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RICHARD FEYNMAN'S CURIOUS LIFE

Lance Dixon

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Richard Feynman as Viewed by a Caltech Undergrad, 1978 – 1982

I grew up in Southern California and was very interested in science as a child, thanks in large part to my father. He had studied electrical engineering at Caltech for both his undergraduate degree and his PhD, and he often went to Caltech's Jet Propulsion Laboratory in his later career as a spacecraft engineer. We would go to Caltech's Alumni/Seminar Days often in the 1970s, when I was in middle school and high school and could start to appreciate them. Thanks to the presence of Richard Feynman and Murray Gell-Mann, Caltech had an outstanding reputation in elementary particle theory, the subject that most interested me in high school (and still does!). So it was not surprising that I ended up at Caltech too, entering in the Fall of 1978.

I arrived at Caltech a couple of weeks early to train for the varsity soccer team. That let me get a feel for the Caltech campus, but I still had not met any professors. Then the other freshmen arrived and we all headed off to Caltech's Freshman Camp, which was held at the rustic Camp Fox on Catalina Island, about 20 miles offshore from the Palos Verdes Peninsula. Amazingly, Feynman was there! I recall vividly Feynman wearing shorts and a hat, sitting cross-legged on the grass lawn at Camp Fox, along with about a dozen of us "groupies" who were trying to soak up his wisdom. I don't remember exactly what he said, but it must have been gripping because I joined the Feynman circle at Freshman Camp every chance I had, and I knew an exciting four years lay ahead at Caltech.

After hearing Feynman convey the excitement of physics, I knew even more clearly that I wanted to be a particle theorist. On the other hand, the upperclassmen I met would say, "Sure, you do" — knowing that 90% of freshmen with that inclination would change their mind after a year or so. So I would add, "...or maybe major in geology or astronomy" to appease them. But I stuck with it, and I ended up double majoring in physics and applied mathematics.

The first couple of years, I didn't take any classes directly from Feynman. Not long before, he had taught Physics X, which was a chance for undergrads to ask him absolutely anything about physics, questions he would answer off the top of his head. But I don't think it was offered (or else I missed out on it somehow). However, during the core Physics sequence, probably early sophomore year (Physics 2), when it was time for us to learn quantum mechanics, Feynman came in to give a few guest lectures. Those lectures were classic Feynman, in the sense that you left them feeling that you had a total, intuitive grasp of the subject — but then when it came time to do a problem set, you realised that maybe there were a few details you still didn't quite understand. I had read some textbooks on quantum mechanics in high school, but probably the wrong ones, because they were full of formalism, and yet I didn't have a very clear picture of what was going on. Feynman took the sum over histories approach with us (of course), effectively introducing us to path integrals, although without calling it by that name. It was probably an unusual way to get to quantum mechanics, path integrals before the Schrödinger equation, but it was certainly inspiring! Feynman's lectures were also video recorded, but I don't know if those particular lectures ever made it online.

One evening, we invited Feynman over to dinner at my Caltech dorm, Page House. The Page House lounge was completely packed. I remember sitting on the floor looking up at Feynman in conversation with Robin Colgrove. Robin was Page House Vice President. He convinced Feynman to come have dinner with us, and "moderated" the free-for-all discussion. I asked Robin to help fill in my memory of how it went. He writes, "my strongest recollection from all the banter in retrospect was how cocky we were (myself certainly included), teasing and needling one of the great figures of twentieth century science, blissfully unaware that we were poking fun at someone not just head and shoulders but probably belt and shoelaces in achievement beyond what most of us would ever accomplish." But that was the thing: Feynman probably encouraged and enjoyed our total lack of deference; he never tried to look authoritative, put on airs, or use unnecessary jargon when explaining things. Feynman also sent Robin a personal thank you letter praising Robin's chocolate chip cookies (one of his proudest possessions).

Robin went on to become a molecular virologist at Harvard Medical School. Feynman's way of thinking about how to develop theories stuck with him as applicable to biology as well as physics: When you have an incomplete understanding you should never insist on a complete theory; you should start with multiple imperfect theories, which can eventually be improved to allow a full theory.

I have taken Feynman's advice to heart too: not so much in the area of developing a new theory to explain physical phenomena, but rather in delving deeply into the structure of known theories. In the arena of "scattering amplitudes", we have a saying that there is a virtuous (not vicious) circle: You develop a new tool to compute something that could not be computed before. Then you inspect the new result, looking for patterns in its structure. These patterns often give clues to understanding of what is going on, as well as tools to compute one step further. Rinse and repeat. Through many rounds of imperfect "theory" and collecting more "theoretical data", you eventually arrive at a deeper and more powerful theoretical understanding.

While I was at Caltech, Feynman had a multi-hour surgery for abdominal cancer. (Lars Brink tells me it was in 1981.) Since Feynman was an icon on campus, and needed a lot of blood, Caltech held a campus blood drive. There was a huge turnout. I remember donating a pint then. Maybe that was what started me on the road to being a regular blood donor. (However, it could also be that the road began later, when I met my wife while donating — she was a nurse at the Stanford Blood Bank...)

Around 1981 – 1982, I took two upper division or graduate courses from Feynman: generality relativity out of the textbook by Steven Weinberg, and a special topics class on quantum chromodynamics (QCD). Much of my research over the past few decades has been on QCD and the relation between quantum gauge theories (like QCD) and quantum gravity. Although I still had a lot to learn about these topics, both as a graduate student at Princeton and beyond, it might not be a coincidence that I work in areas where my first exposure was provided by Richard Feynman. At least it might explain why my intuition for gravity is more on the algebraic than the geometric side.

My final contact with Feynman as an undergraduate was somewhat indirect and not related to physics. It came through a mutual friend, Glen Cowan. Glen is an experimental particle physicist now working in England. His father and my father were good friends, from back in the 1950s when they roomed together east of the Caltech campus. (Another roommate was Ken Wilson, who was getting his PhD with Murray Gell-Mann, and would later win the Nobel Prize in Physics.) Anyway, I got to know Glen, mainly from coming over to his house in Pasadena early every New Year's Day in the 1960s and 1970s, so we could meet his family and walk the few blocks from their house to Colorado Boulevard to watch the Rose Parade. Since Glen's dad was on the Caltech faculty, along with Robert Leighton (who co-authored the famous "Feynman Lectures in Physics"), Glen became friends with Robert Leighton's son Ralph, as well as Feynman.

I was taking German at Caltech my senior year and I told Glen that for my term project I needed to translate something from German into English. He immediately said, you should translate the book "Reise ins Asiatische Tuva" ("Journey to Asiatic Tuva") by Otto Mänchen-Helfen (Berlin, 1931). He then explained to me how, he, Ralph and Feynman were planning to travel to Tuva, but they were not allowed to trade on Feynman's fame to get there. Instead they were arranging to be cultural ambassadors for a visit of Tuvan throat singers to the United States, and so naturally they would have to go to Tuva to scout things out. Inspired by Glen and by the remoteness of Tuva, for my German project I translated some large chunk of "Reise ins Asiatische Tuva" into English. Thanks indirectly to Feynman's fascination with Tuva,

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I too became enchanted, by reading Mänchen-Helfen's descriptions of the nomadic Tuvans, their yurts and throat singing. I also learned, through Glen, how Feynman had such a strong interest in doing and seeing things far out of the ordinary, but that it had to be from the perspective of an ordinary person.

Feynman insisted that theories had to be confirmed by experiment to be relevant: "It doesn't matter how beautiful your theory is, it doesn't matter how smart you are. If it doesn't agree with experiment, it's wrong." During my graduate study at Princeton in the mid-1980s and for five years after that, I worked on string theory, which is certainly one of the most beautiful theories ever. It was a heady time; many thought that a complete theory of all the fundamental forces could be right around the corner. Once it became clear that it was not going to be so simple — and might be impossible — to get sharp predictions from string theory, I looked for another avenue to pursue, one where I might predict something relevant for experiment (remembering Feynman's dictum). This led me toward using string theory, and later more general principles such as unitarity, as computational tools to improve predictions for QCD processes at the Large Hadron Collider. In some ways, unitarity-based methods can be viewed as replacing (for some applications) the ubiquitous diagrammatic technique that Feynman invented in the 1940s. But it can also be argued that the newer methods reorganise Feynman's diagrammatic expansion in multiple ways, and blend it with more general principles in order to render it even more powerful.

I was fortunate to have had multiple interactions with Richard Feynman while I was an undergraduate at Caltech, which greatly impacted my growth as a physicist. Feynman was a true genius, a polymath and a science communicator, the likes of whom can scarcely be found today.