David: Okay. Here we're back again. I should have said it's August 23rd, 2018. About, what? 5:30 PM, and we're in New York City, and David Campbell and Mitchell Feigenbaum are discussing things for the AIP Chaos Oral History. So, I think we'll start with a question about ... Think back ...

Mitchell: Earliest beginnings.

David: ... Yeah. We'll start from the beginning. Think back to your early childhood, and what got you interested in science.

Mitchell: I didn't care much for language. I was totally uninterested in reading. So, my brother learned to read when he was maybe two, three. My mother pushed us, and I adamantly refused, and finally in the first grade I learned how to read, which I never liked doing. So, I became, so to speak, a very good reader. Mother taught me sound methods so I could read anything, and through that means, for that extravagantly good vocabulary. So, I could pretty much read anything, but I didn't like reading, you really think you could ever learn from reading? So, I never liked to sleep, but I would go to sleep very early. I wasn't even allowed out of bed until 7:00, so most of my young life. Who knows? From 5:00 in the morning to 7:00, I would just think.

Mitchell: And what I cared about was looking at things, as I looked very carefully, and tried to figure out what they meant. If one could recall any of them must've been totally verkakte theories passing for an explanation. But I was a very careful observer, and I looked at everything.

Mitchell: Somewhere around the age of five or six ... my father's a chemist, and from discussion [I] knew there were atoms, and one day I realized that the world I saw was just sprinkled, sort of buzzy, with little dots, which on and off happened to me for at least a decade.

Mitchell: It wasn't any breaking down of a shape perspective, a visual field, but it was busy. And I decided, I had very good vision, that I could see atoms. But I never told anyone about that. I knew my father wouldn't believe me.

David: [Laughter]

Mitchell: And I didn't like to read. I didn't really ... I became evidently, arbitrarily competent by high school. But I didn't like ... was totally uninterested in any children's books. And almost immediately in college, starting with Iliad, was obvious there were a lot of things I wanted to read, and I was put on abeyance until graduate school.

David: But you've skipped over high school: was there nothing in high school that interested you in reading?

Mitchell: Just in general that to me was not the path to knowledge. One of the most ... of course I learned mathematics, learned physics. Initially learning physics was exceedingly easy. The serious problems of third bows of a ladder and all those things, I knew that already.

So, that was finally putting on it a theoretical backdrop. That really organized it all and made it transparent.

David: Well, let's slow down for a second. You knew that already from having empirically ...

Mitchell: Experience.

David: Oh.

Mitchell: There's a story recounted in there.

David: So, that “there” by the way is a Mitchell's contribution to the 20th Century Physics volume edited by Bram [Abraham] Pais.

Mitchell: There was a neighbor who lived, let’s say a block and a half away, and I think it was the first time I had seen her or noticed her [I] was on our porch. And I saw this lady walking by and I screamed to my mother, "Come and look," and I said, "Why doesn't she fall over?"

David: [Laughter] How old were you?

Mitchell: About five. But my mother always remembered that. Both she and the woman were embarrassed.

David: I did something like that to my mother. It's a side story. I was a little bit younger than that even, and we were down town in Long Beach, and there was black man there and I said, "Mommy, why is that man black?” It was a really a rather embarrassing situation for everyone. But he answered, “That's just the color of my skin. I'm the same as you.” And it was really ... he took it pretty well.

Mitchell: You told me that. I remember. No, he was gracious.

Mitchell: In any case, we didn't have that many books at home, had a Britannica, a Britannica which I would look at a lot. Articles were largely indecipherable, the E&M article was thoroughly indecipherable.

David: Electricity and magnetism.

Mitchell: Years later, by the time I knew it, looked back, and it was of no utility to a person who knew it. There isn't anyone that article could have serviced. It's hard to communicate stuff. So, I didn't have that many books around. My parents ... my father's exceeding intelligent. Both of my parents, somehow they believed you had to learn things in a class. Most of the things you didn't have to learn quite that way.

Mitchell: It was then the very end of high school was a solid geometry class, and the second half of the book was calculus. The teacher said, "You don't look at the second half at all." And I took a train up to Columbia, and I started reading it, and I read most of it by the

time I came back. I realized it was very easy to learn things from these books. To a prepared mind, easy to learn. I just realized for five hard years at least, I should have done way more than I had done.

Mitchell: The things I learned first few years of college, they're built completely permanently in me. There's the understandings. It's just a part of me. Then, there are other ways of learning en masse, which you can do. We all know how to do, and that's more profitable in many ways. But, the memorial stuff came earlier. What are your thoughts that way?

[Pause: No response from David]

David: So, you've just told me that you went on sort of a binge reading fest starting in graduate school. Could you repeat that, please?

Mitchell: Starting in high school, in college, with the Iliad at first, it was clear it was extraordinarily interesting stuff in literature to read. History did not at all interest me at that point. I was fulltime busy as an undergraduate, and the day I got to graduate school, I started reading. And read a novel every two days. There was psychology that was important to learn. I read some ten odd volumes of Freud. It had become clear starting in college that I had to know much more about epistemology than all of the presentation of physics is fundamentally rhetorical. They're not real proofs, and what it is we know as opposed to the frameworks we discuss them is very important to understand. So, there's a lot of philosophy. I started reading and writing, and several years of graduate school, mostly what I did was to learn to think a lot.

David: So, with all this reading, when did you have time for coursework in graduate school, or did you not find that challenging, or did you not do it, or what's the story?

Mitchell: [inaudible 00:12:16] on that. So, I always walked around all night. So, attended some classes. During the second year, became rather spotty. But, I could do other people's problems for them, and there was a circle of friends who would go to the classes and, you know, I would choose whose homework I would copy that week.

David: [Laughter]

Mitchell: So, nuclear physics, this is not very impressive man named Bertozzi (sp?), who taught a nuclear physics course, went to one lecture, and actually never learned any nuclear physics. The grader in that, name was Chad Jaffe (??) 00:13:24], was maybe Phil Morrison's student, was doing a relativity thesis, and I did some serious assistance for him. He was grading the nuclear physics course, so at some point he said, somewhat embarrassing getting the copy of someone else's exercise, why didn't I just tell him, who I intended copy from?

David: [Laughter]

Mitchell: Did I miss learning nuclear physics? I think not.

David: This was clearly another time. These days that would get you in big trouble. So, let's go back to the start of it. How did you happen to choose MIT for graduate school, and of course, you went to MIT in electrical engineering.

Mitchell: Engineering.

David: How did you transfer to physics, and why, and when?

Mitchell: [Are we on on this thing?] Engineering is, of course, very different from true science. There's physics now has grown to be a bit sum of its parts, too much engineering, as in engineering, you only have to know something well enough to make the thing work that you're dealing with at the moment. That's impressive, knowing nothing of the materials, measuring them only over the regime that you care about. You can build things out of it, and it is spectacular. That has nothing to do with understanding how things work, and that's the critical difference.

Mitchell: Related to that, the engineering degree is a licensed degree. With all of my switching out of courses, which had never been done before, I had too many courses standing behind me. I got first exception exam that had ever been giving in City College of Engineering, and I substituted out of the core courses. The summer before I graduated, the Dean called me in, I had an NSF fellowship at MIT, he said, "Well, there's a problem." For the licensing, I had one course too few. He said, "On the other hand, since you already have acceptance and scholarship, we'll somehow put it under the rug."

Mitchell: It was wrong in the engineering. The idea of an engineering education is Henry Ford. It's the spirit of interchangeability, and the licensing of the degree means you pick one of these people who's good enough grades and you can plug them in. He knows how to do the calculations. The way that's done is there are a hundred identical homework questions everyday. I can do that in my head, so I never submitted homeworks.

Mitchell: But, electrical engineering, while interesting in many ways, is cold. It's getting clear to me however good I was at it, if my heart wasn't in it, I couldn't make myself do it, and I would ultimately fail. It became clear that with no loss, there's time to move parallel, which is into physics. So, that was done within one month of my getting to MIT because ... and why I went to MIT, amongst other reasons, their letters claimed that there's no set coursework, and I could elect to take whatever courses. So, I got there, and there was no EE course. And if I'd said can't do that, have to take an EE course, and it was my [GMIT 00:19:03].

Mitchell: So, there was their advanced undergraduate circuit course, which they would accept as graduate credit that would get me up to the level of MIT. At the end of the first day, when I told the guy how to solve a much harder problem, this meant it was stupid. Their greatest class was Gilleman's (sp) Killeman's 00:19:37] great course. Gilleman is very famous in EE. And it was their circuits synthesis (??) course. It turned out, ten exams, got a 100 in every one. I pointed out better, faster methods to solve varieties of them.

The teacher was absolutely knocked out. I submitted zero homeworks, and with 100 exercises, the same shit that this pablum, this engineering education. Took the final, got 100. Card came, and I got a B+. So, I was out of engineering anyway.

Mitchell: Two months later, right in front of Kresge Auditorium, near my (start of term? daughter's dorm), walked past him, and he turned red and stopped me. He was infinitely embarrassed. He, of course, wanted to give me an A+, but the department policy without sufficient number of homework, never more than a B. So, with all this sweat, he was able to raise it to a B+, and he was mortified. In the engineering, and I like doing engineering also, it's just a different enterprise. And I don't like doing pablum. It's impressive how much is pablum. I think there's no field teaching everything just to taught a method and then do 500 problems. The method's all the same.

David: So, this is a little bit aside, but how would you regard the work you did ... we'll talk about this later in another session on the Hammond Atlas, which involved using some very exotic and high level theoretical physics concepts, but in what might be considered an engineering practical application? Can you compare and contrast that with what [crosstalk 00:22:18]?

Mitchell: It was absolutely engineering. Engineering means ... it's a first issue. There were these databases that came online, coming recently from the CIA, and they were made public circa '88, whenever it was. The database was at three different scales. Maybe one to three million, one to ten million ... no. I don't remember this. One to 35 million. There's a world's size. One to three, five million, that's the high resolution. I want to say, that's correct.

Mitchell: So, it means multiple databases had to be maintained and that (?) [inaudible 00:23:34] appropriate, but the size maps we were intending, wasn't one of them, which would mean a lot of the maps would have to digitize ourselves. It was immediately clear it was all nonsense. You need any three databases. That's what's in Google. It's crap. It just makes the thing small, and then doesn't show it to you, when the scale is small enough, because, of course, they're pretty much infinitely busy. You have to smooth them to the appropriate level, but there's a critical ingredient. The cities of different size, must come out on the correct size because the points that you would hopefully measure to know the coordinates were political data with the cities, so this generalization couldn't suddenly either go on the wrong side.

Mitchell: So, geography believed you couldn't generalize more than a factor of two. It was obvious, you could do factor 20, but you have to understand it's heavy fractal [00:24:59] properties. How well do you have to understand them? Good enough to do the job.

David: Engineering.

Mitchell: And that's a very different problem. Moreover, there is a set of requirements, which was the most interesting part. So, the programming entailed solutions. They're satisfied in aesthetic, as well. That was the most novel part, and I can't talk anymore.