but that was a team with postdocs.

**GRAYSON:** Okay. So you had some lieutenants, as you call them.

**FENSELAU:** Yes

**GRAYSON:** Once again, you brought nothing in the mass spec variety here, so you had to buy equipment here.

**FENSELAU:** [Yes]. The university bought me a mass spectrometer as a startup.

**GRAYSON:** Okay. So that was nice.

**FENSELAU:** That was a Q-TOF [quadrupole time of flight] which I threw out of the lab several years ago.

**GRAYSON:** Okay. So this was one of the VG...

**FENSELAU:** No. It was a...

**GRAYSON:** Applied Biosystems, or AB Sciex...

**FENSELAU:** AB Sciex. But, you know, if you think about the year 2000, right across there, automation really started leaping forward in progress, and the system bought when I first came here was just not competitive in computer control and computer data acquisition, [or] computer processing of the data. So we now have this instrument I showed you in the proteomics facility which is my students' major tool. But that kind of instrument...it's, kind of, a shared instrument, because we use it 49 percent of the time, and the rest of the campus uses it 51 percent of the time.

We do have a [Shimadzu] MALDI-TOF [matrix-assisted laser desorption/ionization time of flight] in the lab, which my students love to use because it's easy and <T: 25 min> they can, sort of, check some of their samples before they go across the street.

**GRAYSON:** Kind of a quick check to find out if they're close before they go use the other big machine.

**FENSELAU:** Yes. And we have had an ion trap with an AP-MALDI [atmospheric pressure matrix-assisted laser desorption/ionization] source on it, but at the moment that's shut down.

**GRAYSON:** Okay. So I noticed with the exception of one, most of the young people I've met are young ladies.

**FENSELAU:** That's right. Did you meet Joe [R. Cannon]? I have one guy right now, and actually, this is the same trend in Bob's lab at Hopkins.

**GRAYSON:** Really.

**FENSELAU:** Yes. I think that we have more and more women in science, and more of them, you know, good students. I also think that some of the men in the department probably have more men in their research groups. So there's a tilt because...

**GRAYSON:** So you think that there might be partially because you're a woman that they would come in and work for your...

**FENSELAU:** Yes.

**GRAYSON:** Okay. Oh, well, that's interesting. Do you get to ship at least many of these people to ASMS meetings?

**FENSELAU:** I try to send everybody to one meeting a year. But because we're so heavily into proteomics, they don't all choose to go to ASMS. So this year, I'm sending one person to ASMS, one person to USHUPO [Human Proteome Organization] one or two people to international HUPPO, which is in Boston [Massachusetts], so it's nearby. Then I'm actually going to send two people to Kyoto [Japan] to the International Mass Spectrometry Conference.

**GRAYSON:** That's good.

**FENSELAU:** [Yes]. I think it will be. One of them is a Thai student [Waeowalee Choksawangkarn] whose government is supporting her to get a PhD here. So they've tested her, and she's very, very good. She is very good. I thought it was a good reward to her to send her to Japan, and she will extend a week and go home.

**GRAYSON:** Oh, [yes], sure. [Yes]. This is the first time that the international meeting meets away from Europe.

**FENSELAU:** Europe.

**GRAYSON:** Is that correct?

**FENSELAU:** [Yes].

**GRAYSON:** [Yes]. That'll be an interesting...

**FENSELAU:** Change.

**GRAYSON:** Change, evolution.

**FENSELAU:** I used to call it the European Mass Spectrometry Meeting, instead of the International. This reestablishes it as international. But the Japanese have been working on this for a long time. As part of the ASMS succession, I was American representative to the committee that organized the international meeting in [1991, when] I met Tal'roze. And at that time, the Japanese representative proposed that we should go to Japan, and a couple of us voted to support that idea. But it didn't work, and I think it was...

**GRAYSON:** This would be for ASMS Meeting...

**FENSELAU:** No for international...

**GRAYSON:** For the international, ah.

**FENSELAU:** The international, I'm talking about International Meeting which was in Amsterdam that year. My point is that was [...] twenty-two years ago they were trying to get us to go...

**GRAYSON:** [Yes]. They've been working on this.

**FENSELAU:** [Yes], and I assume they've been working on it ever since.

**GRAYSON:** [Yes].

**FENSELAU:** So they're going to do a good job.

**GRAYSON:** Yes. [Yes], I'm sure they will. Well, it's my sense that the mass spec meetings really tend to be extremely...I mean, like the international conference, the Japanese [conference,] ASMS, all seem to be very rich, and very strong, and robust, and people get a lot for their dollar, or Euro, or whatever when they go to them.

**FENSELAU:** [Yes].

**GRAYSON:** [Yes]. Which I don't know of any other analytical disciplines that support that many meetings, but still it's not like they are redundant meetings.

**FENSELAU:** Yes. Well, I think you do see some stuff at the fall international meeting that you've already seen, you've recently seen at the spring ASMS meetings. There's some redundancy there. This is going to be the tenth year of Koichi Tanaka winning the Nobel Prize, and I think that's part of the reason that they were able to swing the meeting there.

**GRAYSON:** [Yes]. Has it been ten years, already?

**FENSELAU:** [Yes], 2002.

**GRAYSON:** Wow.

**FENSELAU:** It will be in Kyoto where he works. His company is a major underwriter for the meeting.

**GRAYSON:** That's Shimadzu?

**FENSELAU:** Yes.

**GRAYSON:** Okay. Well, I don't want to get too far into that. I knew we'd want to spend some time on your societal activities with ASMS, and other organizations, but at this point, I just want to, maybe, continue with the academic development and what you've done here at...

**FENSELAU:** Well, let me tell you what I did <T: 30 min> here that was good. Then also, we can talk about some of the students and postdocs that you had [listed]...

**GRAYSON:** Okay.

**FENSELAU:** We've talked about Djerassi and Biemann a little bit, and Burlingame, and Calvin. But so if I were to break my career into phases, I'd say that at UMBC, I learned to work with proteins, and when I came here I went into proteomics. And proteomics has the aspect that you try to analyze a whole bunch of proteins at once, and you don't pay too much attention to any of them.

So we introduced here the idea of using  $^{18}\text{O}$  to provide quantitative comparison between two samples. One's labeled with  $^{16}\text{O}$ , one labeled with  $^{18}\text{O}$ , and we introduced the idea that trypsin and a couple of other—chymotrypsin—and a couple of other enzymes that work by the same mechanism could be used to catalyze the introduction of the  $^{18}\text{O}$ . So it's not a chemical introduction, but an enzyme [catalyzed] introduction. It has the limitation that you can only look at two [mixtures] at a time, compare two mixtures of proteins at a time. [It] has the advantage that you can apply it to a clinical sample, because you collect the sample, and then you do the labeling.

You can imagine that chemical reactions, of which there are some other variations, can be applied in that way. But a very popular way of labeling proteins for proteomic analysis is to grow cells or bacteria in an isotope-labeled growth medium. You can't do that with your patients or even with your large animals. So it's a method that's gotten a lot of application on...

**GRAYSON:** So how does...I mean now, you're doing this for  $^{18}\text{O}$ , but  $^{16}\text{O}$ , you really don't have to do anything. [...] So you're using...

**FENSELAU:** Trypsin...

**GRAYSON:** Oxygenated water?

**FENSELAU:** Yes, 97 percent of  $^{18}\text{O}$  water.

**GRAYSON:** [Yes].



**FENSELAU:** The isotope companies love us. So if you incubate the proteins with trypsin in heavy water, every place you break a bond, of course, you incorporate one  $^{18}\text{O}$ . But these enzymes that recognize—arginine and lysine, in trypsin’s case—still recognize that [amino acid] after the protein’s broken and they’ll bind the peptide a second time if it ends in arginine and lysine. Then when that’s released, another  $^{18}\text{O}$  gets incorporated. So we have to incubate a little longer than you would just for cleavage. That’s one of the things we’ve published here.<sup>34</sup>

**GRAYSON:** Now that you’ve gotten these guys labeled, what happens with them?

**FENSELAU:** Well, so then we have a bunch of labeled peptides from, say, the well patient and we have a bunch of light-labeled peptides from the sick patient. When you mix those two tremendous mixtures together, presumably there’s pairs of peptides. It’s the same proteins and the same peptides, only one set’s labeled with  $^{16}\text{O}$ , the other has these  $^{18}\text{O}$ s in the ends of the peptides.

So then, you run [them into] the mass spectrometer. They go through all of the workup and the chromatography together, the pairs of peptides don’t separate,  $^{18}\text{O}$ s are not separated on the HPLC column. They go into the mass spectrometer. Of course, it can see both masses. So then you can just look at—or you can have your computer look at—the relative sizes of the peaks of the molecular ions and say that there was twice as much of this peptide there for this protein in one sample or another. There’s a lot of [interest in] comparative quantitative analysis.

**GRAYSON:** So you’re looking for...?

**FENSELAU:** Changes in abundance.

**GRAYSON:** Differences between the well and the sick individual...

**FENSELAU:** Yes. Or the young and the old, or...

**GRAYSON:** To get some kind of an understanding of what’s going on from a biochemical, biological, bio perspective.

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<sup>34</sup> Xudong Yao, Amy Freas, Javier Ramirez, Plamen Demirev and Catherine Fenselau, “Proteolytic  $^{18}\text{O}$  Labeling for Comparative Proteomics: Model Studies with Two Serotypes of Adenovirus.” *Analytical Chemistry* 73(2001): 2836-2842.

**FENSELAU:** [Yes]. We were interested in changes that allow cancer cells to become drug resistant.

**GRAYSON:** Okay.

**FENSELAU:** You know most of our cancer drugs work, but after a couple of months, the patient becomes resistant. So that's been a big question. The genes don't seem to change so much, but the proteins must. So we've looked at them.

**GRAYSON:** [Yes].

**FENSELAU:** But we've done that with cell culture. I haven't worked with clinical samples there. But I've been in and out of the cancer area a lot.

**GRAYSON:** Seen all kind of...but you said something that's interesting. I wanted to just ask you this very simple question. When's the last time you looked at a mass spectrum?

**FENSELAU:** Ah, you know because I'm teaching...

**GRAYSON:** Oh...

**FENSELAU:** The answer is yesterday...

**GRAYSON:** Okay. But from a research perspective...

**FENSELAU:** Well, you <T: 35 min> know, we do try to do a lot of quality control, as you go along. So even if the instrumental system identifies a thousand proteins from two thousand peptides, we'll still look at some of them just to make sure everything's working right. Particularly if we're talking about isotope ratios, you know, where the computer has to identify pairs, quantitate the pairs, we usually do some manual checking.

**GRAYSON:** Okay. So you're not willing to cede the authority to the black box.

**FENSELAU:** Right. And I think most...

**GRAYSON:** Curious people...

**FENSELAU:** Yes, are not...[yes]. And our proteomic applications have not been to look for biomarkers for diseases. In fact, the easiest way to talk about proteomics is healthy versus sick, which would be looking for biomarkers for diseases. That's not exactly what we're doing, but it's the easiest way to talk about it.

**GRAYSON:** Okay.

**FENSELAU:** But also, while I've been here though, the whole protein, the whole bacterial analysis thing has come to a head. I told you that at Hopkins, we put bacteria into the 21-110.

**GRAYSON:** [Yes].

**FENSELAU:** Heated it and got some chemicals out which gave really different patterns for different kinds of bacteria. My pathology collaborator [Dr. John P. Anhalt] got all excited there. But those were volatiles, metabolites. When we got FAB, we reexamined the bacteria and found that the phospholipids, which were very favored by FAB, had different patterns with different bacteria. That was interesting too.

But then when we started working with proteins, we found that the proteins are different for different bacteria. We were interested in knowing what the proteins were, but there are some folks who, in fact, several commercial systems right now, do pattern recognition or library matching without paying too much attention to what proteins give you the pattern.

So we've worked out some methods to cleave the proteins [robotically,] maybe with acid rather than an enzyme, then to characterize the proteins in five to ten minutes. This can be presumably, done in the battlefield...

**GRAYSON:** Oh, okay.

**FENSELAU:** Our funding was mostly DoD [Department of Defense] and DARPA [Defense Advanced Research Projects Agency]. So that's been very interesting. It's been not biochemistry of bacteria, but rapid characterization of bacteria.

**GRAYSON:** And there was a whole subset of work done, which I think was based more on pyrolysis, but that multivariate analysis of the mass spectra was used to create these spaces, or...

**FENSELAU:** [Yes]. The Army [supported] that...

**GRAYSON:** Different things would tell you one way or another about it.

**FENSELAU:** But it was... somehow it's never been considered to be reliable. I mean, pyrolysis sounded good to the generals, you know? But the answers were not reliable, and they did eventually give it up. The generals don't like to hear about proteomics, things that are a little more complicated to explain, but this is actually being adapted for clinical applications. I mean, the real market's in every hospital in the country. So the companies—Shimadzu, and Bruker [Corporation], and probably a couple more—who have these library sets and matching programs, and directions for [culturing] have been moving their systems into hospitals. These are often TOF instruments and they're not [yet] approved here by the FDA, but they can be backup in the clinical chemistry lab.<sup>35</sup>

**GRAYSON:** Well, there's this whole subset of instrumentation that goes into looking at ingrown, inborn metabolism there.

**FENSELAU:** Yes. That's small molecule stuff.

**GRAYSON:** [Yes].

**FENSELAU:** Again, I don't know that that's approved by the FDA in our country. Often a lot of clinical labs do it; certainly in Japan it's done routinely.

**GRAYSON:** I think the state of Missouri does that.

**FENSELAU:** Okay. Good for you guys.

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<sup>35</sup> In 2013, the FDA granted approval to Bruker Corporation to market its MALDI-TOF mass spectrometer for proteomic applications. <https://www.bruker.com/news-records/single-view/article/bruker-corporation-announces-fda-clearance-to-market-the-maldi-biotyper-ca-system.html>, accessed 2 April 2015.

**GRAYSON:** Routinely to, you know, identify right off the bat...

**FENSELAU:** The phenylketonuria.

**GRAYSON:** [Yes], and other...I mean, there's like fifteen or twenty different inborn errors in metabolism.

**FENSELAU:** Mm-mm. Do they do it with mass spectrometry?

**GRAYSON:** [Yes].

**FENSELAU:** Okay. Well, that's good to know, to be reminded of, but the bacterial analysis is pretty much based on things that weigh more than four thousand <T: 40 min>, which are considered to be translated proteins.

**GRAYSON:** Okay.

**FENSELAU:** Gene-related proteins. So we take the credit for starting that in 1975, and we always said about pyrolysis that you're destroying all that information that nature put into the molecule.

**GRAYSON:** [Yes].

**FENSELAU:** But anyway, I'm not totally satisfied with the commercial systems right now, because they do not tell you what the protein is. They don't use proteomics. It's so easy to get a lot more information. But they also...okay, those recipes require that you culture the bacteria in a very precise way. That takes four hours to twenty-four hours.

**GRAYSON:** [Yes].

**FENSELAU:** So that's not suitable for the Army's needs.

**GRAYSON:** No. This is...I mean, they have a very strict protocol, and the companies provide all...everything.

**FENSELAU:** [Yes], [yes].

**GRAYSON:** So basically, your person that does the...

**FENSELAU:** Well, yes. The profit's in the supplies.

**GRAYSON:** [Yes]. The person who does the...

**FENSELAU:** Analysis...

**GRAYSON:** Experiments so to speak, analysis, is just following an extremely strict protocol with everything that's provided for them, it's no...

**FENSELAU:** [Yes].

**GRAYSON:** Nothing...now you mentioned Defense and DARPA, so you're getting money from the Defense budget?

**FENSELAU:** Not right now.

**GRAYSON:** Okay.

**FENSELAU:** Not right now.

**GRAYSON:** I mean, when did you start knocking on their door?

**FENSELAU:** They came and they knocked on my door.

**GRAYSON:** Okay.

**FENSELAU:** So my first funding from [DOD]/DARPA was while I was still at Hopkins, and they funded me all through the time at UMBC. But when I moved here in '98 and we had 9/11 and anthrax—Amerithrax—problems in 2001, then everybody got really interested in it. So by coincidence, Plamen Demirev and I published a review in *Mass Spec[trometry] Reviews* in 2001.<sup>36</sup> It's one of my most highly cited.

But now, science moves on, and we've got better ways and better bioinformatics in particular, partly because there's more genomes of bacteria available. So we posted another review in 2008 that's in *Annual Reviews of Analytical Chemistry*.<sup>37</sup>

**GRAYSON:** Okay.

**FENSELAU:** Then a recent paper that I like a lot reports a top-down identification of proteins, and the identification of the proteins for bacteria that don't have sequenced genomes.<sup>38</sup>

**GRAYSON:** Okay. That's, kind of, like an "unknown unknown," as our friend...

**FENSELAU:** Yes. You know, the question always is what's the bacteria? Which we've tried to answer by identifying the proteins, and if the bacteria doesn't have a genome sequence we found we can look at some of the first cousins or we can look at a broader database of bacteria sequences for genes or proteins. Particularly the ribosomes are 90 percent homologous through whole families of bacteria. So that's been...you've also got Nathan Edwards on the list of people to talk about. You know, that's been something that's been an approach, bioinformatics approach, that's evolved through the collaboration with Nathan Edwards.

**GRAYSON:** I'm curious why...well, you say that the Army, the Defense Department, came to you. What did they want you to do?

**FENSELAU:** Well, they wanted me to...they knew about this 1975 paper.

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<sup>36</sup> Catherine Fenselau, and Plamen A. Demirev, "Characterization of Intact Microorganisms by MALDI Mass Spectrometry." *Mass Spectrometry Reviews* 20, no. 4 (2001): 157-171.

<sup>37</sup> Plamen A. Demirev and Catherine Fenselau, "Mass Spectrometry for Rapid Characterization of Microorganisms." *Annual Reviews of Analytical Chemistry* 1 (2008): 71-93.

<sup>38</sup> Colin Wynne, Catherine Fenselau, Plamen A. Demirev and Nathan Edwards, "Top-down Identification of Protein biomarkers in Bacteria with Unsequenced Genomes." *Analytical Chemistry* 81(2009): 9633-9642.

**GRAYSON:** Okay.

**FENSELAU:** And they wanted us to, you know, see if we could do more, and do better.

**GRAYSON:** So they wanted you to continue your bacterial work.

**FENSELAU:** Yes

**GRAYSON:** Okay.

**FENSELAU:** But, in fact, I was [initially] approached by the Applied Physics Lab[oratory], Hopkins' Applied Physics Lab [APL], who are much more...I [had] never heard of DARPA as a funding source.

**GRAYSON:** Sure, [yes]. [Yes]. Well...

**FENSELAU:** But the Applied Physics Lab was [often funded by them.] And they also knew that we had done this early bacteria work. I enjoyed very much working with APL. So that worked out well.

**GRAYSON:** So that was the connection, but were they involved in your work for the Army?

**FENSELAU:** In the first round, which was done at maybe UMBC, the Applied Physics Lab built a suitcase-size mass spectrometer. [In another project we worked with a] local <T: 45 min> company—SESI [Science and Engineering Services, Inc.], funded by, in that case, DoD. They actually fielded our proteomics approach to rapid characterization, And by “fielded” I mean they took it to Nevada and tested it on a [live] release.

**GRAYSON:** So this would be like in a bio war or a bio defense...

**FENSELAU:** On the battlefield.



**GRAYSON:** Warfare type scenario that they were trying to anticipate?

**FENSELAU:** Yes.

**GRAYSON:** And be prepared for.

**FENSELAU:** Yes. Of course, the main source [...] of anxiety was anthrax. [...] But then, you know, the [thinking] became more sophisticated. What if [the microorganism] was genetically engineered? What if it was a new bacterium of some kind? That's why we've gone into trying to identify proteins from bugs that don't have their genomes sequenced.

**GRAYSON:** Do you know if any other mass spec operations or people in bio mass spec were being funded by DARPA or the...

**FENSELAU:** Well...

**GRAYSON:** Other...I mean, were you kind of like the sole recipient of these kinds of funds?

**FENSELAU:** Certainly [others were funded; we ourselves] have collaborated with a group in the Netherlands.

**GRAYSON:** Ah, okay.

**FENSELAU:** Funded by their government. I'm sure that there were other groups. But I will tell you the Army or DARPA, the Defense establishment phases up and down on technology, as you know. So they were hot on it for a while, and right now, I think they're probably not supporting as much mass spectrometry for this purpose. They're trying some new sensors. But they'll come back, you know, when mass spectrometry makes another advance, they'll ask us again to evaluate our capabilities.

**GRAYSON:** Well, it always keeps advancing, so...

**FENSELAU:** [Yes]. By “us,” I mean it may not be my lab, but they’re going to come back to mass spectrometry.

**GRAYSON:** [Yes].

**FENSELAU:** So in that [same] period, I also was asked to work with the FBI [Federal Bureau of Investigations], asked by the FBI to work on the Amerithrax [investigation.]

**GRAYSON:** Amerithrax.

**FENSELAU:** [...] The anthrax that was mailed in envelopes to several people around the country...well, senators and newscasters. We did work with them on that. We were able to demonstrate that the Amerithrax samples were grown on agarose. We could tell them they were grown on agarose. We didn’t get to publish that, but...

**GRAYSON:** [Yes], I was going to ask you if that got in the literature.

**FENSELAU:** But, no. [...] But we did another project with them, where we showed how to tell if a bacteria had been grown with a blood culture, with blood as the food...

**GRAYSON:** Culture medium.

**FENSELAU:** And...yes, and you know we looked for the heme. That one did get published. It’s in *Analytical Chemistry*.<sup>39</sup>

**GRAYSON:** So, but these people are coming to you.

**FENSELAU:** Yes.

**GRAYSON:** Well, that’s nice.

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<sup>39</sup> Jeffrey R. Whiteaker, Catherine C. Fenselau, Dean Fetterolf, Darin Steele, and David Wilson, "Quantitative Determination of Heme for Forensic Characterization of Bacillus Spores Using Matrix-assisted Laser Desorption/Ionization Time-of-Flight Mass Spectrometry." *Analytical Chemistry* 76, no. 10 (2004): 2836-2841.

**FENSELAU:** Well, the FBI of course, is close at hand here. But...

**GRAYSON:** [Yes]. [Yes], but I mean they can reach out to anybody.

**FENSELAU:** Sure.

**GRAYSON:** I have an interesting question and that is, would there be any value, significant value, to isotopically depleted compounds in the biological sciences? Say that you could get ethanol with pure carbon-12, or any other thing that you would like to have as a pure mono-isotopic carbon.

**FENSELAU:** I think a couple of labs have thought about that, including [...] Zubarev and Demirev.<sup>40</sup>

**GRAYSON:** Well, it's hard to get the stuff.

**FENSELAU:** Well, I don't think it was ethanol, maybe, but...

**GRAYSON:** No, but I mean just isotopically depleted...

**FENSELAU:** So I don't think that it's taken hold, so there must not be compelling reasons or somebody would, you know...

**GRAYSON:** Okay. Well, I mean, but it's not easy to get.

**FENSELAU:** [Yes].

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<sup>40</sup> Roman A. Zubarev and Plamen A. Demirev, "Isotope Depletion of Large Biomolecules: Implications for Molecular Mass Measurements" *Journal of the American Society for Mass Spectrometry* 9(1998): 149-156.

**GRAYSON:** Because we've been trying to get—my son's been trying to get—isotopically pure carbon for his MALDI calibrant and it's just like if you want to get carbon dioxide, then you can, but...

**FENSELAU:** Yes.

**GRAYSON:** Who wants to?

**FENSELAU:** Exactly, or maybe ethanol and methanol, but...

**GRAYSON:** But who wants that? You know...

**FENSELAU:** Yes.

**GRAYSON:** The chemistry to take it from that to where he wants it, is just...so I'm just curious if people...

**FENSELAU:** Cambridge <T: 50 min> Isotope [Laboratories] would love to make it but it'd cost a bundle.

**GRAYSON:** [Yes]. [Yes]. I was just curious if there was...if you really could get whatever you wanted in that way, would be very useful in a research project. I don't know.

**FENSELAU:** Well, the NMR folk like to have homogeneous isotopes, either depleted or enriched...

**GRAYSON:** [Yes], they're more into that.

**FENSELAU:** [Yes].

**GRAYSON:** Although, I guess it would be interesting if they could be done cheaply enough that people could take it...

**FENSELAU:** [Yes].

**GRAYSON:** Well, I don't know. Is this a good time to take a break?

**FENSELAU:** Sure. I got through what I wanted to tell you. I wanted to talk about...tell you that we worked with the FBI...

**GRAYSON:** [Yes].

**FENSELAU:** And published part of it...

**GRAYSON:** [Yes].

**FENSELAU:** So I think we're in good shape. Tomorrow [I'll] speak quickly about the people...some of the rest of the list of folks who...

**GRAYSON:** Okay.

**FENSELAU:** [...] You wanted to cover the larger issues like philosophy of education, and I'm going to go right now and get the book for you, before you turn off your recording device.

**GRAYSON:** Great.

**FENSELAU:** Here's how we got all the words in: *Steroid Reactions: An Outline for Organic Chemists*, edited by Carl Djerassi.

**GRAYSON:** Title by...

**FENSELAU:** [Yes]. I don't think it says that in the introduction.

**GRAYSON:** Cute. So you were able to get a copy of that as well.

**FENSELAU:** I likely had to pay for it. [laughter]

**GRAYSON:** Oh, you had to pay...

**FENSELAU:** I don't know. Maybe he gave us each a copy, but you know...

[END OF AUDIO, FILE 1.3]

[END OF INTERVIEW]

**INTERVIEWEE:** Catherine Fenselau

**INTERVIEWER:** Michael A. Grayson

**LOCATION:** Home of Catherine Fenselau and Robert J. Cotter  
Baltimore, Maryland

**DATE:** 14 April 2012

**GRAYSON:** [...] This is April the 14<sup>th</sup>, Saturday. We've had an enjoyable time in the Baltimore area. We're going to continue, hopefully, more or less where we left off. I'm thinking, did we get...I know that when you came to the College Park campus, you once again had to come here without any equipment, is that correct?

**FENSELAU:** Well, without mass spectrometers.

**GRAYSON:** Without any mass spectrometers...

**FENSELAU:** [Yes]. But my startup there, you're always interested in how people obtain their instruments...

**GRAYSON:** Yes.

**FENSELAU:** My startup for making the move included the acquisition of a big instrument. The instrument we got was that Applied Biosystems Q-TOF.

**GRAYSON:** Ah, all right.

**FENSELAU:** And...

**GRAYSON:** So this would have been the late 1990s.

**FENSELAU:** This was...yes, '98.

**GRAYSON:** And so you're abandoning the traditional sector machines...

**FENSELAU:** [Yes].

**GRAYSON:** So to speak.

**FENSELAU:** I'm proud to say College Park has a sector instrument right now. It's a smaller [JEOL] instrument, but it still gives good high resolution, and I can show my students what a sector looks like. It was bought to support the synthetic chemistry.

**GRAYSON:** Okay. Well, I mean there's still a place for that equipment.

**FENSELAU:** Yes.

**GRAYSON:** It's the big push for biological applications has moved these other instruments to the fore, because they're so much more effective in solving the problem or addressing the problem. So you got this...this was the AB Sciex machine, was it? The Q-TOF...

**FENSELAU:** Yes. It was a Pulsar. Then because of the bacteria work we were funded to buy MALDI-[ICR] and also an AP-MALDI ion trap.

**GRAYSON:** Okay, so this was...excuse me, atmospheric...

**FENSELAU:** Pressure...

**GRAYSON:** Pressure ionization.

**FENSELAU:** Ionization.

**GRAYSON:** [Yes]. So that's really different than chemical ionization. But it's kind of similar to it.



**FENSELAU:** [Yes]. I think that's fair.

**GRAYSON:** And that development came primarily out of Canada, didn't it? Applied Biosystems people and Sciex or... I mean, I have a good sense of where chemical ionization came from, but I have a much...

**FENSELAU:** Well, the atmospheric pressure MALDI was commercialized by SESI, the company in Columbia, Maryland.

**GRAYSON:** Okay.

**FENSELAU:** I think that it was probably brought to them by a Russian.

**GRAYSON:** Ah, okay.

**FENSELAU:** It came out of Russian physics.

**GRAYSON:** Ah, all right. But it's become a pretty popular ionization technique in more recent times.

**FENSELAU:** [Yes].

**GRAYSON:** [Yes]. So this got you enough to get some graduate students and your research started, and now are you still looking for postdocs as lieutenants?

**FENSELAU:** [Yes]. So I had, and I brought, serious NIH funding and DARPA funding and then the FBI funding came onboard very fast. So I had a couple of the senior people in my lab help me move, help me make the move, you know. That's serious. We actually had a Fourier Transform ICR [ion cyclotron resonance] instrument at UMBC, which had been bought for the bacteria work, bought by DARPA.

It had a DARPA property tag on it, so we were able to move that. I forgot to say that. And I was really quite amazed that you can wheel a Fourier Transform ICR into a moving van,

and drive it down the highway and wheel it off the moving van, and it works. It's pretty robust as long, as you keep it cold. So that was moved very easily.

**GRAYSON:** So this was a supercon magnet instrument.

**FENSELAU:** [Yes]. It was shielded...

**GRAYSON:** Really cool.

**FENSELAU:** So we were able to set it up without too much trouble.

**GRAYSON:** You obviously talked to someone about [whether] that was the thing to do.

**FENSELAU:** Well, Bob was...we bought it from Bob [Robert T.] McIver's company, IonSpec...

**GRAYSON:** Sure, [yes], [yes]...

**FENSELAU:** And they actually flew out and did the move for us, but subsequently, I mean, after we saw how easy it was, you know...we <T: 05 min> did give that instrument up eventually because it was very good for phospholipids which we were interested in at the time, but not very good for proteins, or even peptides. So we moved it on. We gave it to Peter [B.] O'Connor who was in Boston at the time. He came down in a moving van, and moved it himself without IonSpec support this time.

**GRAYSON:** Oh, that's interesting. I never thought of doing anything like that, but if you can, it's a lot better than warming up the magnet and you know quenching all...getting rid of all the helium, and nitrogen and everything else. That's pretty amazing.

**FENSELAU:** Sure.

**GRAYSON:** [Yes]. That's great. So now you've got some graduate students, some postdocs, and some equipment and you're off and running. There's this, kind of, long history, I think over a period of a decade or more of this bacterial kind of work that I saw on your publications.

**FENSELAU:** [Yes].

**GRAYSON:** But it's not like it's something you really focused on for a short period of time intensely, but it keeps coming back to it. Is that, kind of, a fair assessment?

**FENSELAU:** Sure. Every time the mass spectrometry technology improves, we look at bacteria again to see if [the analysis is] better, you know. So as I mentioned, our first paper was in 1975. Then we revisited it in the '80s and '90s with phospholipids and in the '90s and the 2000s where we were looking at proteins and peptides.

**GRAYSON:** So there's some work on anthracis in here, or did I misread that? There's this business with these particular bacteria that I think are...is it *Bacillus* spores? I guess that's the stuff with the anthrax, Amerithrax, or whatever...

**FENSELAU:** That's the first cousin, [yes]. We did some work with the veterinarian vaccine strain of *Bacillus anthracis* which is not lethal to cows or people, but it does help to develop immunity. But anyway, from my point of view, [it was] available as a really good [sample] to practice our techniques on, demonstrate our techniques on without having to have a special biohazard facility.

**GRAYSON:** [Yes]. Well, that's a serious issue, getting into dealing with some of these—I don't know what you want to call them—biohazardous type of materials.

**FENSELAU:** [Yes], the student newspaper, you know, got wind of this and wanted to know all about our work. So we told them that we had nothing that would infect people in our lab. All my students swore to that. All my students were keenly aware of that, too.

**GRAYSON:** [Yes]. Well, I notice that there's signage that, kind of, encourages people not to enter your wing in the building.

**FENSELAU:** Oh, that precedes my move there. It's got nothing to do with my research. I think it was that...let me say "unassociated people" were getting to be a nuisance.

**GRAYSON:** Just keep out the riff-raff, kind of, so to speak...

**FENSELAU:** Maybe it's [actually] the engineers we were trying to keep out. I don't know, but that preceded me.

**GRAYSON:** [Yes]. Okay. So in addition to going and revisiting bacteria work, what other kinds of things are you doing at the College Park?

**FENSELAU:** Well, we developed this  $^{18}\text{O}$  labeling method that I mentioned briefly yesterday. I would say we were into proteomics from the beginning. NIH funding came through for proteomics projects. People were looking for isotope methods [to] do quantitative comparisons. We put this  $^{18}\text{O}$  method into the literature. We've [also] worried a lot about protein fractionation, published methods on that.<sup>41</sup>

We've also, as everybody else in proteomics, begun to become more interested in bioinformatics. You know, how do we compare our mass spectra to the gene sequence, the databases of sequences? How do we know how good our identifications are, and that sort of thing?

I [opened] the collaboration with Nathan Edwards, who was on our campus at that time. Nathan had a PhD in mathematics from Cornell. His first job was with Celera [Corporation], as Celera had just... I guess when he was there, they finished the human genome sequence, and they had decided to try to work in proteomics next. So they <**T: 10 min**> hired a number of really bright mathematicians to work on the bioinformatics. How do you turn a tandem mass spectrum into a peptide sequence into a protein identification? He was one of those. He stayed there four years. He certainly learned a lot about mass spectrometry.

You know, mass spectrometry-based bioinformatics is different from genomics because genomics usually use actual identification of the nucleoside base to do the searching. We most efficiently use our raw mass spectrum to do the searching. But anyway, he was an expert in that. [When Celera terminated that effort,] the team of [...] mathematicians that Celera had working on it were dispersed all over the country. They all remain in touch, and they're still doing a good job of moving bioinformatics forward.

Anyway, Nathan started to collaborate with us. So one of the neatest [projects] I [have] published in College Park [is] a series of papers where we demonstrated that we could identify proteins from bacteria that did not have sequenced genomes by looking at the proteins in a

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<sup>41</sup> Waeowalee Choksawangkar, Nathan Edwards, Yan Wang, Peter Gutierrez and Catherine Fenselau, "Comparative Study of Workflows Optimized for In-gel, In-solution and On-filter Proteolysis in the Analysis of Plasma Membrane Proteins." *Journal of Proteome Research* 11(2012): 3030-3034.

broader set of bacteria.<sup>42</sup> The first cousins, if you like, had a lot of proteins that were very similar. So that moved things forward. There are still lots of great bacteria challenges, but the idea that we could identify proteins without the genome was a shortcut.

**GRAYSON:** [Yes]. Well, I mean, any of these things are important to moving the field forward and it's moving at a speed that's sometimes too fast, sometimes not fast enough.

**FENSELAU:** And most....

**GRAYSON:** I think the problem then, I think it's pretty well known now, is that the informatics...information, informatics...that whole side of the problem has just gotten a little bit out of hand. I mean, the amount of data that can be acquired is way in excess of...

**FENSELAU:** What we can handle.

**GRAYSON:** How it can be analyzed usefully. I mean, is that a fair assessment of the state-of-the-art today?

**FENSELAU:** Sure. [Yes]. I agree.

**GRAYSON:** And I don't know if anyone has any brilliant ideas about how they can do that analysis. I mean, fortunately, we have people that are attacking the problem.

**FENSELAU:** Yes. Well, the other challenge is to keep the protein identifications related to their biological functions. [We've] talked about the cross-disciplinary need to work with bioinformaticists, but we also have to work with cell biologists, who might have a clue about what it all means. So some laboratories think that when you make an identification by mass spectrometry, you should also confirm it with an antibody blot or with a functional study of the cells of the animals.

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<sup>42</sup> Nathan Edwards, Colin Wynne, Avantika Dhabaria and Catherine Fenselau, "Top-down protein analysis and phylogenetic characterization of unsequenced bacteria." In *Rapid Characterization of Microorganisms by Mass Spectrometry* (eds. Catherine Fenselau and Plamen Demirev,) Washington, DC: American Chemical Society, 2011, pp. 121-142.

**GRAYSON:** So, kind of, the traditional, biological...like, this reminds me of the situation that Klaus Biemann faced when he tried to publish in *JACS* the structure of this...whatever it was the first thing that he was working on...

**FENSELAU:** Yes. Yes.

**GRAYSON:** The editor-in-chief came back and said, “Well, you need to do melting points on this good stuff.” So it sounds like there’s a similar sign of a world view, disconnect between mass spec people and biologists and...

**FENSELAU:** Right. It probably is not necessary to do a biological confirmation on every protein, but the ones that are really interesting, the ones that might be potentially important, need to be followed-up with biology. You know another disconnect was when the organic synthetic people started using accurate mass for elemental analysis. A couple of famous papers showing that the combustion analysis gave the wrong analysis [and] of course, the high resolution molecular mass, particularly of these smaller molecules could [provide] the correct analysis. I remember that one of the associate editors of *Tetrahedron* came and talked to me for a while about how reliable that was, and should *Tetrahedron* expand its <T: 15 min> requirements for elemental analysis to include [mass spectrometry] and now, of course, all of those products are characterized by accurate mass measurements...

**GRAYSON:** Sure, [yes].

**FENSELAU:** And very little combustion analysis is done anymore.

**GRAYSON:** [Yes]. And it’s just the same with regard to structure determination, you know. I mean, so much can be done, well, particularly with NMR now, and mass spec, between the two, and infrared, it’s just...you know those other methods from wet chemical days are just over.

**FENSELAU:** [Yes].

**GRAYSON:** Kind of, really have gone by the by, justifiably so. [...] Do you think that the analytical community is considered to be less than scientifically worthy by their other chemistry colleagues? That seems to be an attitude that I’ve found in places and also the attitude that schools have towards having programs in analytical chemistry.

**FENSELAU:** Definitely it's a problem there. Yes, and the pattern I see most clearly is that the private schools, like Hopkins, don't offer analytical, though there's a lot of analytical chemistry done in their faculties. The state schools have maintained that responsibility because they know that students will get jobs. Students will help local industry. Analytical students are useful. So the powerhouses in analytical chemistry are state universities.

However, I will note that Dick [Richard N.] Zare on occasion calls himself an analytical chemist. He's at Stanford, and that George [M.] Whitesides at Harvard, on occasion calls himself an analytical chemist. I also note that Fred McLafferty, whom you and I would think is an analytical chemist, announced himself as an organic chemist in *C&E News* a few years ago.

**GRAYSON:** Oh, really. He's abandoning the field again. [Yes].

**FENSELAU:** He got some pushback on that, and he recanted and decided that he'd stay an analytical chemist.

**GRAYSON:** Yes, right. I don't think he can get away with that.

**FENSELAU:** [Yes].

**GRAYSON:** Maybe with people who don't know much about Fred, he can, but...[yes]. [Yes]. So your work pretty much has been continuing up to the present time, in this vein. So I'm getting the impression with the improvement in instrumentation, you're also able to do better on the bacteria side of things, and dealing with trying to make more and more sense out of the analysis of these guys.

**FENSELAU:** Well, in [a longer] time frame, I mean you can chop up a bacterium and just do straight biochemistry on it. A lot of people are doing beautiful work that way with mass spectrometry. But for rapid analysis, sure, better instruments always [result in] a better measurement. You know, [there is real] interest in small portable instruments, and this company SESI, and also the Hopkins Applied Physics Lab, have both fielded small MALDI-TOFs that allowed our approach to be demonstrated in open-air releases.

**GRAYSON:** So this, kind of, leads to the idea about the commercial development of ideas. Are you involved in that, in any way?

**FENSELAU:** Not at the moment. Have been a couple of times, I have five patents. But I'm not doing anything right now.

**GRAYSON:** Okay. These patents are...I saw a couple of them, when I did the SciFinder search. There were a few in there that are related primarily to analytical techniques.

**FENSELAU:** Yes. I think there's one instrumental patent, which also has Bob's name on it.<sup>43</sup>

**GRAYSON:** Okay.

**FENSELAU:** But I have not gotten rich from my patents...

**GRAYSON:** Well, [yes], that's another issue. I'm not sure that anyone does. I mean, some people do, but ..

**FENSELAU:** [Yes]...they're special...

**GRAYSON:** One person that I think, that I know, is Frechet, Jean Frechet, this fellow, that because so much of his chemistry goes into the fabrication of microcircuits and whatnot. So I think he's fairly well off, from the proceeds on that patent. It'd be interesting to do an analysis of how much, you know...I'm sure there's a spike of, a handful of people who make a living on their patents and the rest of the patents account for next to nothing.

**FENSELAU:** Well, there was a time when I [came to understand]—recently in fact—that having the first paper did not <**T: 20 min**> guarantee that you would be identified as the person who thought of this idea. That you actually had to have the patent to be clearly identified as the inventor, or the person who had the idea. I don't know. Maybe that's easing a little bit, but it certainly does tie the case up legally about who went there first.

**GRAYSON:** Well speaking about priority, it's interesting when I interviewed Bill [William S.] Knowles who was a Nobel Laureate in chemistry [2001], he was working at Monsanto

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<sup>43</sup> Catherine Fenselau and Robert J. Cotter, "Neutralization/chemical Reionization Tandem Mass Spectrometry Method and Apparatus Therefor." U.S. Patent 5,101,105, issued March 31, 1992.



[Company]; he spent his whole life at Monsanto.<sup>44</sup> The work that he did, that he actually ended up, being awarded the prize for, he ensured that it got in the literature as soon as possible.<sup>45</sup> Actually he was subverting some of the internal pathways that you have to go through in industry to get publications out. He recognized that this work was...I don't think he ever thought he'd get a Nobel Prize for it, but he realized that it was important work and he wanted to make sure that it was in the literature quickly.

So he actually went around some of the internal review cycles in Monsanto to get it in the literature right away, which I think stood him in good stead, because he did get the Nobel Prize for it, eventually. But he was aware of that, I think of the primacy. That is, I think, one of the big things with the Nobel Prize is having the first...you've got to be able to show that you're the first and defensibly, through the literature.

**FENSELAU:** Well, as I understand it, that's why Tanaka got the prize and not Hillenkamp.<sup>46</sup>

**GRAYSON:** [Yes]. I don't know what the difference in time was between their various developments.

**FENSELAU:** Probably several years. [Tanaka's company filed a patent on his invention in 1985, and he finally presented his stunning spectra publically at conferences in Japan in May and September 1987. They were passed on to the European community by third parties at a SIMS conference in Munster a week or two later.]

**GRAYSON:** Well that has definitely been a big factor in the rush to biological applications of mass spectrometry and definitely worthy of note by the larger scientific community. There was something in here, I read you'd looked at a cockroach or a bug, or what was that, some kind of a strange bug?

**FENSELAU:** A cockroach, no! I call bacteria bugs. So I may have said bugs, but I really meant bacteria.

**GRAYSON:** Oh, okay. I thought it was...okay, I misunderstood what you were saying.

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<sup>44</sup> William S. Knowles, interview by Michael A. Grayson at St. Louis, Missouri, 30 January 2008 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0406).

<sup>45</sup> W.S. Knowles, M.J. Sabacky, and B.D. Vineyard, "Catalytic Asymmetric Hydrogenation," *Journal of the Chemistry Society, Chemical Communications* 1972, 10-11.

<sup>46</sup> Franz Hillenkamp, interview by Michael A. Grayson at University of Münster, Münster, Germany, 20 August 2012 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0704).

**FENSELAU:** And viruses, we looked at viruses too.

**GRAYSON:** [Yes]. So how does that work, the viral...the study of viruses with mass spectrometry?

**FENSELAU:** Well, we tried to do it pretty much like we did the bacteria. We tried to dissolve the virus, and desorb intact proteins. Of course, viruses there's even...well, as with the bacteria, we chose models, organisms to study that were not harmful to people. I have not yet had an arrangement, which would have to be some kind of collaboration, where I could work with viruses of greater interest, those that are harmful to people. We did some of our bacteria work in collaboration with people at the Army Laboratory at Frederick, Maryland.

**GRAYSON:** Okay.

**FENSELAU:** Then after 9/11 we were no longer allowed access to the biological laboratory at Frederick.

**GRAYSON:** Oh, my. [Yes].

**FENSELAU:** So I'd need to find a virology collaborator to develop a rapid mass spectrometry method.

**GRAYSON:** All right, so what do you do to prepare viruses for mass spectrometry?

**FENSELAU:** Well, we tried to put them in acid and see if they would disintegrate and release their proteins. You know the most abundant protein in a virus is usually the protein that forms its outside shell. You can tell a lot about the virus from the molecular weight of that protein. But there's usually like several hundred of those that are tightly bound together, and you have to get them to come apart. So we have to lyse the virus open, denature the virus [coat] and that can be done chemically, but we have... <**T: 25 min**> as I say, we have probably some proof of concept out in that area, but haven't found the right circumstance to develop it fully.<sup>47</sup>

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<sup>47</sup> Yeoun-Jin Kim, Amy Freas, and Catherine Fenselau, "Rapid Analysis of Viral Glycoproteins by MALDI-TOF Mass Spectrometry." *Analytical Chemistry* 73(2001): 1544-1548.

**GRAYSON:** And then once you've gotten the shell, kind of, in the phase where you can study it, you just use standard...so what, are these fairly high-mass proteins?

**FENSELAU:** Well, of course the ones that are easiest to see are the ones that aren't high mass. The virus that has been most studied is called MS 2. Its coat protein weighs about thirteen thousand, so it's amenable to MALDI-TOF analysis.

**GRAYSON:** Yes. Well, that's the old mass range problem which we don't have any...

**FENSELAU:** Yes, or mass range versus sensitivity.

**GRAYSON:** [Yes].

**FENSELAU:** Yes

**GRAYSON:** [Yes]. So I'm confused; there's always these papers in the literature of people saying that they're working in the 'high' mass. The problem with that rather soft way of describing it is that high mass changes with time.

**FENSELAU:** That's right.

**GRAYSON:** So I wish they'd say the mass range that they consider as 'high', because looking back at it historically, it's not so easy.

**FENSELAU:** Well, you were asking me about what we're doing at College Park, and I guess I'd say that most recently [we've addressed] the idea of identifying proteins, intact proteins, which people like to call top-down...

**GRAYSON:** Top-down

**FENSELAU:** Analysis. In fact, when we looked at the proteins from bacteria with no genome those were top-down analyses introducing the [lysate from] the bacteria, introducing that

mixture through the LC into the orbitrap and also, activating [each] protein for decomposition. The intact protein breaks into pieces [though] not quite as thoroughly as an intact peptide would. There is some good software that was written by Neil [L.] Kelleher's lab that's now commercially available that interprets the top-down spectra. These tandem spectra of collisionally activated or otherwise, activated larger...well, proteins, intact proteins.

**GRAYSON:** [Yes], he comes out of the Fred McLafferty school, right, Neil?

**FENSELAU:** [Yes].

**GRAYSON:** For the top-down thing. So what about the drift [ion mobility spectrometry] work? Are you doing any of that?

**FENSELAU:** No. I'd love to get into that, but we haven't found a problem that was compelling enough to request the funding.

**GRAYSON:** That's a whole other instrumentation area that probably without the requirements, analytical requirements of biological work, would probably not have advanced so well.

**FENSELAU:** [Yes].

**GRAYSON:** It just seems to be...well, it's almost like the old days of GC-MS where it first got together and everybody wants to do this because it's so powerful.

**FENSELAU:** I don't know if it's quite there yet. There's still only two companies that offer it, Waters [Corporation], Agilent...Agilent hasn't sold one yet, they just announced it.

**GRAYSON:** Really, okay. VG is in it, I think.

**FENSELAU:** Okay.

**GRAYSON:** Is it VG now? Or, I can't keep up with...

**FENSELAU:** That's Waters, actually. [...] And that's a nice instrument, and I agree with you, there's some very interesting biological [applications]

**GRAYSON:** What do they call that now, the Waters thing? I can't think of the phrase. You know, they've got to have a little catchphrase for it. But it's basically, it's a drift...

**GRAYSON:** [Yes], ion mobility mass spec. The data that's produced by those things is pretty amazing. It's actually, I think it might be one of the first ways to deal with some of this huge volume of information that comes out of these very [biological applications]

**FENSELAU:** Well, it could also be viewed as another separation technique.

**GRAYSON:** Oh, [yes], most definitely.

**FENSELAU:** And then, still relying on the final mass spectrum for the real identification.

**GRAYSON:** It is...well, the technology just doesn't sit still.

**FENSELAU:** Yes, that's why it's so much fun.

**GRAYSON:** [Yes]. Well, I'm glad I'm not in the instrument business. Because you would never...I mean, it's like being under the gun every year to keep up with what's going on.

**FENSELAU:** One of the reasons I like ASMS is that it's going to be that little poster in the corner that you [almost] didn't see that actually is going to excite the next revolution...

**GRAYSON:** [Yes], [yes].

**FENSELAU:** Do you want to talk about some of these people?

**GRAYSON:** Sure...

**FENSELAU:** You gave me a list of people. We talked a little bit about Djerassi <T: 30 min> already. I told you a couple of Biemann stories. I've talked a little bit about Burlingame.

**GRAYSON:** Well, I was thinking about...how did, I mean, you are coming into this and really high-powered environment...

**FENSELAU:** At Hopkins you mean?

**GRAYSON:** Well at...I mean, even back when you worked for Djerassi.

**FENSELAU:** [Yes].

**GRAYSON:** You know, I mean, I assume that by this time, he was pretty well recognized as a leading...

**FENSELAU:** Yes, and the lab was full of foreign postdocs, right...

**GRAYSON:** So I mean, were you intimidated at all by being introduced to this really high-powered mix of...

**FENSELAU:** No. You know, [the reason] I went to graduate school was to move to the state of the art in chemistry. Djerassi took several students from my incoming graduate class, so there were colleagues there as well.

**GRAYSON:** Okay. And this was an active, intentional thing on your part to try and get into his group.

**FENSELAU:** No. He actually invited me. It's kind of...you know, these are like big mixers, how graduate students get their matches with professors. It's like a big social mixer, but the graduate student has to have heads up to get into an area where there's a career ahead of them. The professors think they need to be able to choose the productive graduate students. And so I probably did not know what mass [...] spectrometry was before I went to graduate school, because it really was so new.

He was actually very active in bringing new techniques into his natural products lab. He also brought thin layer chromatography in during the very first year I was there. It's hard to believe there wasn't thin layer chromatography, but you know, he'd picked it up somewhere, probably in Europe and was as thorough in getting the experts in to teach us how and introducing that to the lab, as he was with the mass spectrometry.

**GRAYSON:** Interesting. So what other things you were going to talk about Djerassi, a little bit more. Do you have any nice anecdotes?

**FENSELAU:** Well, he was a terrific lab manager. I think I also did say you could always get an appointment with him. He had weekly meetings. He...

**GRAYSON:** He separated his two worlds...

**FENSELAU:** [Yes], so admirably, and at the time, I didn't appreciate that, but now I do. He [also made] considerable effort to keep the lab clean. We did not have dishwashers. We did not have technicians. We all were supposed to wash our own dishes, and for a while, he would have a Friday afternoon inspection. You'd either have to hide your dirty dishes, or wash them. I think he finally let go of that, but you know I learned a lot about how to run a lab from being in his lab.

**GRAYSON:** Well, it's easy, I mean, particularly for some people, it's easy to turn a lab into a super mess.

**FENSELAU:** [Yes]. My students, the people who have gone through my lab, many of them run their groups also with weekly group meetings, and some of the things they learned from me, you know, some of which I learned from Djerassi. So I have great admiration for the man. He's managed to become famous for a lot of things since, besides chemistry...

**GRAYSON:** [Yes]. So do you see him anymore? I mean, run into him on occasion or whatever?

**FENSELAU:** Yes. Bob and I had dinner in a group of thirty with him in March of 2011, in Washington, DC. His son and his grandson were there. His brother was there. You know, it was a nice social event.

**GRAYSON:** [Yes]. So I mean, on occasion you do run into him...

**FENSELAU:** [Yes].

**GRAYSON:** He still knows who you are...

**FENSELAU:** Yes. He does. He usually sends me an email when I get an award or something. So he also...

**GRAYSON:** He's aware of...

**FENSELAU:** He's reading *C&E News*, I think. Which is cool.

**GRAYSON:** *C&E News* is really good. It's probably one of the best sources of information about chemistry that there is in my estimation.

**FENSELAU:** Definitely.

**GRAYSON:** So he's still a good guy. He's still alive. He's getting up there.

**FENSELAU:** I think he's [nearly] ninety...[yes].<sup>48</sup>

**GRAYSON:** Oh, wow. Okay. So because he had already been in industry when he went back to academe and you met up with him in your career, okay. Who else is next that you wanted to spend a little more time talking about?

**FENSELAU:** Well, you have a bunch of my coworkers [listed] here, [Martha] Vestling, [Yetrib] Hathout, Fabris, Demirev. I've already talked a little bit about Nathan Edwards now, this morning. So I could say a couple of things about these guys if you want me to.

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<sup>48</sup> Djerassi celebrated his ninetieth birthday in 2013.



**GRAYSON:** [Yes].

**FENSELAU:** Martha Vestling—just to start at the top of <T: 35 min> your list—was teaching in a four-year college and managing to direct undergraduate research. She liked to come to the mass spectrometry meetings. When I met her, she was ready to have a change in her life, you know? We're all supposed to change our job every ten years, or [so.] So she came to UMBC and joined the NSF facility there. I guess, I did say that when I left Hopkins, I was able to continue, or renew, or get a new NSF funding for a regional facility there.

**GRAYSON:** Oh, okay.

**FENSELAU:** So Bob and I both had NSF facilities for a while. We had different instrumentation and different clientele, so it worked okay. Anyway, so Martha came as a senior scientist, and was with us for four or five years, was terrific. You know maturity in the lab is always great.

**GRAYSON:** [Yes].

**FENSELAU:** And did things like made a book of the laboratory procedures, which I wasn't taking the time to do. And then, when the NSF...the NSF regional facility grants did have sunset clauses, as you may know from Mike Gross. When the facility ran out of its NSF funding, she spent a year at DuPont and then took...she's now the staff mass spectroscopist at the University of Wisconsin. I don't know how many instruments she directs, but besides providing the measurements and occasionally collaborating with the faculty, she also does an enormous amount of training of graduate students, teaching them to use the instruments themselves. She's also been an international instructor in MALDI-TOF. She's given courses in this country and she's been invited to several South American countries to teach, to give short courses in MALDI-TOF. So she is having a nice career of her own.

**GRAYSON:** So how long did she spend in your lab?

**FENSELAU:** I'd have to check, but I think it was four years.

**GRAYSON:** Okay. Any other...

**FENSELAU:** So you've got Fabris on this list, and most of the names you've picked out are from UMBC. Dan Fabris came as a postdoc from Italy and turned out to be a really good experimentalist, and did some beautiful early electrospray work on protein metal binding complexes in my lab. Then when I left UMBC, as I explained yesterday, they hired him and put him eventually on the tenure track for faculty and he became professor there [through] the last ten years.

He moved a year ago to SUNY, Albany, State University of New York at Albany. He had developed his own line of work at UMBC, studying protein RNA complexes. He went to SUNY-Albany to join a center for [the study of] RNA [...]. So he turned out to be a very good thinker as well as a very good experimentalist.

**GRAYSON:** I was just curious, when you mentioned the fact that he was so good in the lab. Did you find that the various people you interacted with had these kinds of traits that some people you didn't really want in the lab? Some people you really encouraged to be in the lab, or...

**FENSELAU:** I did have to let one postdoc go after three or four months. So you know, sometimes it works it, sometimes it doesn't.

**GRAYSON:** Because of not being able to deal with the laboratory...

**FENSELAU:** He couldn't carry out an experiment.

**GRAYSON:** Okay. But I mean, I assume...well, I guess they had something up here that they could rely on, if they couldn't do lab experiments...

**FENSELAU:** Well, not in that case, you know. I like to find out what a person's skills are and then let them go in that direction. I learn a lot from them usually that way, too.

**GRAYSON:** So this particular person didn't really have the skills.

**FENSELAU:** Perhaps...you know, I wondered how a PhD had been granted.

**GRAYSON:** Oh, this is a postdoc.

**FENSELAU:** [Yes].

**GRAYSON:** Oh, oh, okay.

**FENSELAU:** And some quiet inquiries <T: 40 min> suggested that most of his experiments had been done by someone else. I wasn't sure if his mentor knew that.

**GRAYSON:** [Yes]. Well, that's certainly not a good thing. Reflects poorly.

**FENSELAU:** [Yes]. So he needed to be out of science.

**GRAYSON:** [Yes], reflects poorly on the institution as that he came from. So okay. We don't want to go there. But it is...I mean, you can spot them, I guess. This is...

**FENSELAU:** Well, he wasn't spotted until he got to me.

**GRAYSON:** [Yes], but, I mean, you did...

**FENSELAU:** [Yes], eventually. [...] That was scary to fire a postdoc, so I actually called Fred McLafferty and said, "Is it okay to fire a postdoc?" He told me that sometimes it was good for the postdoc, that in one case in his lab he'd fired somebody and the guy had gone on to do well somewhere else. He encouraged me to do what had to be done.

**GRAYSON:** Well, you know, and then you owe it to yourself as well. If you see the guy's not performing, then...

**FENSELAU:** Yes. Yes.

**GRAYSON:** But that's the only person or you only had that one, kind of, negative experience.

**FENSELAU:** Probably not. You know, I've dealt with a hundred students and postdocs.

**GRAYSON:** But that one sticks out.

**FENSELAU:** That one sticks out. [Yes]. Then you've got Yetrib Hathout on your list, which is not the right way to say his name, but I never did get it right.

**GRAYSON:** Okay.

**FENSELAU:** He's from Morocco, educated in France, and I don't know if the name's Moroccan or French. But anyway, he is also a very gifted experimentalist and gifted thinker. He had received his PhD in France in a cell biology lab, which used LC-MS. His professor there...well, in several cases, I've been sent really outstanding people who weren't going to be given a chance in the country they were coming from. Because Yetrib was Moroccan, his professor was concerned that he might not get an academic appointment in France.

**GRAYSON:** [Yes].

**FENSELAU:** [His professor] thought he deserved an academic appointment.

**GRAYSON:** There was a certain amount of tension there?

**FENSELAU:** And still is, and the French can't decide how xenophobic they are anyway. So he came to me. He got off the plane without knowing really any English. I pulled up the college French we were talking about yesterday, and he learned English very quickly. He's really...

**GRAYSON:** That had to be an interesting interaction, where you're...

**FENSELAU:** But he turned out to be good across the whole spectrum of science. You know, he could culture cells. He could do chemical reactions. He could run mass spectra. He could use the computer and interpret data. So I was just really pleased with him. He had to stay with me for some years. Maybe he was with me six years, because it took him a couple of years to decide he would try for a green card. Then it took him a couple of years to get a green card.

So I benefitted greatly from his presence in my lab. He helped train students, helped train some of the other postdocs. He now has a faculty position at George Washington

University. His laboratories are at Children's Hospital, [where] he's up to his ears in proteomics work.

[...] It's a pleasure for me to talk about these folks. Shall I, kind of, keep moving?

**GRAYSON:** [Yes].

**FENSELAU:** You've got Plamen Demirev [on your list,] and this is another scientific colleague who's had a big impact on my career and is also now a very good friend. Plamen is Bulgarian—was Bulgarian. He got out of Bulgaria in the 1980s, before the fall of the Soviet Union. They let him out to train, gave him permission to go abroad for two years for postdoctoral training, but they kept his wife and his newborn twins in Bulgaria to be sure he'd come home, you know. His father had been a geologist. It was an academic family, and this is what he wanted to do. So he went to Djerassi's lab.

**GRAYSON:** Oh, wow.

**FENSELAU:** Djerassi spent some of his childhood in Bulgaria, but again, Djerassi had this reputation for welcoming postdocs from everywhere.

**GRAYSON:** [Yes].

**FENSELAU:** So he spent a year in Djerassi's lab, and decided that wasn't the right environment. I don't know if Djerassi <T: 45 min> suggested it, but somehow he came to me next, you know, for the second year out of his country. He was, and still is, a terrific, very bright man, very hardworking, ambitious fellow. He'd been trained formally as a nuclear engineer. I guess if you're in Bulgaria, that's what they let you do. He liked mass spectrometry a lot. He participated in some of the...I was talking about building the intellectual foundation for working with larger molecules. [...] He and Bob and I coauthored the paper on the rates of fragmentation of heavier compounds, fragmentation rates as a function of mass.<sup>49</sup>

**GRAYSON:** Okay.

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<sup>49</sup> Plamen Demirev, J.K. Olthoff, Catherine Fenselau, and Robert J. Cotter, "High-mass Ion Fragmentation as a Function of Time and Mass."

**FENSELAU:** And you got that paper yesterday, when we talked. It's *Analytical Chemistry*, 1987.

**GRAYSON:** Okay.

**FENSELAU:** So he went back to Bulgaria then, and they got him a new, I think, Hitachi [Ltd.] mass spectrometer in the Academy of Sciences. [Bulgarian science was] structured, [intellectually structured] based on the Russian system. So he did work there and was able to publish there, was able to keep the mass spectrometer going pretty much on his own. There was no hard currency to pay a repairman. Then I think that as the Soviet Union was falling apart, he moved his family to Sweden. So he spent, I don't know, six years, eight years in Sweden, kids' formative years for his children. They speak Swedish, Bulgarian, French, German, and English.

**GRAYSON:** Oh, wow.

**FENSELAU:** And then, eventually [he] decided that the family should come to America. So once again, I had the opportunity to have him in [my] lab. He came to me when I was at UMBC. He [held] an appropriate title, and was a big help in research there, and particularly in the move to College Park. So he honchoed that move. Then spent a couple of years at College Park with me, until he got his green card straightened out, and now he's at the Hopkins Applied Physics Lab. We still write things together, [but] we haven't worked together [for a while.]

**GRAYSON:** [Yes]. I see there's some things that's 2001, 2002.

**FENSELAU:** Those were written at College Park.

**GRAYSON:** [Yes].

**FENSELAU:** There's a [2011 book] that...

**GRAYSON:** [Yes]. Oh, [yes], here, [*Rapid Characterization of Microorganisms by Mass Spectrometry*]...<sup>50</sup>

**FENSELAU:** [Yes]. So we still are good friends, even though we haven't gotten to do research actually together for a while. So I'm fortunate in having really competent colleagues. I'm moving down through your list. Oh, Ian Jardine. We should talk about Ian Jardine. Okay. We'll talk about Ian Jardine for your microphone, because his present title is Vice President for New Product Development—I think that's right—at Thermo [Fisher] Scientific. So he's a very major force in the progress of mass spectrometry. He particularly led Thermo into biological applications. So the course of [this] science is being set, to a large degree by Ian Jardine's decisions about new product development. [...] He came [to my lab] while I was still at Hopkins, came as a postdoc.

This was another example, where his mentor thought his career would have more potential in America than in Scotland. He was very smart, very hardworking, had an adorable accent, all the ladies loved him. He met and married his wife...while he was at Hopkins, in my lab. We published exploiting that new technology of GC-MS with selected ion monitoring. He published a number of drug metabolism studies.

He then spent a couple of years at Purdue in the School of Pharmacy, then a few more years at the Mayo Clinic. He said that he was sitting in his office watching the snow fall one day, when Bob Finnigan called him and said, "Would you like to move to California?"<sup>51</sup> <**T: 50 min**> So he joined the Finnigan, ThermoFisher Company and has been a leader there ever since.

**GRAYSON:** Did he have any experience in mass spectra before he came to you?

**FENSELAU:** Yes. I should have...I'm glad you asked that, because he trained with [R.] Ivor Reed...

**GRAYSON:** Oh, okay. Sure

**FENSELAU:** ...who was one of the generation of physical chemists, or physicists, who worked with mass spectrometry before it was commercial [instrumentation.]

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<sup>50</sup> Plamen A. Demirev and Catherine Fenselau, eds., *Rapid Characterization of Microorganisms by Mass Spectrometry*. Washington, DC: American Chemical Society, 2011.

<sup>51</sup> Robert E. Finnigan, interview by David C. Brock at Los Altos, California, 4 December 2001 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript #0227).

**GRAYSON:** So he could step right in, basically, to your shop and be productive pretty quickly because he had [the right background]

**FENSELAU:** Sure. We could learn from each other.

**GRAYSON:** [Yes].

**FENSELAU:** Because he knew things I didn't, and probably vice versa. I wanted to...well, okay. I have mentioned to you Michael Colvin, who was my oncology collaborator at Hopkins. All of Ian's early work on the cancer drugs has Michael's name on the papers too.

A wonderful technician in the lab who worked at Hopkins, is Sharon Pallante Morell. [...] Her name on the papers is Pallante, she married late. She moved to UMBC with me, and was the department manager there, left the lab to become a manager. After I left UMBC, she stayed on, and completed the renovation, a very extensive renovation of the chemistry facilities that I'd gotten started.

**GRAYSON:** So she's, kind of, like become a principal investigator in her own right?

**FENSELAU:** No. She was the staff administrator in the department there. Now, she's retired. But no, she moved to UMBC, left the lab you know, left science, as it were. But was responsible for quite a lot of facilities development, teaching assignments, you know making the department function.

**GRAYSON:** Work.

**FENSELAU:** [Yes]. So that was important. I want to mention a couple of...and I'm coming to the end of our list here, graduate students. Because the list you selected didn't have any—by chance—didn't have any graduate students. As we talked about yesterday, I did not have many graduate students at Hopkins, but one of my first graduate students there is also one of my most successful graduate students. Richard [B.] van Breemen, is his name. He is at the University of Illinois in Chicago, the School of Pharmacy.

**GRAYSON:** Okay.



**FENSELAU:** He got his PhD in a pharmacology department. I don't know, he runs a lab of about twenty mass spectrometers, and a big group right now. He studies nutraceuticals, small molecules which are not necessarily drugs, you know, and "studies" means sometimes identifying them, sometimes doing quantitation, sometimes correlating their abundances in collaborative clinical studies, just lots of LC-MS.

**GRAYSON:** That's what he's doing now?

**FENSELAU:** Now, yes.

**GRAYSON:** Because here he was doing some glucuronide work...

**FENSELAU:** That's right. That's right. We were looking at, not only making and characterizing glucuronides, but we demonstrated that they actually...some of them, these drug metabolites, are chemically reactive. And that the reactions they can carry out are not good for people, alkylation of proteins, basically. So he did a really great job of demonstrating that.

**GRAYSON:** There's an outlier here: "Derivatives of dicyclopentadiene in ground water"...<sup>52</sup>

**FENSELAU:** You're good. Okay. My first interaction with the Army...

**GRAYSON:** Oh, okay.

**FENSELAU:** The—what was it called—Rocky Mountain Arsenal, was outside of Denver [Colorado] at that time. One of the chemists there asked me to get involved in thinking about some of the problems they saw coming on, which included their vast...their little ponds full of terrible chemicals [possibly] leaking into the groundwater of the nearby communities. They had probably made chemical warfare reagents there during the war, but after the war, they'd let some of the companies come in and make pesticides on the grounds.

It was really the pesticides that were their chemical waste problem by the time I was working <**T: 55 min**> with them. So that paper with Richard, is looking at what happens to cyclopentadiene which is a starting material for some of the pesticides that were made there.

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<sup>52</sup> Richard B. van Breemen, Catherine C. Fenselau, Robert J. Cotter, Allan J. Curtis, and Gaydie Connolly, "Derivatives of Dicyclopentadiene in Ground Water." *Biological Mass Spectrometry* 14, no. 3 (1987): 97-102.

What happens to it when it sits in the ground for some years? It's a small molecule. It was easy to analyze. So we actually identified quite a few metabolites, if you'd like to use that term.

I want to mention by the way, that the fellow who engaged us in that effort was Eddie Jones. [Mr. Eddie Jones] was an African-American [supervisor in the Army lab there,] and gave my career a little bump, a little boost right then.

**GRAYSON:** [Yes]. So this is a case where he came to you.

**FENSELAU:** Yes.

**GRAYSON:** Okay. You're having people come to you frequently, you know.

**FENSELAU:** I was visible. He probably became acquainted with me either through ASMS or through an ACS [American Chemical Society] lecture tour I did. I did some ACS lecture tours.

**GRAYSON:** So you know there was this whole period when the environment was a big part of the mass spec.

**FENSELAU:** Sure.

**GRAYSON:** You could come to the conferences, and environmental papers were all over the place.

**FENSELAU:** Yes.

**GRAYSON:** You never...you did some of it, but you didn't really get buried in that activity.

**FENSELAU:** That's right. I was working in a medical school, and so, you know...

**GRAYSON:** [Yes], okay. But you had the tools to do these things.

**FENSELAU:** That's right.

**GRAYSON:** So that's a good...okay. So any other individuals that you wanted to talk about.

**FENSELAU:** Yes. I want to talk about another graduate student, this is one from UMBC. His name is Igor Kaltashov.

[...] And I told you that I went to the International Conference in Amsterdam in 1991, and that I met Victor Tal'roze there. And that I found the reference compound to use to measure the basicity of arginine at a poster session.

**GRAYSON:** Right, right.

**FENSELAU:** And Tal'roze was very interested in making US connections, so he invited Bob and me to be visiting lecturers in Phystech [Moscow Institute of Physics and Technology] in Moscow [Russia]. We spent some time there, and the Russian physicists criticized my lectures for not being as quantitative as they were accustomed to. That's a fair evaluation, but usually my audiences don't complain about them not being quantitative enough.

**GRAYSON:** [Yes], interesting assessment there.

**FENSELAU:** Tal'roze introduced us to the chairman of one of the departments at Phystech, as they call it. They wanted to send some of their students to North America. They said, "Would you rather have a postdoc or a graduate student?" Bob said, "Postdoc." I said, "Graduate student." So Igor came, and I think he was pleased to be selected. I'm not sure he actually had a choice in the matter. But he was, of course, a brilliant student. He was much more quantitative than most of our chemistry students.

**GRAYSON:** So that's a...

**FENSELAU:** He came out of a physics training program.

**GRAYSON:** That's a characteristic of the Russian worldview of science, is a super quantitative kind of thing.

**FENSELAU:** Well, at least, this group that we fell in with. Before 1990, they gave national exams and directed the top 1 percent into physics, because physics constructs weapons.

**GRAYSON:** You didn't have any choice.

**FENSELAU:** I think you did not. I think if you wanted to be a physician, you got to go to Siberia. [laughter] So there were a lot of Russian physicists in 1990 who really were interested in biology, could apply this rigorous training, quantitative training. And you know they're all over our discipline, right now, as instrumentalists, bioinformaticists. We're very, very fortunate, I think. Even [Alexander] Makarov who invented the orbitrap comes out of that tradition.

**GRAYSON:** [Yes].

**FENSELAU:** So Kaltashov came with a master's in physics, and UMBC let him TA the physical chemistry lab.

**GRAYSON:** Wow, there you go.

**FENSELAU:** And though he was an outstanding TA, at the same time, he took the undergraduate organic course in order to take the undergraduate biochemistry course. You know, he, kind of, did a retread to broaden into...

**GRAYSON:** Chemistry, biochemistry...

**FENSELAU:** [Yes]. Did that of course, very successfully, and got his PhD

**GRAYSON:** So but I mean he had to be proficient in English.

**FENSELAU:** Yes, he was, and if he...

**GRAYSON:** Was this part <T: 60 min> of, I guess his training in Russia?

**FENSELAU:** Yes. Well you know, I believe that either they had already required the students to learn English or everybody got put on a crash course. So in 1992 when we visited some of these secret science cities that are in a ring around Moscow—Tal'roze brought us into the one that he was in charge of—we found that even the older people were having daily English lunches. They were really serious. You know, we were able to help a little there.

**GRAYSON:** What time period was this?

**FENSELAU:** This was 1991, '92...

**GRAYSON:** Early '90s.

**FENSELAU:** [Yes].

**GRAYSON:** But he came here in, like, 1995, I see...well, you're publishing stuff in 1995.

**FENSELAU:** I think that it was probably 1992.

**GRAYSON:** And so, okay. So it took him a while to get his feet on the ground, and get going...

**FENSELAU:** Well, it took us...well, you know, I met Victor in '91. Then we did this return visit, and the arrangements were made. So...

**GRAYSON:** How long were you there?

**FENSELAU:** Oh, just...I don't know, a month.

**GRAYSON:** Okay, [yes]. So basically, you were like guests...his guests?

**FENSELAU:** Yes, or guests of Phystech.

**GRAYSON:** Phystech, and then, they really wanted to show you the ropes.

**FENSELAU:** He was very generous, we went to this previously secret science city, whose name I can get for you, if it's important. We went to a machine shop that had like thirty stations, mud floor, I mean dirt floor. I don't know if that was [for] better [electrical] grounding or just...

**GRAYSON:** [Yes].

**FENSELAU:** But there were only three or four people working there at that point. Things had fallen apart already, and they pulled cobalt rods in front of us, out of the water to show us some of the research techniques.

**GRAYSON:** Oh, we want to look at those, do we?

**FENSELAU:** And you know some people we met there, died of various cancers in the next couple of years. I mean, people seemed to have a life expectancy of fifty, who worked in these radiation...

**GRAYSON:** [Yes], cobalt sources, are not all that nice to be waving around.

**FENSELAU:** [Yes]. So anyway...

**GRAYSON:** And the political environment then was...I'm not sure if I can characterize it. But I mean basically...

**FENSELAU:** Fluid.

**GRAYSON:** [Yes], fluid probably is the best way...

**FENSELAU:** Tal'roze was a very canny fellow who hoped to take advantage of the fluidity. He did send his grandson to be trained here. Actually, he was a PhD student at Hopkins. Then eventually, as you probably know Victor, himself moved here. I think I...

**GRAYSON:** [Yes].

**FENSELAU:** And died in California.

**GRAYSON:** [Yes], that's fairly recent, wasn't it?

**FENSELAU:** Yes

**GRAYSON:** [Yes].

**FENSELAU:** So I want to tell you about Kaltashov...okay. So he was one of my best students at UMBC. We published a number of papers on the gas phase structures of peptides. If you put two charges on them, the structure changed as the charges repelled [in the gas phase.] He postdoc'd with Bob at Hopkins, and he now is a professor at University of Massachusetts-Amherst...

**GRAYSON:** Oh, okay.

**FENSELAU:** And still doing really nice work there. So I'm proud of van Breemen and Kaltashov [and most of my other students.] I only want to mention two more people. You're being very patient with me.

**GRAYSON:** No, that's fine. I mean, you know that's what we're here for.

**FENSELAU:** One of them is Barbara [S.] Larsen, who was a postdoc when I was at Hopkins. I had a lot of postdocs, but she stood out for a couple of reasons. She is married to a man who I think works for Hewlett-Packard, not Agilent.

**GRAYSON:** I think you're right.

**FENSELAU:** And they have this nice house in the Pennsylvania/Delaware area. She finished her degree with Doug [Douglas P.] Ridge at University of Delaware and wanted to postdoc with me. So she was going to drive down every day from [Delaware], and that usually doesn't work. But she seemed very determined, so I said we could try it. Then she broke her leg, and...

**GRAYSON:** Now she's coming to UMBC...

**FENSELAU:** She's living in Delaware.

**GRAYSON:** And she's coming...

**FENSELAU:** To Hopkins. This is Hopkins, [yes].

**GRAYSON:** Okay.

**FENSELAU:** And she broke her leg, and that seemed like it was going to impair the drive. She came by train every day and took a taxi to the lab. She did not make money, you know, did not clear a profit in this year. But she did it. She got there every day, and eventually the leg got better, and she could go back to driving down. But she was very determined to bring this off properly. And she already knew, I think, that she was interested in going into industry <**T: 65 min**>. So we found a collaborator from...I have to check, one of the oil companies, not Exxon, but... and he let us look at oil, as a mixture, you know. This was in the NSF facility, so although it was in the medical school, it was okay to look at oil. We published this...Barbara did the best we could with this new state of the art MS50, high resolution sector instrument. Now, you know since then, the Fourier transform ion cyclotron resonance instrument resolution has taken over the oil field, but this was a start. It was an improvement over the low mass instruments, and the...

**GRAYSON:** [Yes]. My understanding is that the engineers back in England were working on trying to get it so that, it had enough resolving parts it'd go reasonably high up in mass, maybe couple hundred, and be able to resolve sulfur-32 from O<sub>2</sub>.

**FENSELAU:** [Yes].

**GRAYSON:** And that was one of the driving forces behind their push for increased resolving power, from what I gather.

**FENSELAU:** Well, we certainly wanted to take advantage of both the increased mass range and the really improved resolution to apply it on another class. There are a [set] of samples that are classical hard samples for analytical chemistry, and refinery bottoms are certainly one of



them. Yes. So that's Barbara Larsen's success story, and she did get this nice job at DuPont, and is still there, [still] in the field...

**GRAYSON:** [Yes], staying at DuPont seems to be a measure of some type of certain brilliance, because it's...

**FENSELAU:** It's hard...

**GRAYSON:** It's a tough environment.

**FENSELAU:** Yes. They keep changing their...they've changed their business plan dramatically in the last decade...

**GRAYSON:** [Yes]. [William J.] Simonsick is another person you know, I think...

**FENSELAU:** Yes.

**GRAYSON:** [...] He's managed to survive there, whatever it is they do there to their employees...

**FENSELAU:** He's another clearly bright guy, too...

**GRAYSON:** [Yes].

**FENSELAU:** Well, so I think that DuPont has a couple of track, career tracks. Barbara—I don't know about Bill Simonsick—but Barbara had gotten into the track where you can go through promotions parallel to management, but still be in the lab. I don't know what they call that, career scientist or something. [...] Then of course, you have additional responsibilities. She has spent a lot of time in court for the company, and so on. Anyway, I was very proud of her as a postdoc.

The last person I want to comment on is Henry Fales, who was...I would not call him a mentor, but certainly a dear colleague. When I came to Hopkins, when I got my first job, I told you yesterday I didn't have an instrument for nine months or something. I drove to NIH a couple times a week and used instruments there, and used Hank's instrument. I used instruments

in another division with a man named William [R.] Landis, and got some papers out, you know, despite not having an instrument.

So I have kind personal feelings towards Hank, but I wanted to comment on a couple of things about him, more generally. He deserves a lot of credit for getting NIH to fund mass spectrometry. I mean, claiming that I was, you know, the first trained person in a medical school. There were groups from Klaus' lab that also came into medical schools early. But I think Hank was involved in reviewing or in discussions with program officers there, and convinced them, by his own work demonstrations, that this was going to be an important technique for biochemistry and medicine, that they [should be] interested in funding. So he has always gotten a lot of credit for getting funding to the external community.

The other thing I want to say about Hank is that, when ASMS started, lots of us were going to the meeting who weren't physical chemists. But we have to give Henry [M.] Rosenstock and Joe [L.] Franklin, and the other physical chemists who started the society, a lot of credit for setting up a really good constitution. I mean, the format of the meetings and the constitution are just so much better than many of the other organizations I'm active in.

One of the opportunities our constitution allows is nomination for officers. You know, there's a nominating committee...[but it is also possible] to nominate by petition. So <T: 70 min> after a while some folks decided that we needed to have [some] biochemistry on the board because there was a growing use of the instrument in that area. So by petition we nominated Hank. He ran, and he won. He was the first biological person to be on the board. He was a good person [to send in,] because he could joke with the physical chemists.

**GRAYSON:** [Yes], no. Hank was a wonderful guy.

**FENSELAU:** And, you know, ease the incursion, if you like.

**GRAYSON:** [Yes]. I mean, he came across as being very personable and nonthreatening. I mean, you didn't feel as though Hank was trying to pull some trick over you. But he was in a sense, but in a very pleasant and kindly way, and...

**FENSELAU:** Sure.

**GRAYSON:** And trying to promote... I mean, it's the importance of guys like that... unfortunately, that was one of the people who I was supposed to interview...

**FENSELAU:** Oh, and you missed him. [Yes].

**GRAYSON:** I missed him by probably...what makes me a little unhappy—or maybe I shouldn't say this—but I kept asking the board to give me direction...

**FENSELAU:** Oh, [yes], to give you permission...

**GRAYSON:** [Yes]. And finally when they did, it was too late. If they had responded when I initially asked...

**FENSELAU:** You would have nailed him. No, he was really...

**GRAYSON:** That would have been a fantastic thing. I know that...

**FENSELAU:** He was really important in opening the area...

**GRAYSON:** He is. He is...

**FENSELAU:** [Yes].

**GRAYSON:** And I'm glad that we were able to get part of that video in the...

**FENSELAU:** From the symposium...

**GRAYSON:** The CHF website on mass spectrometry. So...

**FENSELAU:** Yes. Well, I just wanted to say that. And then eventually, there were some [other] elected biochemists. You know I was put on the board as an at-large member, and Jim McCloskey was elected in the presidential succession. But Hank was the first, and he was put on by petition. So okay, I think that's all I was going to say. Now are there any more names you want to...

**GRAYSON:** Well, there's just a few. This one, you know, I did an interview with Sy Meyerson. I see that you coauthored a publication with Sy on organic ions in the gas phase.<sup>53</sup> This was in the 1970s, so it's probably right after your organic...

**FENSELAU:** He was still working then. [Yes].

**GRAYSON:** [Yes], you're organic, more organic-like. So how did you and Sy Meyerson get together on this?

**FENSELAU:** I think he probably sought me out as a result of ASMS presentations, but I was interested. In my thesis, I put deuterium atoms in to study hydrogen, to track hydrogen transfers...

**GRAYSON:** Sure.

**FENSELAU:** In things like the McLafferty rearrangement. He was also interested in that. That paper probably—the paper you're looking at—has maybe nine addresses on it. It has some very large number of authors.

**GRAYSON:** We've got Sy, and you, and Young, Landis...

**FENSELAU:** But the addresses...

**GRAYSON:** Oh, the addresses, oh [yes]. I don't have the paper here...

**FENSELAU:** It's a very complex collaboration.

**GRAYSON:** [Yes]. There's Landis, Selke...

**FENSELAU:** He worked with me. Selke was a third, another address.

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<sup>53</sup> Seymour Meyerson, Catherine Fenselau, J. L. Young, W. R. Landis, Edward Selke, and L. C. Leitch, "Reactions of Aliphatic Aldehydes under Electron-impact." *Organic Mass Spectrometry* 3, no. 6 (1970): 689-707.

**GRAYSON:** Okay, and Leitch, L-E-I-T-C-H...

**FENSELAU:** Some of those are the old oil company guys...

**GRAYSON:** [Yes], [yes].

**FENSELAU:** So everybody seemed to have one [labeled aldehyde to contribute]...is it aldehydes we were looking at?

**GRAYSON:** [Yes]. We're doing "Reactions of aliphatic aldehydes under electron-impact."

**FENSELAU:** You really need to get the front page of that paper to count the number of labs. Sy pulled this all together, and the reviewers, you know, were kind about the paper, but they did say that they were quite impressed with the number of laboratories that managed to coordinate, kind of, coordinated to collaborate on this.

**GRAYSON:** [Yes]. I mean, it's interesting that Sy was able to do all this stuff in the petroleum industry. But it was...like I say Joe Franklin, and Field, and Munson, and these guys were doing really good, basic science in the petroleum industry.

**FENSELAU:** [Yes], Sy is obviously, a very smart man.

**GRAYSON:** [Yes]. Oh, [yes], definitely.

**FENSELAU:** The other person we ought to mention is Jack Sharkey.

**GRAYSON:** Oh, yes, definitely.

**FENSELAU:** I need to get you that picture. Jack was...well, he worked for a coal company, instead of an oil company.

**GRAYSON:** [Yes].

**FENSELAU:** That was coal in Pittsburgh, and he was very active in Pittcon. He was really, again, an advocate for mass spectrometry, and he made darn sure in those early years that there was mass spectrometry in the Pittcon program, the Pittsburgh Conference program. He made sure that some of the mass spectroscopists got some of the awards, and just worked on our behalf, in his own quiet way.

**GRAYSON:** I remember Jack from <T: 75 min> being the person who introduced me, the first paper I gave at Pittcon.

**FENSELAU:** [Yes]. Okay. Well, he probably arranged for you to give that paper there. Put you in the program.

**GRAYSON:** Probably.

**FENSELAU:** [Yes].

**GRAYSON:** He knew I was barely dry behind the ears, if so. He was very kind to me and, you know, made sure that I was comfortable about standing in front of this humongous group, because this was one of those early GC-MS papers. Of course, this was when people were all enthralled with...

**FENSELAU:** Excited, [yes]...

**GRAYSON:** What was happening there, so the place was packed. But...

**FENSELAU:** Yes. So we need to keep him on record as being an important promoter in the early days...

**GRAYSON:** Maybe if I get around to talking to Sandy someday, we can...

So actually, there is some person, one person we probably should talk a little bit about, and he's not with us. He's not here right now, a man by the name of Bob Cotter.

**FENSELAU:** Oh, I talked to Bob and we decided what I want to say about Bob, who for your microphone is my husband. It was a great pleasure to collaborate with him, when we worked together at Hopkins. It's been a great pleasure to live with him after we got married, after we were married.

**GRAYSON:** So but, I mean, you did have a little bit of a competitive— like you say, when you left Hopkins, and he kept the equipment. You had to get some...get your own. So I think there was...

**FENSELAU:** Sure.

**GRAYSON:** There was some kind of...

**FENSELAU:** Well, there's not a negotiation at the scientist level [when you leave a university.] The university has their rules and the rules are that if NIH gave the money to buy the equipment to Hopkins or to Maryland, then the university owns it.

**GRAYSON:** Ah, okay.

**FENSELAU:** And you're allowed to use it. And as I said about moving the Fourier transform instrument from UMBC to Maryland, that had been bought by DARPA and it had a DARPA property tag on it. They had actually not given it to the university.

**GRAYSON:** Oh, okay.

**FENSELAU:** So they allowed me to move it. Then when I wanted to discontinue that instrument at Maryland, I had to get their permission to turn it off. They tried very hard to find another lab for it, DARPA did. So that's an unusual situation. But anyway, NIH, NSF legally give the equipment to the university. So there was no bad feeling or no negotiation...

**GRAYSON:** Okay. So it was just a matter of this is the way it is based on the...

**FENSELAU:** Yes.

**GRAYSON:** So you two had this exciting exercise of trying to get someone to dig around behind an instrument, and find a property tag.

**FENSELAU:** Well, we knew at Hopkins...I mean, I did have to prove at UMBC that there was a DARPA tag. But that was a smooth transition [from Hopkins to UMBC.] We have a little article in *Rapid Communications* which shows both our labs all together, because we do have lots of laboratory social events together.<sup>54</sup> And we have continued to collaborate.

When Bob got the distinguished award from ASMS last year, he funded a reunion of the two labs. Of course, Hopkins was [our lab jointly for a while.] Well, anyway, all of our students were invited to this big party, so it extends their network too...

**GRAYSON:** Sure. [Yes], definitely. [Yes], that's a good network to be part of. I notice that in Tanaka's Nobel lecture at the end he acknowledges both you and Bob. So there's a connection there that's obviously a little bit more than just random. So, I mean, you have been interacting with him, or I mean, what's that?

**FENSELAU:** Oh, okay. So we had...well, in Djerassi's lab, I met a couple of Japanese postdocs, right. Those connections kept...we kept those connections. Then when they could, they started inviting me to speak in Japan. Then pretty soon, they [were inviting] Bob to speak in Japan. [Bob participated in the Second Japan-China Joint symposium on Mass Spectrometry in Osaka in 1987, the second conference where Koichi Tanaka presented his high mass laser desorption time-of-flight breakthrough. Bob met Tanaka at that conference and even took a photograph of Tanaka and his poster showing the first desorption and detection of protein ions over 70,000 Da. Subsequently, Bob (and I) reported that breakthrough globally. And we made a point to continue scientific discussions with him whenever we encountered him at international conferences.]

**GRAYSON:** Well, I mean, you did a good job of...

**FENSELAU:** For science, I think.

**GRAYSON:** Well, [yes], and also getting the work recognized in an area that...I mean, what would have come of it if you hadn't promoted it?

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<sup>54</sup> "Research Centers: Mass Spectrometry at Johns Hopkins and the University of Maryland Baltimore County" *Rapid Communications in Mass Spectrometry* 8(1994): 763-765.



**FENSELAU:** [...] Actually, we were invited to the Nobel Prize ceremony as sort of [by chance.] Each winner can make a list of people [to be invited,] and most winners are academic and they have all these students and postdocs, previous students and postdocs. In [John B.] Fenn's [Nobel Prize, Chemistry, 2002] case, people who shared some of the patents with him were invited.

But Tanaka didn't have students and postdocs. We asked if we could be invited [as friends.] We figured what the heck? <**T: 85 min**>

**GRAYSON:** [Yes], why not?

**FENSELAU:** We were invited. So, you know, it's possible he had added that [comment to his talk] just because we were there.

**GRAYSON:** Well, it's like I say, I notice just little things like that, you want to know a bit more about, because, I mean, it's not that there's obviously interaction there...

**FENSELAU:** Sure.

**GRAYSON:** Was valuable for both sides.

**FENSELAU:** We like to say that we are Nihonophiles...

**GRAYSON:** Ah, okay.

**FENSELAU:** You know, we like Japan a lot. We like Japanese food, culture, people. My son was an East Asia studies major at Harvard with a specialty in Japanese [culture and language].

**GRAYSON:** Okay, there you go.

**FENSELAU:** And he took my grandson to Japan last summer. So, I mean, this is a genetic Nihonophile.

**GRAYSON:** Oh, wow. So I wanted to spend just a little bit of time with regard to your name. Your maiden name is not Fenselau.

**FENSELAU:** It's Clarke.

**GRAYSON:** It's Clarke. Okay. So then you married Allan Fenselau.

**FENSELAU:** [Yes].

**GRAYSON:** And so your public name is Catherine Fenselau.

**FENSELAU:** I have one paper with Djerassi with the name "Clarke." Then I have many papers with Fenselau, and so when we were divorced I just, kind of, kept the name professionally.

**GRAYSON:** [Yes]. By that time it was pretty well established in the literature.

**FENSELAU:** Homeland Security [finally] got after me for using two names. So now my passport says Cotter, my bank account says Cotter. My tax report says Cotter.

**GRAYSON:** Don't want to run afoul of those people. Most definitely you don't want to get involved there.

You have been involved in a number of organizations in your career, both as working for them, and also as being active in societies. So has there been a fairly evenhanded treatment of you as a woman in these various organizations? Or is there some that have, kind of like, maybe you're less than a first class citizen?

**FENSELAU:** Well, you know first of all, I should talk about ASMS. We talked yesterday that mass spectrometry was a new technology, at least new on a large scale, and that it had to welcome folks who weren't trained, and there were people in it who weren't PhD's, who weren't formally trained in it. Those are the kinds of situations where women often get in on the ground floor. Computer science also. I did discover one woman who did mass spectrometry applications before me, and she was an employee, I think, at CEC, and there were probably some other ladies who worked in the lab.

**GRAYSON:** [Yes]. I know who you're talking about. We're trying to get more information. It's too bad we can't get more information about her, because I think she was very important in the development of their application of the instrument to petroleum analysis.

**FENSELAU:** But anyway, I had no problem being received at ASMS, which wasn't ASMS.

**GRAYSON:** No, it was ASTM [American Society for Testing and Materials], which was kind of...

**FENSELAU:** Because they, sort of, welcomed all comers, whatever shape you were in.

**GRAYSON:** [Yes]. They were pretty wide open.

**FENSELAU:** And the physical chemists were outstandingly cordial. Henry [Rosenstock], who worked at the Bureau of Standards near here, whom I could see regularly [at the local discussion group] was wonderful, wonderfully cordial. And as I say, at the same time, Hank was making inroads as a biochemist. So I didn't feel...so anyway, ASMS, I slid into without any hesitation.

I've been active more recently in ACS. You know that more recently in ACS as more and more percentage of the chemists in the country are women, the ACS has less and less problems with it. I should also mention that when Madeleine Jacobs became the Executive Officer of the American Chemical Society, suddenly women started getting awards and women were on the nominating committees and the selection committees and...<sup>55</sup>

**GRAYSON:** Interesting.

**FENSELAU:** So ACS opened up. I think we have to give Madeleine, although she would never admit it probably, you know, credit for driving that transformation...

**GRAYSON:** I saw her Thursday at the CHF activities. She was there.

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<sup>55</sup> Madeleine Jacobs, interview by Hilary Domush at American Chemical Society, Washington, DC, 28 May 2009 (Philadelphia: Chemical Heritage Foundation, Oral History Transcript # 0669).

**FENSELAU:** So ACS has opened up, not just to me, but to women <T: 90 min> at the awards level.

I was the founding president of U.S. HUPO, so there was no problem there.

**GRAYSON:** [Yes]. Tell me about this HUPO thing. It's...

**FENSELAU:** Well, let me say one more thing about...

**GRAYSON:** Okay.

**FENSELAU:** Which of them do you want first?

**GRAYSON:** You continue...

**FENSELAU:** The one time when I really did feel like there was some problem that might [have occurred] because I was a woman was when I was submitting papers to a journal. There were a couple of my papers in a row that were rejected. And the reviews weren't that bad. So it seemed to be for emotional reasons they were being rejected. Of course, emotional can be for a lot of things; maybe they didn't like the Hopkins address.

But anyway, this was by an associate editor, so I finally got my nerve together. This is probably the only time I was ever this assertive. I called the editor-in-chief, and said, "I think you have a problem with this guy. He doesn't like my papers, even though the reviews are okay." The guy resigned at the end of the year.

**GRAYSON:** Oh, really?

**FENSELAU:** The associate editor who had given me so much grief was no longer an associate editor, and my papers after that went into that journal smoothly, so that's a time where it might have been a problem. And I don't mean to be Pollyanna. I told you yesterday about my salary being [bumped] twenty-five percent...

**GRAYSON:** [Yes], that was interesting...

**FENSELAU:** Without comment. There are probably lots of other things. But on the other side though, sometimes people beginning from Lyndon Johnson on, 1960s people, institutions thought they needed to have women on their committees and needed to have women up front. So sometimes you can get overworked because you're a woman as well. We used to call that affirmative action-itis.

**GRAYSON:** Affirmative action-itis, okay.

**FENSELAU:** So it goes...it cuts both ways.

You were asking me about HUPO. Okay. So when proteomics...that term was first used by an Australian graduate student, I think in 1994.

**GRAYSON:** Proteomics?

**FENSELAU:** [Yes]. But it's obviously, it's a copy on genomics.

**GRAYSON:** [Yes].

**FENSELAU:** And a very bright, aggressive man named Sam [Samir M.] Hanash decided in the early 1990s that we needed to develop proteomics differently—and probably lots of people talked together—decided we needed to develop proteomics differently than genomics. The genome had been sequenced in a very limited number of labs, probably fewer than six. The public sequence was done completely in American and British labs. All these other countries were really angry, because they didn't get a piece of that action, for prestige reasons.

**GRAYSON:** Sure.

**FENSELAU:** [Eventually] they got access to the sequence, [but] for a little while they didn't get access...that wasn't open, but now it is. So [Sam and others] decided to try to make an international organization and make sure that the proteome effort was more widespread.

**GRAYSON:** Okay.

**FENSELAU:** So I give Sam Hanash credit for leading the founding of the international HUPO organization.

**GRAYSON:** How do you spell this name?

**FENSELAU:** H-A-N-A-S-H.

**GRAYSON:** Okay.

**FENSELAU:** And S-A-M-I-R. He's Lebanese [American], I think. But he works at...

**GRAYSON:** So HUPO stands...

**FENSELAU:** He was at Michigan, University of Michigan, and now he's at an institute [Fred Hutchinson Cancer Research Center] in Seattle [Washington].

**GRAYSON:** Oh, okay. [Yes].

**FENSELAU:** But anyway, [yes]. So HUPO was founded in...

**GRAYSON:** And this stands for...

**FENSELAU:** Human Proteome Organization.

**GRAYSON:** Okay.

**FENSELAU:** And, you know, we did realize shortly that there are going to be other interesting proteomes, you know plants, bacteria. So probably the mission statement says, "and associated proteomes" or something, but the [big] idea was to try to spread [the science] out a little better...

**GRAYSON:** So this is a fairly recent development in the...

**FENSELAU:** [Yes]. I think we're having our twelfth meeting in Boston.

**GRAYSON:** Okay. The U.S...so there's a U.S...

**FENSELAU:** No, international...

**GRAYSON:** There's an international HUPO...

**FENSELAU:** Actually, it rotates between geographic parts of the globe, and it was in...well, you know, so it's in Korea. It's in China. It's in Japan. It will be next year in Japan. Last year it was in Switzerland. This year it's in Boston.

**GRAYSON:** Okay.

**FENSELAU:** I'm actually on the planning committee for that, but...

**GRAYSON:** And then, there's the U.S. HUPO, which is kind of like a...

**FENSELAU:** National subsidiary of it. So you know, you can't...well, we like to talk to people that are closer, that are more accessible. So each country has its own proteomics organization <**T: 95 min**>. The nice thing about US HUPO is it has about six hundred people.

**GRAYSON:** [Yes], I was wondering the size of this...

**FENSELAU:** It's the way you and I remember ASMS.

**GRAYSON:** [Yes]. [Yes]. It's fun to go to because you know most of the people...

**FENSELAU:** You can see everybody, [yes].

**GRAYSON:** And you're not being run over by a bunch of other people.

**FENSELAU:** Yes, exactly.

**GRAYSON:** All right, during your career, the women's movement kind of came on the scene. Did you ever feel...I mean, you never really identified with that, I don't think.

**FENSELAU:** I was too busy doing science.

**GRAYSON:** [Yes].

**FENSELAU:** But on the other hand, I benefitted from it. I had a note here to myself, to tell you that I have been fortunate several times in my career. First, I think Sputnik was good fortune, that the government was very enthused about supporting the training of scientists and began to include women. The [executive order] that Lyndon Johnson signed, that's how I got my big raise. That was important for women in my generation, and I told you a lot of my college classmates got into law school after that.

Then I have to admit the women's movement was beneficial to me. I didn't deny it, but I was pretty busy doing what I thought was my part for it, [supporting women in science.] I got, in the 1980s, I received—in 1985, I think—I received an award [Garvan Medal] from the [American] Chemical Society, which is given to women chemists. So there was a big debate at that time in—I don't know, *C&E News* and other places—about whether they should even continue this award because it was for women chemists only. And when getting ready for this discussion with you, I reread the talk I gave when I accepted that award. I had made the argument that we had to make the point somehow that there was good science being done by women. The organic division gave an organic award and there were, like, sixteen thousand women in ACS and [only] eleven thousand organic chemists, and six thousand physical chemists. Organic has had an award. The physical chemists had an award, so you know, the larger group [(women)] deserved an award.

**GRAYSON:** [Yes], [yes].

**FENSELAU:** You can make [that] kind of argument for it. That award has thrived. It's still being given by the ACS.



**GRAYSON:** Okay, excuse me here, I've got to look here. Did you ever feel... I mean, you had a family, so this was a... it took a lot of energy to keep your career focus and raise kids. So was that...

**FENSELAU:** Yes. Yes. Well, I really wanted to have a family. And I think that's an important part of my being a role model, is that I'm a scientist with a family. When I was at Berkeley as a postdoc, I became aware of a female scientist who was a professor in, I think, the microbiology department, who had four kids. I thought that was a terrific role model. It can be done. It could be done. Now what I didn't know was [if] she had a babysitter or nanny or something for those four kids. I did [also,] in fact. Allan and I had a full-time, 8:00 AM to 6:00 PM, babysitter, not a live-in. But anyway, the same lady, same nice Irish family [for more than eight years,] and she had four daughters, so we had built-in evening babysitters, if we needed them. That worked okay for the kids.

I was disappointed that my children did not want to be in science. I mentioned that yesterday. They thought we worked too hard at it. We loved it too much. So we told them, that was okay if they weren't in science, but we hoped they found something [else] that they were passionate about.

**GRAYSON:** Sure, [yes]. I think that's our attitude as well. So you were very active in the American Society for Mass Spectrometry. So how do you see that organization having changed from when you became a member and then through actually holding responsible positions in that society, and today?

**FENSELAU:** Well, you know, it's gotten remarkably strong. It's a very important leader in science, more broadly than just in mass spectrometry. I have to give the physical chemists who wrote the constitution, again, a lot of credit for envisioning the kind of organization that would endure and would strengthen. I think it was very important <T: 100 min> that we hired Judith Watson Sjoberg. I was on the board at the time, and I didn't understand how important a professional manager—that's not quite the right word, but staff—could be.

**GRAYSON:** [Yes].

**FENSELAU:** Burnaby Munson was the last program chair who pasted up the program himself. I was the first program chair who didn't have to paste up the program. And I think that was a very important decision. It's been good for Judith too. She has a whole company now and manages several organizations. So I've been really, very pleased [with ASMS leadership.] And I'm pleased that it's moved on to generations who don't have anything to do with [the founding]. In fact, most of the physical chemists have passed on. Even if I call myself a second generation, we're not leading the organization anymore, either. But there are very energetic,

enthusiastic people in charge. The board structure is really good, because it generates a balance and a variety of ideas and the fact that they meet in person is really important. I hate conference calls, you know. I watch some organizations evolve so that the professional manager is actually making the decisions.

**GRAYSON:** [Yes]. I could see where that could happen, particularly in a conference call situation.

**FENSELAU:** Yes. So I'm delighted that it continues to be strong. I don't mind that it detracts from Pittcon. I struggle with the fact that it pulls a lot of good science out of American Chemical Society meetings, but those meetings are so large and...

**GRAYSON:** [Yes].

**FENSELAU:** In so many different hotels, anyway. We have a lot of fun at ASMS. You know, I love having the elevator door open and three people come out that I know and haven't seen for a year, and being in one site was, of course, a nicer situation than we now have. But we'll see how it [evolves.] It would be okay with me if it leveled off, if attendance leveled off for a while. But that's apparently not even happening in Canada with this Vancouver meeting.

**GRAYSON:** Apparently not. I mean, I think there was some concern at last year's conference being away from the East Coast, there's just such a dense population of people who would attend the meeting, and being in Denver. I think the attendance was a little bit less than the previous year or the past years...

**FENSELAU:** Although, bad economy too.

**GRAYSON:** Well, that's the other thing. But, I mean, given the state of the economy, I think everybody felt the attendance at Denver was good. I think it didn't drop off really significantly...

**FENSELAU:** [Yes]. I didn't notice any fewer people...

**GRAYSON:** Well, I think it's you know, maybe a hundred or so less. But if they sold out all of their hotel rooms in Vancouver, then I guess, like you say, there'll be people coming from the Far East to attend. My sense is, it's still...I mean, it is an international meeting even though I

know that the board and everyone else wants to keep that phrase out of the name of the society and the meeting. But it is international.

**FENSELAU:** Yes. I'm proud of that too. I think that most of the Europeans who come are, in fact, postdocs. The "Herr Professors" don't come unless they're especially invited. But at least those postdocs will grow up thinking that's a good meeting to go to.

**GRAYSON:** So it has...let's see. We served on the board together for a while. From that period, I'm trying to recall what the size was back then. It was not nearly as big of an operation as it is now. I don't think we had much more than a thousand, twelve hundred people back then. I don't know. Do you have any numbers there?

**FENSELAU:** I don't have any numbers. [Yes]. We've handled the growth somehow. I think probably...

**GRAYSON:** Well, I remember this kind of tension. Well, do we want to get bigger, or do we not want to get bigger?

**FENSELAU:** Do we have any control over this?

**GRAYSON:** We don't have control over it, and you know there's...if you get bigger, there's more work and harder to make the meeting the collegial type thing that you would like it to be, when we had five, six hundred people. But then on the other hand, do you want to get smaller? That means that the discipline is, you know, falling by the wayside. So it's like, okay...

**FENSELAU:** Well, one of the things we have lost by becoming big is there's no more an effective conference dinner, or conference party <**T: 105 min**>, because there are just too many people to have in one space.

**GRAYSON:** Effectively.

**FENSELAU:** [Yes], effectively. I think we didn't even try it in Denver last year.

**GRAYSON:** I think that's correct. I think that Judith [Sjoberg, Executive Director] really wasn't able to find anything that seemed to be appropriate. With that size of a group, it's really

hard unless there's something that's very specific to that particular area. I think when we were in Seattle and went to Boeing's aerospace museum [it worked well]

**FENSELAU:** Oh, that was a good party, [yes].

**GRAYSON:** That was, I think, a good event, because that was a unique place, and it was a very interesting setting, and I think it worked well.

**FENSELAU:** [Yes].

**GRAYSON:** But if you can't find something like that in an area, then I think you're...

**FENSELAU:** Well, when we take you out to Fort McHenry today, maybe we should think about whether that would be a good thing for the group to do here.

**GRAYSON:** So when are they coming here?

**FENSELAU:** 2014.

**GRAYSON:** Okay. I think they're going to come to St. Louis either after that.

**FENSELAU:** So we're going to be in Minneapolis [Minnesota] in...

**GRAYSON:** Minneapolis next year.

**FENSELAU:** And then Baltimore...

**GRAYSON:** Baltimore in '14, and then I think St. Louis in '15. So [yes].

**FENSELAU:** Well, St. Louis will be fun. We've been there once. We've been there once, haven't we?

**GRAYSON:** [Yes]. [Yes]. I think there might have been one way back in the past. I've got the list.

**FENSELAU:** I tried to go through the Arch and failed, for some reason.

**GRAYSON:** Well, let me see. Let me look at my little list of things here and make sure that we've gone...

**FENSELAU:** I'm checking all mine, too.

**GRAYSON:** All the items that...well, I don't have any additional...

**FENSELAU:** You asked me last night when we were not recording about undergraduates, and I could just say...

**GRAYSON:** Oh, yes, yes, yes...

**FENSELAU:** [...] Okay. So undergraduates, I think that scientists feel that they're obliged to try to get younger people interested in science, part of our responsibility to science. I haven't done very much in K-12 myself, but I have always had undergraduates in the lab. I've always had a small number of undergraduates in the lab, because they really do require a lot more attention from somebody than a graduate student or certainly than a postdoc, but they can be quite productive. I've always tried to choose undergraduates who were going to be PhD's rather than physicians or dentists, because I thought their motivation would be better. The woman we have right now in the lab, [Maria Oei] who you briefly encountered yesterday, is a freshman. I hope she'll work with me for four years. She's very bright. She's very conscientious. She's very interested in science. We're trying to get her funding from some of the many programs that College Park has for undergraduate research. Her family is [an Indonesian]-American family who own a bakery in Wilmington [Delaware. ], so she brings us great goodies.

**GRAYSON:** Oh, there you go.

**FENSELAU:** At holidays, at appropriate holidays.

**GRAYSON:** A certain advantage there.

**FENSELAU:** That's right. Take advantage of all our connections, [yes].

**GRAYSON:** Now, you did mention that you only take on one of these individuals at a time.

**FENSELAU:** Yes. At College Park, I've taken on one at a time. Yes. I may have had two on occasion at UMBC, but, you know, that's just because getting them started requires such an investment of personnel time from the laboratory. They could hurt themselves if they're not carefully instructed and carefully kept an eye on, and...

**GRAYSON:** [Yes]. This was an issue with my son, Matthew, at Northwestern [University], when...he uses a fridge, you know, one of these things. He does...

**FENSELAU:** Walk-in...

**GRAYSON:** Condensed phase matter physics stuff...

**FENSELAU:** [Yes].

**GRAYSON:** Where you've got this super ultra-low temperature...

**FENSELAU:** Yes.

**GRAYSON:** And there was a problem with the equipment and someone could have gotten seriously hurt, if they had made the wrong move. When he found out...basically the thing wasn't working and they were trying to fix it. When he found out what they were doing, he hit the ceiling. You know, you have to...and these were graduate [students.... He said,] "You know you have to tell me about these things!"

**FENSELAU:** Oh, [yes].

**GRAYSON:** You have to keep me informed because you could have literally killed yourself.

**FENSELAU:** Yes. Well, that's a good point. When something goes wrong, they should let us know.

**GRAYSON:** Maybe you did [something to that] <**T: 110 min**> and caused it to go wrong, maybe you didn't, but whatever...

**FENSELAU:** Tell us...[yes].

**GRAYSON:** It's you need to report it to someone who knows, understands the equipment, and not try to [fix it yourself]

**FENSELAU:** Well, that's a good example of what I'm talking about, and the issues in my lab would be a little different than that, but still we're talking about high-voltage instruments...

**GRAYSON:** Oh, [yes], [yes]. You can get hurt seriously, and it's something that is important. I think the idea of taking only one at a time is probably smart, you know, because the last thing you want to do is have something happen that's untoward. Okay, I think I probably exhausted you with this conversation.

**FENSELAU:** Oh, it's been more fun than I thought it would be, Mike.

**GRAYSON:** Oh, good. Well, I mean that's what I'm trying to do is just have fun. I don't want to make this into an onerous task, or anything.

[END OF AUDIO, FILE 2.1]

[END OF INTERVIEW]

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