

## 1 EARLY YEARS

### 1.1 FAMILY HISTORY

Whenever I am asked where I am from, I always want to answer “Caltech.” In fact, I did not set foot on the Caltech campus, and barely in the state of California at all, before graduating from high school in Tucson, Arizona. But Caltech was so formative in my life that anything that came before pales in comparison for me. However, I will start in the usual way, with a bit of family history. This gives some context for later life, and may provide unexpected insights.

In the town of Hawthorne, in Westchester County, New York, you can find the Joseph Polchinski Company,<sup>1</sup> which has sold cemetery monuments since 1883. It was founded by my great-grandfather, whose name I share.<sup>2</sup> My father shared the same

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name, but my grandfather was an *Arthur*. So I am a *Junior*. Among family I was distinguished as *Joey*, and a few of them continue to use this even now.

My father's grandparents came to the United States around 1870, part of the vast European migration driven by the combination of starvation and ambition. One of them, Joseph, was from the region between Poland and Germany, while the other three were from Ireland. Joseph brought his expertise in stonework with him, founding the monument company and the florist next door. These supported his family for two generations, before they began to spread in the usual American way. The monument company is now owned by another family, but I am always honored to see that they have kept the name for its historic value.

I know much less about the family of my mother, Joan Thornton. From a very young age she was raised in a series of foster homes. She ended up with a warm-hearted German-American family, but she seemed to retain a melancholy from her difficult earlier years. I got only some basic history about her, and she never felt a desire to learn more. She was born in Pennsylvania, but her final foster family was in the same New York town as Joseph Polchinski's family and his monument company. Her ancestry was a mixture of Irish and other parts of the British Isles.

Growing up in the same small town, my parents Joan Thornton and Joe Polchinski married in 1951, when Joan was nineteen and Joe was twenty-two. I was born three years later, in 1954, and my sister Cindy three years after. Our family was a rather typical one for the rising American middle class in the 1950s. My father left the family business to earn a degree in accounting. He went to work for Schenley, a distiller, commuting by train to his job at

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**Figure 1.1**  
Polchinski family, New York, ca. 1960

the Empire State building. My mother worked for a few years in an office, then became a full-time homemaker.

Neither of my parents expressed an interest in science. My father did say that he had wanted to study chemistry but could not because he had not taken German. But our conversations rarely turned to science. More common subjects were sports and games, though we did like games like bridge which had some aspect of mathematics. He was highly competitive, a trait that I picked up. In other directions, my father's reading tended toward history, and my mother's toward fiction.

### 1.2 EARLY SCIENCE AND MATH

My own interest in science appeared early. When I was six, my passion was the *How and Why Wonder Books of Science*. This was

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a series of several dozen books, each centering on a subject such as Dinosaurs, Atomic Energy, Chemistry, and Rocks and Minerals. Each was forty-eight pages long, but in a large format that was packed with information. The figures were hand-drawn but appealing. I waited eagerly for each new issue. Once, I misbehaved rather badly, playing with an ember from a campfire, and the new issue was taken away from me for a few days; it was an effective punishment.

A few years later, Isaac Asimov's books in math and science drove me. So also did science fiction, by Asimov, Clarke, and many others, giving an inspiring if unrealistic picture of what science might do. Unfortunately, the science books and teachers through high school made little impression. At that level the subject was too purely descriptive.

I remember asking my physics teacher, what is the speed of gravity? He did not understand the question, even though I drew a diagram illustrating how you would measure it. Another misunderstanding, at an earlier age, was a test question: Which is strongest: (a) pressure, (b) electricity, (c) gravity, or (d) magnetism? I knew that the question made no sense, but having good test-taking instincts I knew they wanted the answer *Gravity*. But this could not be correct: I could lift up my hand even against the gravitational attraction of the entire earth. So I chose another answer almost randomly, refusing to make the choice that I knew was wrong. I probably made a token argument with the teacher, but I was used to losing those. But the smallness of gravity is indeed one of the principles of physics.<sup>3</sup>

One very exciting moment, on the other hand, was reading (no equations at this level) how an electric field can make a magnetic field, and a magnetic field can make an electric field, and these

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two together made a wave that was the origin of light. So my future in science was clear, even if it took a few more years to get the details. Thus, from an early age I was drawn to the basic principles of physics. I am very fortunate that I have been able to spend my life studying this, and contributing new understandings.

With math, one gets closer to the real subject at a younger age, so the classes were more interesting. I raced through my courses, meeting the new math in fifth grade. This program was a response to *Sputnik*, and the perception that the US was falling behind the Soviets in science (the *How and Why* books likely had the same origin). I can remember the school assembly, where all the students and their parents learned about this new thing. The plan was actually rather bizarre. Students would first learn such abstract notions as sets and operations, only moving on to arithmetic after the theory was understood. It is hard to believe that anyone thought this was a good idea, and indeed it faltered in a few years, but it was perfect for me.<sup>4</sup>

Unfortunately, I missed the full benefit of the new math because we moved to Tucson, Arizona, a year later. My father was looking for a better job, as an account manager at Merrill Lynch, a stock brokerage, and Tucson had one of the available openings. Perhaps too my parents were ready to leave the small town they had grown up in. So the chance to race ahead in math was delayed a little. I missed another chance around the same time: my father was second in line among the applicants for a position as business officer at the Institute for Advanced Study, where my connection with science may have been accelerated.

Canyon del Oro (CDO), my combined junior high/high school, was a new school, and a small one, which would limit me in some

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ways. But I had the good fortune that my first math class was with Ed Baceski. Mr. Baceski loved math, and he made it a game. For example, completing a problem set would lead to a code to unravel (and you could short-circuit the problem set by working backward). In retrospect, Baceski was a bit like the new math, not ideal for the typical student, but great for me and a few others. Early on he set the Gauss problem, summing 1 to 100, and after I solved a few of these I was allowed to race on in the textbook on my own. I completed four years in one, through geometry. My most vivid memory was starting trigonometry, reading on my own, and not getting the point of this *sine* and *cosine*. But after a couple of days it suddenly fell into place, and it was wonderful.

The next year, I took advanced algebra, the highest level offered in this small school. It was taught by the football coach, leading to more of the sorts of disagreements that a student doesn't win. In retrospect, there might have been a right way and a wrong way to make such points.

Having run out of math classes, I spent my first high school year commuting evenings to the University of Arizona for calculus, driving with my father or some older students. Unfortunately, this did not go well. Part of this was the instructor, who contributed little insight or inspiration. One day we had a substitute, who regaled us with stories about math, and in particular challenged my precocity with examples of great mathematicians who had accomplished much more much earlier than I (he could see that I was full of myself and needed this). But then it was back to the regular teacher.

The second problem was that I couldn't really grasp calculus, just as earlier I couldn't get trigonometry for a while. But in this

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case it took three years, when I took college physics and found out what calculus was really for. (Mathematicians might tell you that it has other uses, but they would be wrong.)

Disappointed by the class, I decided I could learn math on my own. I chose a book on group theory. Unfortunately, I again seemed to lack the knack of the subject, and my effort faded. I ended up spending most of my last two years of high school studying no math. Science was similar. My small school had no advanced courses, so after racing through the sciences that were available I found myself with a year of no math or science classes at all, spending it taking the other required courses to graduate a year early.

### 1.3 FAMILY

My sister Cindy and I seem as different as two people can be, in personality, interest, and career. Where my passion was physics, hers was animals, horses in particular. She took only one year of college, and that was to mollify our dad. She was then a groom at a large stable near Santa Barbara. Over the years she has owned horses, bred them, competed with them, and most recently served as steward at horse shows all over the country.

To support her interests, she also served as a police officer for almost twenty years. This is something I could not imagine doing; for one thing, I can't make quick decisions. But she did this with aplomb. Cindy is not academic in her interests, but she is extremely capable. Yet another difference is that I have always been shy, working up from extreme shyness when young to mere introversion today. My sister is the opposite, taking great pleasure in meeting and talking with people from many walks of life.

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In spite of our differences, we have always gotten along well, and she is a great supporter. She has often told me that she looks forward to traveling with me to Sweden when I win the Nobel. That is not going to happen, but I did take her to the Large Hadron Collider (LHC) a few years ago.

My parents were as helpful as they could be, given that they did not understand what this alien in their family was doing. My father was the type who always had to be in charge. When I told him what I was learning in school, especially later on when we got to relativity, he told me that this could not be true. So my father, I am sorry to say, was a bit of a crackpot when it came to physics. The number of people who have never studied science but still feel qualified to present their ideas is remarkably large: notably, 99 percent of them are male. Indeed, my mother did not have such theories. She did make it a point, many years later, to tell me that she had been very smart in school. Unfortunately, the limitations experienced by so many women prevented her from pursuing this.

### 1.4 INTERESTS

I did have some stimulation outside of school, notably science fiction, telescopes, and chess. I mentioned science fiction before. It is curious to recall that this was almost entirely through books. *Star Wars* was still seven years away, and with a few exceptions like *War of the Worlds* and *2001: A Space Odyssey*, there was not a big market for science fiction movies. It is remarkable how it now dominates.

My interest in telescopes began with the surprise gift of a four-inch reflector from my parents when I was twelve. This was an



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excellent idea. Tucson was then a rather small city, and we lived on the edge, where well-separated houses trailed off into desert. The seeing (air clarity) and darkness were incredible. My interest was drawn to picking out galaxies, finding as many of the Messier catalog as I could. My interest was mostly visual; I was too young to follow the science.

After exhausting the potential of the four-inch, I set out to build an eight-inch reflector. I did not have a large budget or a lot of mechanical aptitude, so the results were mixed. I made a creditable mirror, working it against another glass using progressively finer grit and measuring my progress with the help of the University of Arizona's astronomy club. But the mechanical support was built with whatever wood I could get hold of, patterned on a scaled picture of the Hale telescope. This worked, and was great for showing off, but it was well short of the real capacity of an



**Figure 1.2**

Joe and the telescope he built, Tucson, ca. 1966

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eight-inch. Still, finding the Crab Nebula was one of my favorite challenges. Seeing Andromeda was easy even by eye, and I still can pick it out in Santa Barbara on a good day.

Chess dominated much of my school years. I learned the moves from my father when I was young (aside from some confusion about the pawns). After occasional games with my father and a few friends, my interest exploded when I got to CDO and discovered a group to play with. For the next five years, at almost every lunch period or other break, we would pull out our boards and play. As I got better, I played in local tournaments, and in larger ones in Phoenix. This was a lot of fun, and virtually my only social life. In my last two years, when I had run out of math and science to study in class, I spent many hours studying chess books, about chess openings, and attacks, in particular.

There is an anomaly here, which has always puzzled me. Based on my progress in physics, first in progressively more advanced courses, then in original research, and finally in significant discovery, you could say that in physics I am the analog of a fairly strong Grandmaster. In chess, I started out as a beginner, and in a few years had worked my way up to the level of a good recreational player. In my last two years, working nearly full-time on chess, I expected to continue to improve. Instead, I came to a virtual standstill.

Chess has a nice numerical system, called Elo. Based on their wins and losses, each player has a numerical rating. Grouping them, they are designated . . .  $D < C < B < A < \textit{Expert} < \textit{Master} < \textit{Senior Master} < \textit{Grandmaster}$ . Roughly speaking (the full theory is more elaborate), if two players are separated by  $M$  levels, the relative probability that the higher ranked player wins is  $3^M$ . When I

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started out I was a *D*, a beginner, and after three years I rose to *A*. But I never quite reached *Expert*, much less the promised land of *Master* and beyond.

I have always wondered why. Are chess and physics so different, that one can be a Grandmaster in one, and not even an Expert in the other, in spite of similar efforts? Seeing younger and younger teens achieve Grandmaster has always amazed me.

I got one clue when I ran into a high school chess buddy many years later. When I had first met Keith Nelson in school, he challenged me to a game. Having faced such challenges often, I expected a quick victory, but he beat me. I was sure that with a bit more concentration, I would set things right. But he beat me again! Over time I won a share of the games, but he was clearly the better player. So, perhaps twenty years later, I ran into Keith again. I had not known of his interest in science, but he had in fact become a professor of experimental chemistry at MIT. And as we began to reminisce, he astonished me by recounting in detail our first two games, which I could remember only dimly. Evidently, he had a phenomenal memory, at least compared with mine.

Indeed, I have always felt that I did not have an especially good memory. In one of my first classes in college, the instructor told us that you do not need a good memory to do physics, because you can derive everything from first principles. If I had had any doubts that this was the right field for me, that sealed it!

Beyond the issue of memory, I did not have a real knack for chess. I was conservative, using a few basic attacks and waiting for the opponent to make a mistake. I did not like to advance pawns, because the effect is irreversible. This is not the way that Grandmasters think! Likely with training I could have done much

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better, but not been a prodigy. I am curious, what distinguishes these different mental strengths?

### 1.5 TRAITS

One thing I want to do is to recall some of my development as a physicist. There are a number of traits that have played a role here. Many of these have already come up in the discussion of my early life.

To start with, my parents and relatives could see from a very early age that I was not a normal kid. I could solve puzzles and games at a level far above my age, and my general knowledge was advanced. So from a young age, this was my identity: being very smart. It has stayed with me as I have moved from level to level, all the way to string theory.

On the other hand, I have noted that I was painfully shy all through school. I tried to keep conversations as short as possible, so as not to bore people. Only gradually, in college and beyond, did this fade.

I also think I have some lack of common sense. My poor telescope design was one example. Another was my two-year gap in high school math: with common sense I should have looked for advice. And my approach to chess also seems to show a lack of common sense.

In a sense, shyness and lack of common sense were two sides of the same coin. If you talk to other people you learn things. If you don't, you have to figure everything out yourself. Even after maturing from shyness to introversion, I tend not to ask questions or seek help. This may be one of the reasons that my science didn't really reach its peak until rather late.

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### Notes

1. [The Joseph Polchinski Company has since been renamed Polchinski Memorials, Inc.—Ed.]
2. [A picture of Joe's great-grandfather appears on the memorial website: <https://www.polchinskimemorials.com/about-us-3/>.—Ed.]
3. In retrospect, gravity could have been correct, depending on the context. Since gravity is the only force that is always additive, a large enough body of matter will attract with great strength. So in the extreme case, gravity does win.
4. I have just learned, from Wikipedia, that Richard Feynman was on the California State Curriculum Commission at just this time and was one of those to criticize the new math.

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# Memories of a Theoretical Physicist

A Journey across the Landscape of Strings, Black Holes,  
and the Multiverse

By: Joseph Polchinski

Edited by: Ahmed Almheiri

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