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Richard Feynman - Session I

March 4, 1966

Interviewed by: Charles Weiner
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Abstract:

Interview covers the development of several branches of theoretical physics from the 1930s through the 1960s; the most extensive discussions deal with topics in quantum electrodynamics, nuclear physics as it relates to fission technology, meson field theory, superfluidity and other properties of liquid helium, beta decay and the Universal Fermi Interaction, with particular emphasis on Feynman's work in the reformulation of quantum electrodynamic field equations. Early life in Brooklyn, New York; high school; undergraduate studies at Massachusetts Institute of Technology; learning the theory of relativity and quantum mechanics on his own. To Princeton University (John A. Wheeler), 1939; serious preoccupation with problem of self-energy of electron and other problems of quantum field theory; work on uranium isotope separation; Ph.D., 1942. Atomic bomb project, Los Alamos (Hans Bethe, Niels Bohr, Enrico Fermi); test explosion at Alamagordo. After World War II teaches mathematical physics at Cornell University; fundamental ideas in quantum electrodynamics crystalize; publishes "A Space-Time View," 1948; Shelter Island Conference (Lamb shift); Poconos Conferences; relations with Julian Schwinger and Shin'ichiro Tomonaga; nature and quality of scientific education in Latin America; industry and science policies. To California Institute of Technology, 1951; problems associated with the nature of superfluid helium; work on the Lamb shift (Bethe, Michel Baranger); work on the law of beta decay and violation of parity (Murray Gell-Mann); biological studies; philosophy of scientific discovery; Geneva Conference on the Peaceful Uses of Atomic Energy; masers (Robert Hellwarth, Frank Lee Vernon, Jr.), 1957; Solvay Conference, 1961. Appraisal of current state of quantum electrodynamics; opinion of the National Academy of Science; Nobel Prize, 1965.

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Part I: The Early Years

Weiner:

This is a tape-recorded interview with Professor Richard Feynman, in his home in Altadena, California, on March 4, 1966. Charles Weiner will occasionally interrupt with questions. Let's start at the beginning.

Feynman:

You start by interrupting me with a question.

Weiner:

That's right. It saves interruption later. Let's talk about the earliest recollections you have of your family, your neighborhood and your home.

Feynman:

Nothing scientific, just a simple —? I don't know what to say. That's a hard one. I have lots of recollections, little bits and pieces.

Weiner:

Let me ask where you lived in Far Rockaway, was this —?

Feynman:

I was born somewhere in New York, but I don't remember anything except Far Rockaway, and then we went for some time, I remember, to a house in a place called Baldwin, on Long Island, where I think we lived a year or a half a year or a summer. And then, sometime after Far Rockaway, we went to live in Cedarhurst, but then by that time I was nine or eleven. Then we came back to Far Rockaway again. That gives an outline of where things were.

Weiner:

When you have recollections of Far Rockaway, what sort of a neighborhood was it?

Feynman:

There were these two periods, the first and the second. The first time I can't remember very well at all. I remember moving to the house. We walked along. It was a big house. We lived there with my cousins, a cousin family, I mean — my mother's sisters. The two families lived together in a big, rather large house, with a big garden. We had a couple, a man and a woman, who took care of it. I can't remember which period exactly. But the first time — my earliest recollection is of moving to that house from somewhere unknown, where my cousin was in a baby carriage, so I couldn't have been more than five. Therefore it was the first time, and we were moving, so I remember it. The road, the sidewalk — there was nothing. It was mud, it was dirt.

Weiner:

Was this near the beach?

Feynman:

About two miles from the beach. We used to go to the beach very often.

Weiner:

What was your father's occupation?

Feynman:

My father had different jobs and different occupations. The earliest — he apparently wasn't too successful, I suppose. I don't know. I mean in the beginning. The ones I remember are, for a while he sold "Whiz," which was some kind of stuff for automobiles, accessories. We had the garage full of Whiz of different kinds — like Simonize. Then he was in the cleaning business. He had a cleaning chain called Sanis Cleaners, New York, which he had with a man whose name was Brockman. (I'm beginning to remember that.) But the two of them had been partners earlier in a real estate business that didn't work out, until a third man, Paul, I think his name was, was brought in who was clever enough to first oust my father and then his partner. So he got put out of his tree. And then he went into the uniform business.

Weiner:

On the cleaning business, you mean this was dry cleaning stores?

Feynman:

Dry cleaning stores, yes. He told me, but I don't remember that he was the first dollar cleaners. But I don't know.

Weiner:

This would put it, by the way, in the twenties some time.

Feynman:

Probably. I can't swear by the dates. I'm rather confused, after that he worked for a uniform company, as a sales manager of a uniform outfit called Wender and Goldstein, which was a big uniform company. And there I would say he was successful, because he was in the uniform business from then on. I remember most of the time his being in that business. But now that you ask me, I remember all these other businesses.

Weiner:

What was his educational background, do you recall?

Feynman:

I don't know it too well. I understand that he went to high school all right. He lived in Patchogue. He apparently had been taught by his father and also by some special tutors from time to time that his father got for him. He presumably went through regular high school. He went to a kind of medical school, the Homeopathic Institute or something. It's a strange kind of medicine. But as far as I know the story, which I don't know very well, he didn't have much money so he lived in a house where people were very poor, and he got involved trying to help them, and upset. So for one reason or another he stopped his medical school education.

Weiner:

I see. Where was he born, do you recall?

Feynman:

Probably in Patchogue. No — he was born in Minsk. At five he came over to the United States with his father and mother. Then he lived in a town, Patchogue, in Long Island. It's out on Long Island.

Weiner:

I know where that is, it's near Brookhaven.

Feynman:

Yes.

Weiner:

And your mother?

Feynman:

My mother comes from a family which was originally German, but which have been here — her parents came at a young age. Her father was a very successful business in that business. In fact, he was called the "Father of the trimmed hat business."

Weiner:

What was her maiden name?

Feynman:

Phillips. Her father's name Henry Phillips, and her name was Lucille.

Weiner:

And what was your father's first name?

Feynman:

Melville.

Weiner:

So she was born in this country, and she lived…?

Feynman:

Yes. She had a fine education. She was a relatively successful man's daughter. She went to the Ethical Culture School, which apparently had considerable influence on her.

Weiner:

In New York? Manhattan?

Feynman:

Yes. That's right.

Weiner:

And did she go to college?

Feynman:

No. That's as far as she went. No, she didn't go to college.

Weiner:

So if I interpreted correctly what you said about your father, he didn't?

Feynman:

I don't think he ever successfully went to college. However, he did teach himself a great deal. He read a lot and he studied a lot, because, as I know now, he understood a great deal about science, by teaching himself or by learning from his father or from other people. He was rational. He liked the rational mind, and liked those things which could be understood by thinking.

Weiner:

When you say he was interested in science, or knew about it, in what way was this expressed?

Feynman:

As far as I'm concerned? Well, these two stories are rumors, as far as I'm concerned, but the story is that before I was born he told my mother: "If it's a boy, he'll be a scientist." But you'll have to talk to my mother to verify this. I don't know if I got the story right.

Weiner:

Is your mother alive?

Feynman:

Yes. She lives in Pasadena. No, my father's dead.

Weiner:

When did he die?

Feynman:

1948, probably — l948, probably — 1948, 1947, 1949, something like that.

Weiner:

After that your mother moved to Pasadena?

Feynman:

Quite a bit after that. She lived in New York a while. She's only been here about seven, eight years. Anyway, he said that to my mother, before I was born. And he played a lot with me. I mean, we had a very good relationship. We fooled around a lot. He'd tell me about things all the time. And the other rumor, which I can't exactly remember, is that when I was very small, he went to a company that made bathroom tiles and got a lot of old extra tiles, you know, and then he would stand them up on my high chair, on end, in a long row — as you do with dominos. Then when we'd get all ready, I would be allowed to push it at the end, and the whole pile would go over. We'd play this game. But you'd have to verify it with my mother, of course, because I don't remember exactly. But he would then take a game. He'd say, "Now we put a white one, now a blue one, now a white one, now a blue one." Sometimes I'd want to put two blue ones together and he'd say, "No, no, must be a white one now." My mothered tell me that she would say, "Now let the boy put a blue one." He'd say, "No, we have to get him to understand patterns." This was the only thing I could do at this age, to think about patterns and recognize those things as being interesting. After a short time with this game, I could do extremely elaborate patterns. I mean, once I paid attention — two blues, a white, a brown, two whites, to two blues, a white — and so on. So he started in as early as he could with what he said was a kind of mathematics, sort of the shadow of mathematics. He was always playing games and telling me things, which he realized were scientific, bearing relation to science.

Weiner:

This pattern recognition training, you say, was in your high chair, so this was very young?

Feynman:

Very young, so it's not in my memory. It's been told to me. But then there was something else that I do remember, because when I got into kindergarten, which is of course much later, six years old, they had a thing in those days which was weaving, so called. They had a kind of colored paper, square paper, with about quarter inch slots made parallel, a quarter inch wide, and then quarter inch strips of paper. See, one was the

woof, and the other was — whatever it is, warp. You're supposed to weave it and made designs. You see? That was regular and interesting. Apparently that's extremely difficult for a child, and I was especially commented on. The teacher was very excited and surprised. I had no difficulty. I made elaborate patterns correctly by doing this thing, without any difficulty, whereas it was so difficult for most other children that they don't do that in kindergarten any more. So apparently I had learned something already, back then.

Weiner:

Did you do any drawing in this period? Do you remember any?

Feynman:

No, I was no good at drawing, ever. I don't think I was. My father was fairly good at it, and he would try to show me some things with drawing, much later. I don't know the dates, but I remember him explaining to me how to make letters by dark on the one side — the light comes from one side. You know, like sign letters, or they looked like the gold letters that they used to glue up against the butcher stores. If you just imagined that there was a strip of letter there, and just colored it on one side, from the way the light would have caught it, it gives that effect. And so on. He'd show me tricks in drawing, but I wasn't ever very adept at drawing. I didn't pick that up.

Weiner:

Let me ask at this point whether there were any brothers or sisters in the family?

Feynman:

There was a sister. There was a brother that came after approximately three years. Or maybe I was five, four, six, three, I don't remember. But that brother died, after a relatively short time, like a month or so. I can still remember that, so I can't have been too young, because I can remember especially that the brother had a finger bleeding all the time. That's what happened — it was some kind of disease that didn't heal. And also, asking the nurse how they knew whether it was a boy or a girl, and being taught: it's by the shape of the ear — and thinking that that's rather strange. There's so much difference in the world between men and women that they should bother to make any difference, a boy from a girl, with just the shape of the ear! It didn't sound like a sensible thing. Now, I remember that I had another, a sister, when I was nine years old, so it's possible that I'm remembering my question at the age of nine or ten, and not at the age of the other child, because it sounds incredible to me now that I would have had such a deep thought about society at the earlier age. I don't know. I can't tell you what age I was, but I remember that, because it was an interesting answer. I couldn't understand it

really. They make such a fuss — everybody dresses differently; they go to so much trouble, their hair different — just because the ear shape is different? What sort of an answer is that?

Weiner:

There was a nine year difference, then, between you and your sister.

Feynman:

Yes, then my sister came later, when I was nine years old.

Weiner:

I see. Any other brothers or sisters?

Feynman:

No. No. But we lived in this house where there were cousins, and we lived together, so it was very much as if it was brothers and sisters.

Weiner:

How many children in the cousins' family?

Feynman:

There was one three years younger than I, a girl, and a boy three years older than I. We played together.

Weiner:

How long did this go on, living with the cousins?

Feynman:

Well, I don't know. Did I live with the cousins before? Yes. First there was a period when we lived together in this house when I was young, for a few years. Then when I was maybe ten, we went to this town of Cedarhurst, where we lived separately for a while, till I was probably eleven. Maybe we were there two years or possibly three. Then we went back to Far Rockaway again, and again lived with the same cousins, and that was for a rather long period.

Weiner:

Did you remain in that same house during this period?

Feynman:

I can't tell you. I don't think so. I don't know.

Weiner:

Do you know the relationship with the cousins? Were they first cousins?

Feynman:

Yes, first cousins, the children of my mother's sister.

Weiner:

I see. Do you remember what the father of that family did for a living?

Feynman:

He had a man. What did he do for a living at that time, the father? I don't know. He worked in a shirt business for a while. My knowledge now is that the situation in the family was that my mother's sister was a very superior woman, full of intellect, liked plays and reading, and that she married a man whom she thought was of her intellectual height, you know, and so on. But he was a rather dullish, uninteresting, not very able man. So rather than his developing for her a fine home, with the finances and so on, they had troubles, and he had always relatively mundane jobs in shirt factories, or maybe as head of shipping in a shirt business or something of this kind. So there was a certain problem there. I think both of the mother's married — didn't have too good financial luck. The husbands weren't as successful businessmen as the father had been.

Weiner:

That perhaps explains the family set-up.

Feynman:

It does explain why they lived together, definitely. You see, the house was left by the father of the two girls, my mother and my aunt, as part of his estate. Oh, in the first period, he lived there, and so did the mother of the girls. My grandfather and grandmother lived there. My grandfather used to sit me on his lap and give me half a dollar every once in a while. I remember now. And then he died. Then the grandmother

was still there, and she was ill always. She'd lie always on a couch, around, until she died. So that was the first period in that house. Now I remember.

Weiner:

I see. Then you're saying that the grandparents and the two daughters, with their families, at one period lived there together.

Feynman:

That's right.

Weiner:

It must have been a big house.

Feynman:

It was a very big house. Yes. And there were maid's rooms upstairs and so on.

Weiner:

Were there maids?

Feynman:

Yes, there were maids, in the kitchen. And then later on, when — in the later period there was a couple who lived there, who took care of the house, when I was nine or ten. The second period. Let's give these things two names, the first and second period, because there was an interval in between.

Weiner:

There were four children in the house, then.

Feynman:

Yes. Possibly more. Possibly. My memory is not good. There were other cousins, which possibly lived there part of the time. Because I remember them as fairly close for some interval, but I don't know. That would be earlier. The later period was definitely just the two families.

Weiner:

What about books around the house? Your father had these interests. Did he have books at home?

Feynman:

There were books. My father had books. He didn't have scientific books in the conventional sense. He would have books of the kind — not this book, I'm making it up, but something like DEVILS, DRUGS AND DOCTORS, or MEN, MEDICINE and — something. You know this kind of thing. That level of books. In the second period, at the age of about eleven or twelve, something like that, I found, up in the attic, an algebra book that my mother or my aunt had had in school, and I started to work from that. So there were books. It was possible. Why was I interested in algebra?

Weiner:

Yes, why did you use that book?

Feynman:

I don't know, but see, I was interested in the mathematics and the science earlier. I've missed the — the timing has got shot now, because we're talking about books. But my father, you see, interested me in patterns at the very beginning, and then later in things, like we would turn over stones and watch the ants carry the little white babies down deeper into the holes. We would look at worms. All the time playing — when we'd go for walks, we'd look at things all the time, and then he'd tell me about things of every kind. The stars, the bugs, geometry things, and so on. He was always telling me interesting things — the way birds fly, the way ocean waves work, or something, you see, the weather. I don't know why, any more, but there was always talking about the world, from every angle. Not just mathematics or anything like that, but the whole business he was interested in, and he was always telling me things. So he therefore developed somehow, inside me, more or less naturally, an interest in anything rational and scientific. So I knew, by the time I was being put to bed at night (because I'd been pretty good at arithmetic by this time, you see, and I'd heard about algebra), I asked him what was algebra? He said that it had to do with doing problems. This I remember exactly: "It's a way of doing problems that you can't do in arithmetic." I said, "Like what?" He said, "Like a house and a garage rent for $15.00. How much does the garage rent for?" I said, "But you can't do that at all!" He left me with that answer. He didn't tell me what algebra was. But that's the kind of relation. So I knew that algebra was something interesting, and therefore, I was somewhat frustrated in discovering what it was. I'm sure that it would be perfectly natural, if I found a book marked algebra, to become quite interested in what the heck it is, you see. I don't know what I did with that book. I mean, I can't remember finding the book. I probably got it at too early an age. I can't remember what I did with it.

Weiner:

Did you go on any trips during that second period?

Feynman:

No, we didn't travel much. In the summer we would go to the beach.

Weiner:

That was, of course, nearby.

Feynman:

Yes. That's right. We didn't travel much. I think we weren't too well off. In fact, I know at that period my father was making $5000 a year, because he let me take the check to the bank, and it was about $100 a week. So I used to take the check to the bank.

Weiner:

This is the twenties? That second period puts you in the twenties?

Feynman:

The thirties, something. I was twelve or thirteen. 1931, 1932. It's in the thirties.

Weiner:

In the Depression period.

Feynman:

Yes. That's right. He was in trouble. That's why we probably moved back there. There was probably trouble between the two families, a little bit. I guess. I don't know. It's circumstantial. And then they moved back because of still higher financial difficulties and it was the only solution. I can't tell you, but it sounds logical now. I never felt poor. I never felt poor. I never felt anything. In fact, I remember distinctly, when I was going to the bank — you see, it was very good. My father knew how to teach me. He said, "You take the check to the bank." This way I knew how much money was what. And I remember thinking to myself that that's a very nice amount that everything was all right, we lived fine, and that my ambition would be to earn that much money. So I knew I wanted about $5000. That's all I needed. It's interesting — I remember these things, now

that you ask me to tell about it, I recall all these little dopey things!

Weiner:

They all fit together. Did you ever get into Manhattan to do anything in the city?

Feynman:

Yes. My father would often take me, for instance, to the museum. The Museum of Natural History was a great place. We would go look at the dinosaur bones and all this stuff, you know. It was great. See, I can remember — I remember my father talking, talking, and talking. When you go into the museum, for example, there are great rocks which have long cuts, grooves, in them, from the glacier. I remember, the first time there, when he stopped there and explained to me about the ice moving and grinding. I can hear his voice, practically. That's the kind of thing he would do: he would explain all this stuff, you know — that this ice moves; it looks solid, but it moves, with this tremendous weight and all this height, gradually, year by year, an inch every year, grinding and pushing — and so on. He described vividly what was going on. That's the kind of thing. Not just "This is glacier cracks," you see — quite different. I mean, the ice had to be felt, as you saw the top of it. Then he would tell me, "How do you think we know that there were glaciers all over the world at a certain time?" See, after we would look at it, he would say things like that -– "How do you think anybody knows that there were glaciers in the past?" So I said maybe — I don't know, I don't remember exactly. But this is the kind of thing he would say when we were all finished, and then either I would be clever enough to say, "Well, that's the way we…" or I would say, "I don't know." He'd point out, "Look at that. These rocks are found in New York. And so there must have been ice in New York." He understood. A thing that was very important about my father was not the facts but the process, the meaning of everything, how we find out, what is the consequence of finding out such a rock—with a vivid description of the ice, which was probably not exactly right. Perhaps the speed was not an inch a year but ten feet a year. I never knew. He never knew. But he would describe anyway, in a vivid way, and then always with some kind of lesson about it like, "How do you think we ever find these things out?" And there, of course, was standing if front of me, the method. But that's the kind of guy he was. So it's not hard to understand I've been interested in science. It was very good.

Weiner:

Was this a sort of regular thing, or was it spontaneous?

Feynman:

No, it wasn't regular. I don't think it was regular, but it was fairly often.

Weiner:

And you still think here we're talking about the same period, about aged 12 or 13?

Feynman:

Yes.

Weiner:

Before high school?

Feynman:

Oh yes, definitely before high school. Definitely. Earlier, probably. Probably quite early — probably very early. Probably he took me to the museum when I was quite small, and then at other times. I know that my cousin — another cousin — not the one we lived with—lived in New York, and invited me to New York at one point when I was a young kid maybe twelve, I don't know. She's six years older. Something like that. And she invited me to New York. It's a famous family joke, you know — she thought she'd show me New York and the buildings and everything else, and as soon as I got there she said to me, "What would you like to see?" "I want to go to the museum!" was my answer. And so she had a dull day, what she called a dull day, taking this young squirt through the museum. But that was what I thought New York was. The only thing that was good in New York. Because I'd always gone to the museum when I went to New York, and I loved the museum.

Weiner:

"New York is the Museum of Natural History surrounded by water."

Feynman:

Exactly. Yes. Right. Right.

Weiner:

When you went, did you ever go with your sister? She was younger, of course.

Feynman:

She was nine years younger, and she was too young.

Weiner:

That's right. How about the cousins.

Feynman:

She may have come. No. No.

Weiner:

So it was just a father-son thing.

Feynman:

It was our family. The science didn't spread to the other family, but it did go into the sister. The sister is now a Ph.D. in physics.

Weiner:

Your younger sister?

Feynman:

Yes.

Weiner:

Where did she did get her Ph.D.?

Feynman:

She got it at Syracuse University. She got her BS at Oberlin, Ohio. Now she's working for Ames Research in — space, something.

Weiner:

Is she married?

Feynman:

Yes.

Weiner:

What is her name?

Feynman:

Joan Feynman — Joan Hirschberg.

Weiner:

That's very interesting. Evidently your father's influence spread.

Feynman:

She said that it was because she would overhear us talking, and then she would ask me things, and I would explain it to her. That's what she says. It wasn't so direct in her case.

Weiner:

What about school in that period? How'd you do in school? Do you have any recollections of it? This is pre-high school?

Feynman:

I recollect that I was fairly good in school, that I was also a good boy, except for some minor traumatic experiences and difficulties. I was always very upset if something went bad, if I was bad about something. I always tried to be a good boy. That's discipline. Also, I was fairly good in school, definitely above average, but in arithmetic it was very easy. It was too easy. For instance, when I was ten or eleven I was called one day from the class to a previous class that I'd been in, by a previous teacher, to explain to the class how to do subtraction. I had invented (they claim) a better way of doing subtraction than they were using, that she liked. She'd forgotten it in the meantime, and I was called from my class to explain it to them. Everybody says I invented, but I don't believe it. I believe what happened was that I learned that method of subtraction in the Far Rockaway School, and that in the Cedarhurst School they used a different scheme which was less efficient. It corresponded to crossing numbers out and reducing them out by one. I had a way of carrying the little one that you had to subtract, much as you carry in addition; whereas they would reduce the upper number by one, I would increase the lower number by one, when you had to subtract. And probably I learned that in the other school. But at any rate, I was already known as some kind of a whiz at arithmetic, in grade school.

Weiner:

And did your grades reflect this?

Feynman:

I think so. Of course, in arithmetic they probably reflected it very well. I think in arithmetic there was no question. But in the other subjects, I was pretty good but I didn't really like them too well. I probably was average or a little, you know, above average — 80 percent or something. Satisfactory in everything else, but very good in arithmetic. Not extremely good in everything else, no.

Weiner:

Were your teachers in arithmetic women teachers?

Feynman:

Yes, usually. In the later part, when I got back to Far Rockaway and I was [inaudible] arithmetic and so on, I had taught myself enough algebra — I'm just trying to remember, I'll never get the timing right or the order right — but back in the school, probably near the last grades, I had learned how to solve simultaneous equations, linear equations, like two equations with two unknowns, and I made up a problem with four equations and four unknowns. I made up a set of four equations, in A, B, C, and D, to solve. But I made them up — I know I did — I picked numbers for A, B, C, and D, and I made up equations with were right for those numbers, so I knew the answer. But that wasn't it — I took these equations and then I went through a formal procedure for solving them. You eliminate A, or whatever I did, I don't remember, but then you get three equations, three unknowns, and you get two equations, two equations, and you get one equation, one unknown, and there you are. Then I'd get one variable. But, in other words, I made up a problem and then wrote the whole formal solution, but I made up the problem so the answers would be integers, and not just arbitrary, and I gave it in to the teacher of arithmetic in the grammar school. She thought it was so impressive, but she didn't really know much about it, (they don't know much in grammar school) that she took it to the principal, who apparently did still remember a little algebra, who went over it and said it was correct, and signed her name and complimented me for doing that, being able to do that. I remember doing that. That's just to give you some idea.

Weiner:

Why did you do it?

Feynman:

Probably, at that time, to show off. I mean, I don't know, but presumably to show off. I don't know exactly.

Weiner:

Was it a home?

Feynman:

Yes, of course.

Weiner:

Not part of a homework thing?

Feynman:

No, it had nothing to do with the school.

Weiner:

Did you show it to your father?

Feynman:

I don't think so. I don't know whether my father would have been able to follow it. By this time I had taught myself something, about mathematics. He knew the ideas of mathematics, but I don't think he formally could do the things so well. I'm not sure whether he would have been able to do that, or whether I showed it to him. I just remember this. I also remember, near the end of school, when I was in the last grade, being curious about how you take square roots, and asking a teacher who was not a woman teacher, but a man — that's why I remember this — how you take square roots. He was pretty good. He taught science also. He was not really good, but —. He looked it up in a book, how to take square roots. He'd forgotten. He knew, numerically. Then he showed us the rules. And he was always throwing the bull. He was the biggest liar in the world. So he starts out to show us this rule. For instance, he says, you have 116, now you take the 1, take the square root, then you cut off two numbers — and he did it hesitantly enough, because he didn't know it very well. Then he told about doubling what you got, and dividing into that — oh yes, and then you have to add the squares here, and all this kind of crazy rules, if you know the rules. A friend of mine — I had a friend, who asked him, and he showed us, and it came out right. And we were sure that it was a fake that he had just fiddled around to make it work as he went along, because it was so crazy. So we went home and we fiddled to try to find out if it really worked. And sure enough, it really worked. We didn't trust it, when he told us the way of doing it. By that time I had a friend, by the way, who was as interested in science as I was, and we did much together. That was about twelve. Second period. Then we did lots of stuff together. We studied

together; we argued together, we did chemistry experiments.

Weiner:

Do you remember his name?

Feynman:

Bernard Walker.

Weiner:

What happened to him?

Feynman:

He got into business, so to speak — a sort of semi-engineering business, and now is completely business.

Weiner:

Did he follow through on the technical or scientific education?

Feynman:

No. I think it was family influences, the importance of money and business, so that be became more a salesman than an honest scientific man. A mixture. At first he had developed a process for metal-plating plastics, and done some research to develop it. Later, I got a job with him, from 1939, probably.

Weiner:

Metaplast Corporation?

Feynman:

Metaplast Corporation, right. I worked there. Let me tell you about that later, perhaps. But anyhow, that was his intermediate stage, when he was still partly connected. Since then he's gone entirely into business.

Weiner:

Did he stay with you through high school?

Feynman:

No. No, he was not in high school with me. It was grammar school.

Weiner:

Do you have any other recollections of that period? Do you think of anything else that may be significant?

Feynman:

Quite a bit, yes. In the first place, I remember, in the period between when I was in Cedarhurst—this has to do with science, now; there's lots of stuff, it's infinite — but when I was in Cedarhurst, the first time I came there, I had to meet the new boys. You know, you move, and you have to get along with the new boys — you know. I had a thing that they had never seen, which I had discovered by accident. The clothesline of the day, if you light it and then blow it out, smolders red like the end of a cigarette, and it goes on and on. So I used to use it as a clock, to know when to come home, by marking it off in ink. And I carried this thing around. When I got to Cedarhurst I still was doing this particular dopey thing, and the kids saw this thing, and they said, "Oh, that's a great idea." And they all had them, which they used to burn each other, and this kind of shocked me and disturbed me. It was the beginning of the whole thing, you know. But I remember distinctly being upset by the fact that they didn't use the thing in a good way, but they were using it, not the way I meant, see. Incidentally, I discovered also about that time that the device was not as good as I thought, because I put it on my bicycle and drove around, and because of the air blowing on it, it burned too fast. So I discovered a fault in the design of this clock! Anyway, at that period I was very interested in science, during the period when I was at Cedarhurst, which was nine, ten, eleven. I really developed a lot of science. I did lots of experiments. I remember bottles of water with oil would separate — dumb things, you know, just looking. Then later I gradually began to do experiments. I had chemistry sets. Also I acquired a friend whose name was Leonard Mortner at Cedarhurst, whom I've known for rest of life. Accidents were such that we were always together. He lives out here now and I see him once in a while. He's an engineer. He taught me things that I didn't know, and probably the other way around. He taught for the first time, really, about atoms. My fathered probably told me a few times but I didn't remember. He explained to me about water — you can keep breaking it up and breaking it up and breaking it up, and at last, if you break it at the last, to the end — I said, "Why not?" He said, "Well, it turns out there are little particles." I remember him telling me about atoms, so I learned. And then he knew about chemicals enough to know. You see, we had a chemistry set. There'd be a little box full of what might be calcium oxide. Then you'd see in the catalog — you get such a box, costs 10 cents — he'd discover that calcium oxide is the same stuff that they use in mortar for buildings, you know, lime. So we would go in the night and sneak and get a bottle, a

mayonnaise jug, full of that stuff, which was at least worth a few dollars, you see. So I had a chemistry set which had a lot of little boxes, and then big bottles of calcium oxide, borax, and other things which he had found out from his brother were common objects. (I'm just trying to remember things). I also was interested at that time in electrical things. I bought a pair of earphones from some man, to do some experiments. They didn't work, the earphones, and so I took them apart, and saw the reams of wire. You know, it was a kind of child, not really — ruining sometimes, and fooling around sometimes, and sometimes making something. I remember other things, as long as we're talking about it. I remember, at one point, I got in my mouth one of those chemicals from the chemistry set. And I was horrified. Might be poison, you know. Whereas my friend Leonard said to me, "Don't worry. Probably tastes a little sour and salty, doesn't it?" I was amazed at his brilliance, because that's exactly how it did taste. It was sodium hypo-something. Hyposulfite. It was in fact partly acid and partly salt. He knew that all salts taste salty, but I didn't know it. You see, I thought salt that you had on the table tasted some way, and that the other salts didn't necessarily taste the same. But he knew enough. Apparently he knew quite a good deal.

Weiner:

Was he older than you or the same age?

Feynman:

He was not much older, if he was older.

Weiner:

But he wasn't in the same grade in school?

Feynman:

No, there was one year's difference between us.

Weiner:

So you knew him from the neighborhood rather than as a classmate?

Feynman:

Yes. Anyway, in that period I was acquiring a great deal of scientific knowledge of a childish kind. My father bought me a telescope, and I played with that, made tricks with lenses and images, and little fooling's-around. Then there was an experience in which science came in, in a funny way. I was not good in athletics. This always bothered me

when I was a kid. I felt like I was a sissy. I couldn't play baseball, which was to me, at this childish age, a very serious business. I had trouble learning to ride a bicycle. I'd sort of cry because I couldn't do it, you know. Then finally I could do it. I was a rather weakish sort of a child. That's also important, because I was worried when I went to the new neighborhood, whether I would be accepted by the kids. So that I remember — that burning thing was important, that they liked it and they used it, so I was in, for a while. Every once in a while I would get kicked out of the group. We had a hut, for instance—there was a little group — and I'd get kicked out for something. But each time I'd get kicked out for something, I'd invent something to get back in—like a periscope for the hut, or a design for a second story, or something. Anyhow, to get back to the other story, I would go to school, and at some period some bullies began to have fun. When I would come into the play yard, they'd hit me, knock me over. One would stand behind me, say, "What are you doing here today?" — poom, you know. And I didn't know how to handle it. I couldn't handle it. It was really quite a miserable and unhappy experience. But about that time, approximately that time, I overheard some kids talking as we were going into the school, older kids from a higher grade, and one was saying to the other, "Rust? Rust is iron chloride." Well, it was natural for me to realize that what wrong right away, and say, "No, excuse me, rust is iron oxide. Oxygen comes from the air and it mixes with the iron and it makes iron oxide." These kids eyes popped out and they asked me a lot of other questions. They were seniors, you know, in a higher grade. So the next time I came into the courtyard and these guys started to fool around, these other fellows came over and stopped them, and said, "No, we want to talk to him," and so on. They talked to me quite a bit, and they would talk to me quite a bit. You know, I was competent, with their science. Actually I was probably making it easy for them to pass the questions. But they got interested in me, and that stopped the other guys, and everything was all right after that.

Weiner:

Was this a junior high school?

Feynman:

No, this was grammar school. It was sixth, seventh grade, something — no, fifth year. Fifth year.

Weiner:

They were probably in their eighth?

Feynman:

Sixth, seventh, probably, yes. I was in the fifth. I was in the third, fourth and fifth in that school. There are a lot of things. Let me tell more, now I remember. When I was in

arithmetic class, we were learning for the first time presumably — I think for the first time — decimal fractions, and we had problems. One of the problems was 3 1/8. I wrote 3.125. Then it hit some chord in memory and I wrote "equals pi, equals circumference, ratio of circumference is equal to diameter of a circle." The teacher came by and looked at this and crossed it out, and said, "No, pi is 3.1416." I remember that. My father taught me about pi before I had learned in the school the decimals for fractions, and explained decimals. See, I was really ahead in arithmetic. I remember him telling me about pi as a great and marvelous mystery. Everything was always dramatic — that all circles have the same ratio of the distance around to the distance across, and that this number, this strange number, is of very great significance, and is a marvelous number. So pi was like in gold letters, you see. So I thought I'd hit pi again at last, in the school, when I saw the decimal, but it wasn't quite right. I just say these things to give you some idea of the relationship of what I knew from the home to what was going on in the school.

Weiner:

And in the neighborhood, as a matter of fact. You managed to relate it to that.

Feynman:

Yeah. Yeah.

Weiner:

The Cedarhurst period, then, seems to have been a very fruitful period.

Feynman:

Yeah, that is when I really began to change. I had had a chemistry set even earlier, when I was in Far Rockaway, in another house which I have forgotten now. My father gave it to me for a birthday present, or somebody gave it to me for a present — the earliest one. What happened to the earliest one was, it was too early. I played around with a little bit, and a lot of the kids from the neighborhood came, and I showed them the chemistry set. They were big boys, and they took the thing outside, while I stood more or less helplessly by, and they mixed everything with everything else and poured it on the sidewalk and tried to put a match to it. I stood far back, because I was afraid it would explode. It was full of water, of course, it wouldn't explode. But I still remember that it was brownish and made bubbles, when you mixed everything together. But that was not the way I thought to do things. This, to me, was a kind of destruction. This was not the thing that a chemistry set was good for. You see, I never played that way. I never played chaotically with scientific things. I realized that their real value was in doing something carefully and watching what happened, and it was real pleasure. It was worth it. And this

other stuff was just a terrible, silly way to behave. But anyway, I was too young then to want another set or to do anything with it. In those days I just played. But in Cedarhurst is when consciously the science really developed, until I was doing a lot of things.

Weiner:

You didn't mind playing with someone else if he would take the same approach.

Feynman:

That's right, of course, like Mortner, for example, yes, sure. We played a lot together.

Weiner:

Before you got to high school, let's take a bit more of that period.

Feynman:

All right. Let's put us back in the house in Far Rockaway, the second time. By this time, having had this Cedarhurst experience, it was not long after I was in that house that I got a laboratory in my room. I had had, in the basement of the other house, a sort of lab, here I tasted the chemicals and—oh yes, we also played a trick on my mother there. We put sodium ferrocyanide — sodium ferrocyanide? — or something, in the towels, and another substance, an iron salt, probably alum, in the soap. When they come together, they make blue ink. So we were supposed to fool my mother, you see. She would wash her hands, and then when she dried them, her hands would turn blue. But we didn't think the towel would turn blue. This was all in the Cedarhurst era. Anyway, she was horrified. The screams of "My good linen towels!" But she was always cooperative. She never was afraid of those experiments. The bridge people, the bridge partners, would tell her, "How can you let the child have a laboratory?" This was later, too. And so on –- "And blow up the house!" — and all this kind of talk. She just said, "It's worth it." I mean, "It's worth the risk." She understood that it was worthwhile. She didn't like it that we ruined her good towels, at all. But we tried to get the stain out, we boiled them, we did everything. It just turned yellow from iron oxide.

Weiner:

Then she encouraged your father's help to you, too.

Feynman:

Oh, yes. Oh, yes. OK, I'm supposed to get back into the house in Far Rockaway, second time? All right? So now, I'm getting a real laboratory, a better one, in my room. My

father got an old packing case from a radio, a big thing about five feet long and three feet high. I started actually by making things out of erector set motors and so on, and playing. He had said to me, "Electrochemistry is a new field, very important field, so what's electrochemistry? It's the action of electricity on chemicals." I still remember. See, I loved my father. Everything he told me was great. I still remember having a little pile of some chemical; I can't remember what, from a chemistry set, and taking the two wires from the electric plug and putting them into the dry chemical. Nothing whatever happened. But that was my first to discover what electrochemistry was — see; because he'd told me it was a big deal. See, that kind of stuff. Anyhow, we got this laboratory, from these beginnings, which were on the floor — junk was piling up, and then when we got this lab, we put everything in it. I had this laboratory for years, even when I was in high school. I kept it. We moved it and everything. In that house, I was still not in high school, but I was developing electrical interests. Crystal sets — I had a crystal set in the house that I'd used to listen all night to "The Shadow," and ENO Effervescent Salts were being sold on the radio, and all this kind of stuff. Then, by buying in rummage sales, I would gradually get one tube sets and things like that, which I would fix, and connect the battery that I had — this old storage battery.

Weiner:

How'd you know how to fix them?

Feynman:

I don't know how I learned all this. It's probable that what happened is — you see, they probably were not broken, in. an unobvious way. They were probably broken by, when you look inside there's a wire hanging off here, there's a connection. It began that way, you see, and then as you got deeper in it, you got more and more involved, and you learned more about it, you see. That's the way the thing is. At the beginning I would fix, if I could, simple things in a simple way, and so on. I'd be very excited if it would work. Then I would try to get distant radio stations with this thing, and sit up all night, and have speakers and electrical things. Then also, I guess I did — it was electrochemistry — I found out that if you put the 110 volt line through an electric light bulb, so you don't blow a fuse, through water, it would boil the water. Oh, we used to develop pictures in those days, too, in our basement.

Weiner:

Who's "we" in this case?

Feynman:

You know, the cousins, and so on. We developed pictures. I remember using the developing trays, which were waxed, so that they were insulated, putting water in them,

and boiling it — and watching the most beautiful phenomenon at the end, when all the water boils away, and the last bit of water, it's dry, is making sparks, because it's breaking the circuit. And the sparks move around, because it breaks here, but the water flows, you see, and it flows here and connects, and then it makes another spark here, and finally, these lines of salt, and beautiful yellow and blue sparks! It's a very beautiful thing. In fact, now that you remind me, I think I'll have to set one up and see what it looks like, after all these years. I used to boil water all the time with this thing.

Weiner:

Did you enjoy working with your hands?

Feynman:

Yes. I did like this laboratory very much. I worked all the time. I connected the whole house up with wires to my lab, so that I could plug in with my earphones to my radio upstairs, anywhere in the house. Then I used that system in many ways. I would also pipe power down, and you could put a loudspeaker somewhere in the house, and go upstairs and broadcast from it, and all this kind of stuff. I found a way to connect into the radio, and so on. I was really learning — I mean, I'd begun to know something already.

Weiner:

We're now in Far Rockaway. How did this relate to the science courses you took in school?

Feynman:

They weren't related yet. When we did finally get a science course in school, which was in the eighth grade, I was considerably beyond the course. In fact, I had lots of trouble, because I remember, my friend and I — the man drew on the blackboard (I still remember, you know, he's going to explain how a projection system works, you know, the projector that makes pictures on the wall) — so he drew a light bulb, and he draws a lens and so on to explain. Then he draws lines coming out of the light bulb parallel, the rays of light going parallel to each other. So, I don't remember whether it was I or my friend, but one of us said, "But that can't be right. The rays come out from the filament radially, in all directions." I don't know if I used the word "radially," but anyway, we explained. He turned around and said, "I say they go parallel, so they go parallel!" Well, this didn't sit well with us, because I knew, certainly, that no matter what he said, the rays didn't go parallel. But that was the level of the class. We were ahead of it, and we knew the errors in everything that was taught. I never learned anything in the class, except that a meter was 39.37.

Weiner:

You remember that?

Feynman:

Yes. He was extremely good at teaching memory. He had a little side course in which he taught memory. He had a clever little sub-thing; I remember distinctly, because he said, "Now we're going to remember how many centimeters in a meter." You see? He said, "Now, a number is hard to remember, ta-ta-ta" — he would explain something. It was Public School No. 39, so that helped with the first two digits, and I don't remember the rules for the second digits, but I remember 39.37 was the number.

Weiner:

39 was the number of the school, you remember?

Feynman:

That's right. It helped to remember the 39, you see, so you could remember that easily. I don't remember how we remembered the 37, on top of that, after the 39, but he had some gimmick.

Weiner:

Do you recall how you reacted to that course? I think right here you're demonstrating that you have a magnificent memory. This could be through association and through other things.

Feynman:

Of course. The man himself as apparently — as I look now, with older eyes, I can interpret — but the man at that time was a sort of a heavyish, loud, kind of difficult fellow, but he had interesting things about memory. Because for a child, even if it's wrong, it's fascinating. I mean, he can make it interesting. So he was an interesting character. But we had to call him Major Connolly, because he had been a major in the First World War, and so he still had his title, you know. So we called him Major Connolly, without it bothering us any, because we didn't make any significance of it, but it was important to him, apparently. He did try to teach this thing. Nobody — you see, the thing is, you have to realize, it's an actual desert. The school is absolutely empty. Look, that little thing in arithmetic, four equations, four unknowns — the principal had to look at it. Nobody knew anything. And he knew more than anybody, but not much, see. But the thing is, he was a liar. He would tell stories about when he was in the war. He was in an airplane, and he helped the man invent the machine gun which shot

between the propeller blades as the blade went around, because first they used to shoot the propellers off. And he was in the plane when they were making tests, and something went wrong, and they shot the propeller off, and as he was coming down, the wing fell off, and all kinds of stuff, he would say. I don't know whether, at the time, I believed it or didn't believe it. He was difficult. One had to be careful with him. He wouldn't tell you anything right. I knew that.

Weiner:

You knew it at the time.

Feynman:

Yeah, I knew it at the time, because the scientific things, they were cockeyed. And also the stories were often incredible. Incredible. Amusing but incredible stories about his exploits in the war — he was such an important character, he was always in the forefront of everything, a very important development, like the machine gun. And then to save himself, after all the terrible things that happened to the airplane! It was impossible. Shouldn't we have some coffee?

Weiner:

I'd like to — it's very interesting, just the one final point — you had confidence that you knew —

Feynman:

— why don't we talk while we have the coffee?

Weiner:

All right. You had confidence in what you knew, at that stage.

Feynman:

Oh, yeah. Oh yes.

Weiner:

Was this self-conscious confidence? Did you realize that that's what you had?

Feynman:

No. You see, it was confidence because, it was true. I can't explain it to you. It wasn't that I knew that I was smart. It was just that — you see, scientific things are rationally right. It isn't as if I had learned history, and someone would then tell me that the fact I had memorized was wrong, and I would have confidence because I knew I'd looked it up in the book. But the fact that the light had to come from the filament radially, it never even seemed to me as a fact that I had to learn. It seemed to me, from my other knowledge, sort of obvious. How the hell can it come out parallel? There isn't any filament up there, you see; the filament's all here. I don't know if you can understand it.

Weiner:

I do, I do.

Feynman:

The thing was not a matter of confidence in knowledge, but simply an understanding of the world, a world view by which this was evidently false. That's all.

Weiner:

But you can relate it to other things.

Feynman:

It wasn't a matter of confidence. It was just a matter that this was obviously cockeyed. I can't explain it to you. It just seems to me it was wrong, it was clearly wrong. See, I'd already got the idea of what I look at, what I see. That was certainly brought in from my father directly — that things I see, the things that are seen, or the things that even are not seen, but if you look at it very carefully — that that's the way to know what's right, and that many people have said things, without looking, that were wrong, because they didn't look. That aspect was vital, of course, to science. And that I knew. I knew that people, authorities, often stated things that weren't true, because they didn't know, and they would just say it. So this was just one of those things to me — I mean, somebody claiming he knew this, and he had to say it. I knew what he was worried about, I'm sure. I mean, I can't remember for sure my feelings, but I believe I knew, that I had the feeling, and my friend had the feeling, that he was just upset because in front of the whole class we caught him, and he probably would even have to admit that he — If he didn't want to try to defend himself, he would have admitted. It was obviously right. I think we both understood that he was defending himself against criticism, by just simply saying, "It's true." I'm not sure, but I believe that.

Weiner:

That's a mature attitude, but not too mature for the age.

Feynman:

There were two of us, and we would talk about it.

Weiner:

That was the extent of the science, then, in the grade school, just one course?

Feynman:

Yes, it was one big general science course.

Weiner:

Was it a year or a semester?

Feynman:

No, no, it was just one day a week — the science class. The girls didn't go to it. The girls had some other thing. We had shop and science, and they had cooking and maybe dressmaking or something, sewing or something. It was one of these small bits of science. Oh, there's a very important thing I forgot to tell you. I was going on about the last year, approximately the last year in the grammar school. I had gotten pretty good, see. I mean, I'd done these things and I was very interested, and I knew a lot about things. My dentist was to me the scientist in the town — that is, the professional man, who had something to do with science, you understand. So I looked at him as though he were a scientist, because I knew no better. I would talk to my dentist about many things. I would get a rash on my face or something, or some tooth thing. I would ask details, and he would give me details, tell me all about how the teeth worked and how the rash worked, as much as he knew, and he was a source of information in science. Because I asked so many questions, he realized I was quite interested, and so on, and he had, as a patient, a teacher in the high school. He told the teacher in the high school about this kid. So the teacher in high school, whose name was William LeSeur, said, "Let him come around after school one day a week to the chemistry laboratory where I teach and he can play around and so on" — you know, in the laboratory. Help out. Assistant. "Lab assistant, while we clean up," and so on. So I used to go once a week to the high school in which Mr. LeSeur taught. Also another man who was there, Johnson, took a great interest in me — particularly Mr. Johnson — and let me have things to play with and do experiments. You know, he'd teach me stuff, we'd do some experiments, I'd clean up apparatus, and we'd talk about how things worked. I learned a great deal there. This was while I was still in grammar school.

Weiner:

How long did that go on?

Feynman:

Well, during the whole time — probably about nearly a year or maybe it was a half a year.

Weiner:

Your last year in grammar school.

Feynman:

Yeah. I remember that just suddenly, because I remember, in my other science class, with Major Connolly, I gave a demonstration of electrolysis to the kids, for which I borrowed electrolysis apparatus from the high school, and carried it through the streets on my bicycle. I thought it was the most expensive, remarkable piece of apparatus. Did you ever see them? It was the standard equipment, like a big H, you know, with graduated things and two stop-cocks — yeah. And then with platinum electrodes in the bottom. That, to me, was — ooh! — very valuable and marvelous. I carried it as best I could through the streets on my bicycle, and took it to make the demonstration. But I pushed the cork up, that held the electrodes, too hard, and broke the glass. I was terrified and upset by this. This I remember very distinctly—it was very serious. I tried to wax it closed. It was leaking while the demonstration was going on. When I took it back to the guys in the high school, I was rather upset, unhappy — I thought it was so valuable. But they didn't seem to think it was so bad. It was all right. You know, those things happen. And so nothing bad happened to me.

Weiner:

Did you consult with Mr. Johnson and Mr. LeSeur? I mean, did you have an opportunity to discuss specific problems? Did they try to interest you in new things?

Feynman:

Well, we talked about all kinds of things that would come up. They'd be talking to each other and I'd overhear. Or, I'd ask those questions that they may or may not be able to answer. I remember one particular question — it's the only one I remember, because they didn't give me a satisfactory answer. Or maybe they did. Anyway, I remember the question. "If everything is made out of atoms, and they're always jiggling and moving about, how is it that something that you find that's very old — like, you make a screw, now, and you leave it alone a long time, it still has the sharp corners of the screw. Or you

make sharp things. How do the sharp things stay sharp for all this period of time, if the atoms are always jiggling?" In answer they told me about the fusion of metals, that if you put gold and silver together there is a gradual mixing. But I didn't feel that that was an answer. I mean, that's the kind — of level at which the whole thing was. I would ask questions. They would answer something, and so on. I was learning a lot. I can't remember specifically what. I certainly learned a great deal. I saw apparatus, I did experiments —

Weiner:

— apparatus in that environment, a laboratory environment, rather than in your own home-made one.

Feynman:

Yeah. Also, I made a discovery, accidentally, by the seventh grade of school, the last but one. One day I was playing with my various pieces of equipment. I had a microphone, I had loudspeakers. I'd go to more junk and rummage sales and get junk. I had a loudspeaker that had no tube just the unit. I also had earphones. I had this system, connecting all over the house. I would try the earphones around and the speakers and so on. I had them both connected into a double plug, like the one over there — I mean, two-way plug. I was going to plug into the line, to listen, but I had them both connected. So therefore they were connected together. All right? Now, while I had my earphones on, I had my finger accidentally poking in the hole of the loudspeaker and jiggling, touching it, making a noise — and I heard the noise in the speaker. You see, the loudspeaker had a permanent magnet; when I shook the thing, I generated a current. So I had a telephone. I mean, I discovered that I could hear that. I'd discovered a kind of microphone. I hadn't had a microphone a before. I made all kinds of experiments. I would talk from upstairs to downstairs and so on. I remember this particularly, because in the history class we were learning about the telephone, and I said I'd give a demonstration of the telephone. So I got a long vacuum cleaner cord and two plugs on each end, and plugged my loudspeaker to one end, to talk into, and the earphones at the other end. I went out of the room, you know, and had the wire running under the door, and listened, and somebody said something, and I came in and told them what they said. It was mine, I'd invented it, see? But I know now, as a matter of fact, that that was the design of the first kind of telephone.

Weiner:

The Bell one.

Feynman:

Yeah. Yeah. That's the way it was in fact. If I had known that (I didn't know that) I

would have been even better in my history class, because I explained that my telephone was not really the right kind. I knew that it wasn't. But I didn't know that it was in fact historically the right kind.

Weiner:

In a couple of cases, you volunteered, then, to do extra things, demonstrations?

Feynman:

Well, that was probably the result of the teachers. You know how the teachers try to involve the children. They would say, "Now, you have projects for this and that" — you know. I don't know how, whether I volunteered or — I can't remember, all I remember is doing it.

Weiner:

It was not at all unusual?

Feynman:

No, I don't think so, there were different —

Weiner:

— other children would bring in something?

Feynman:

I think so. In the same period, before I got to high school, when I was in this Far Rockaway house, my cousin, who was three years older, had gotten to high school and was studying algebra. And he came home — see, he had a great opportunity, he could study algebra. So he came home, and he wasn't very good. Or maybe he wasn't so bad, but anyway his mother always thought the poor boy needed help. She probably overdid it. But anyway, the algebra was a terrible business, and so she tried to help him with the algebra. I remember the first day when he came home and he had this algebra business, and his mother was trying to help him. I sat quietly on the porch where they were talking about it, listening with all ears, trying to understand it. After his mother went in for some reason or other, I said to my cousin, "What is this algebra? What does it mean, that X? What does it mean 2X plus 3 equals 12 —?" No, let me make a good problem, 11 –- "2X plus 3 equals 11, what does it mean?" He'd say, "X is some number that you don't know, and 2 times the number plus 3 equals 11." I said, "You mean the number's 4?" He said, "Sure it's 4, but you did it by arithmetic. You have to do it by algebra." I've always

pitied the poor fellow. I don't know what my reaction was at that time. But whatever way I did it, I wouldn't give a damn — I know I didn't care — to find out what way you had to do it, because it seemed to me, if I did it, I did it. But he was forced in the school to have to try to find a mystic way to do it, which I now know what it is. The mystic way is to write underneath, "Minus 3 equals minus 3" — we add, you know — or 3 equals 3 — we subtract — because equals subtracted from equals are equal, and then — And all this formal business: that way, he was getting thrown off the wagon, because he understood as much as I did on Page 1, which was X with some number and you have to find out what it was. But he was terrible in algebra and flunked most of the time, because there's something the matter with that. I'd learned already something about education, because I tutored later, and to make sure that the idea of the subject was clear, and not to get mixed up with the formalities. I learned that from my cousin's difficulties. But I also learned what algebra was like, that X would represent a number, and that it was not so hard. That was my beginning with algebra, which ultimately led to the four equations, four unknowns business — you had to find four numbers, you see. But I got started with it, and then I began to do the formalities, but I understood it. Anyway, I got interesting in that. But another thing — because of his difficulties, he had a tutor who came, whose name was Maskett. He's now at the University of Virginia — Al Maskett — something like that — Albert? He came to tutor my cousin. I, of course, was the young boy fascinated with mathematics, so I was permitted to sit and listen the first time. Just to listen. Not to say anything. Then after the class, I talked to this fellow Maskett a little bit, and he became very interested in me and helped me a great deal. What I talked to him about was the following. I can remember it now, I can almost see it. I had discovered a formula for doing the following problem. Suppose you want to add 1 plus 2 plus 3 plus 4 and so on — I don't know why, but suppose, you know, up to some number. I had discovered that with the odd numbers, a certain rule worked — like 1 plus 2 plus 3 is 6, 1 plus 2 plus 3 plus 4 plus 5 is 15 — I guess the rule was, you multiply the number, the odd number, by half of one more than the odd number. Something like that. Some rule. Then, at even numbers, I tried to find the rule, and I eventually found the rule for even numbers. So I remember going around — I still remember –- "Suppose," I would say to my friends, "suppose a theater has a new idea. Instead of charging a definite amount for a movie, it charged" — because I always wanted to make application of these –- "1 penny for the first person who comes, you see, so everybody comes quick, and then the next person who has to pay 2 cents, the next one 3 cents, and so on and so on, until 100 people come. Now, how much money will they collect? In the movie, from this?" So they would sit, you know, and — that was my machine. I could do it, you see. Well, I showed this to Mr. Maskett the first time, and he showed me that the two rules which I had could be made into 1 — you multiply the number by one more than the number and then divide by 2. I'd had to have two rules. I was very excited by this. But he was excited, apparently — I mean, I would judge — from the fact that this little boy had cooked this thing up. So he was always interested in me, and he would tell me little things and help me along — like that, the formulae could be made one, and so on. He kept encouraging me in various ways to discover things. So I had lots of good contacts. Now, you asked me some time ago, before we recorded when I began to feel

original — when I began to feel disconnected from — I don't know what you called it, the umbilical cord, or something. But you see, from the beginning I was disconnected. I was trying to find a formula for adding the integers together because I wanted the formula. I didn't care; it didn't mean anything to me, that this was worked out by the Greeks or even by the Babylonians in 2000 BC. This didn't interest me at all. It was my problem and I had fun out of it, you see. It was always that way. I was always playing my own independent game.

Weiner:

We're still talking about this earlier period.

Feynman:

Yeah. I think I've about exhausted it by now! Yeah.

Weiner:

You were still living —

Feynman:

— yes, in the same house.

Weiner:

Maybe now we should get on to the high school period, if you're ready? I'm not rushing you.

Feynman:

OK. I am ready. It's interesting, just to get the whole thing — you ready? Yeah. And then another tiny thing from that period — earlier, even — is that my father used to sit me on his lap, and the one book that we did use all the time was the ENCYCLOPEDIA BRITANNICA. He used to sit me on his lap when I was a kid and read out of the damned thing. There would be pictures of dinosaurs, and then he would read. He read the long words –- "the dinosaur" so and so "attains a length of so and so many feet and the head is so and so many feet," six feet wide or something. He would always stop and say, "You know what that means, 50 feet high and 6 feet wide, or 20 feet high and 6 feet wide?" "It means, if the dinosaur's standing in our front yard, and your bedroom window, you know, is on the second floor, you'd see out the window his head standing looking at you. That's what 20 feet is, because the height of one story's about 10 feet. Further. If he tries to put his head in the window, he just can't quite make it, has to

break the sides." I give this illustration because he would translate everything, and I learned to translate everything, so it's the same disease. When I read something, more or less, I always translate it as best I can into, what it really means, you see. So I learned that then. And the reason I remember this is because I had a friend who had an encyclopedia too — this guy Bernie Walker. He had a thing called THE BOOK OF KNOWLEDGE, which was designed more for children, better for children. I couldn't stand it. It was very poor. The facts were never sharp, you never were sure that — you know, you had to get the feeling of depth, honesty — I can't explain it to you. Maybe it's fixed a little bit to make it easier. You never felt right, you know. Furthermore, the thing that bothered me the most was the index. My father taught me how to use an index, and that doggoned index would have things under W — under W you'd have to look to find "What is a horse?" or "What is the history of the horse?" — under W! This I realized. I mention this because you were talking about the fact that I didn't respect authority. Not only that but I also realized that there were stupidities in the world, that people made dumb books. I'd already learned a lot by the time I was coming into high school of disrespect for authorities, for certain authors, for opinions of people. I knew the world was a dopey place, and that there were only a limited amount of people who had this rational—you know, like the NEW YORK TIMES was a good newspaper, the encyclopedia was —

Weiner:

— what paper did you read in your house?

Feynman:

I don't think I read. My father read the TIMES. That's probably why I knew it was a good paper. Then I went to high school. OK?

Weiner:

Yes. Let me ask at this point, when you were in grade school, did you view going to high school as a new, important stage?

Feynman:

Oh yes, sure. I mean, I was interested in learning, of course, and the high school was opportunity. After all, in high school the kids were learning algebra. I mean, you know, this same business — my cousin would have the opportunity. So, I went to high school. Also, I liked the high school. I knew some of the teachers, you remember, I went to the high school—because after all, they had all this apparatus, they had all these classes. It must have been great to be in high school.

Weiner:

Where was the high school located in relation to your home?

Feynman:

A mile away. We walked every day.

Weiner:

This was Far Rockaway High School? Was that the name of it?

Feynman:

Yes. So I went to high school.

Weiner:

Excuse me for another interruption. This would be in about 1931?

Feynman:

Just so. In the beginning, I discovered the algebra class was impossible for me. It was terribly boring.

Weiner:

In your freshman year?

Feynman:

Well, yeah, because I'd learned the algebra. After all, I was doing four equations, four unknowns, and all kinds of wild things, and they were learning X plus 2 equals 6, and subtracting 2 from each side. I could see the answers before they wrote the equations. It was just terrible. I stood this for an entire semester, half a year nearly, because I was a very timid boy. I didn't just run up and say, "Look, I know all this stuff." But ultimately I was essentially forced into it. I said to the teacher, "It's horrible, I'm not learning anything," and so on — or maybe she even suggested it — I can't tell you now, but anyhow, I was sent — I think partly on my own power, that I had enough nerve to say something — I was sent to the head of mathematics called Dean Ogsberry, who was called the Iron Duke, because he was also the disciplinarian, so it was in some awe and fear that I went to his office. He was a very difficult fellow, in a certain way, — really very kindly, but the boys all thought the other way. But he had to be a disciplinarian. So I went in and I told him my problem. "Oh," he said, "you find the algebra too easy, do you? All right. I'll give you a problem. You sit over there and solve it. When you've

finished solving it, I'll look it over, and I'll decide what we can do." He gave me a problem. He made it up, you know, simplify something complicated and solve for X and some fraction. Well, the darned thing went up to a quadratic equation. I didn't know how to solve quadratic equations, and I kept doing everything under the sun — divide X, put on the other side — all kinds of things. I couldn't figure out how to solve the darned thing, and I was going around in circles, and sweat was pouring out. He said, "Take your time," and all this kind of stuff. I remember it. It was very dramatic, you know. Somebody else was in the office and they said, "Don't listen to us, just go ahead, work, take your time." But taking any time didn't make any difference. I was going around in circles. I couldn't get out the number from the quadratic equation, even by trial and error, because it wasn't one that came out X equals 2. In fact, I realize now he'd simply written some complicated expression with Xs in it, to find X, and it wasn't from a textbook, and it didn't come out easy, and I couldn't do it by trial and error, and I couldn't get it. So he looked at the papers, which were all scrawled all over, you know, up and down, upside down, everything turned inside out. He looked the whole thing over. I was sure I was going to get sent back to Grade 1, but he said, "No, you can go into the Second Grade." He'd probably seen that some of the steps were all right, that I was just stuck in one place, which it turned out is true. The quadratic equations were only in the second year. Anyway, he sent me into another class which was called 2X — not the regular 2 — which was for people who'd flunked math 2 the second year, and had a special teacher known as Battleship Moore, who was especially good with students that weren't very good. So I was put into this class. They had had everything before, but anyway they'd been the lower end of the class. She was very good at teaching this. So I was in that class, and I learned stuff from her, because there were things that came up in that class that I didn't know, like quadratic equations. Some stuff I learned from her, but I quickly learned for myself, you know. I knew where the problems were. Then I would learn by myself. I also remember a thing that happened in that class. See, when I first went into that class I was, along with the others, a dumb one, like the others, because it was ahead of me, so to speak. But one day she writes equations on the board which is something like 2 to the X equals 32, 2 to the X power equals 32. What's X? Nobody can make head or tail of it, it's a new problem, and they haven't the slightest idea. I said, "X is 5." "How do you know?" "Well," I said, "32 is 2 times 2 is" — and so on – "so it has to be." The point is I understood what the problem meant, whereas the others didn't understand what the problem meant. And that's the real horror of teaching. You can teach all the formalities you like, but the unfortunate students never learn what the idea of it is, whereas if you understand the idea it's relatively easy, you don't need the formal things so much. Anyway, the fact that I was able to get X equals 5 out of that made all the other students partly angry, a little jealous, not really, probably — and a lot of them admiring. You know. And I became somebody in the class. They thought that I had learned it somewhere else and that even amazed me more, that they should think that you had to learn something like that in order to do it — you had to study it somewhere. It seemed to me obvious, you see. I began to learn about how the minds of other people work, and it was more surprise to me that they thought I had learned it somewhere, that they couldn't see, after I explained it to them, and then it was obvious. It's the same as

your question, how did I know, did I have confidence, and that the rays came out radially. It was sort of like, the facts of the world. It was almost evident that that's the only thing it could mean, you know.

Weiner:

This implies that you felt there was a certain structure to this knowledge.

Feynman:

I don't know. I can't say. It seems to me if you say 2 to the X equals 32, I know what it means. X always represents some number, so if the number happens to be up there as an exponent, does it make any difference? I mean, we knew about exponents. Does it make any difference the problem? It's 2 to the something is 32 — the [inaudible] of 32 is 2 to the 5th. I can't explain to you why. I never understood what the matter with everybody else was. I never really understood what the trouble was. The thing that bothered them was that this was an entirely new matter, and how could this fellow know it? Only by having studied it before. But to me it was not an entirely new matter at all; it was the same old principle. You use X for a number that you don't know, and the answer to, 2 to what power is 32 — It is not something I have to study before. I remember this distinctly, because it gave me a feeling of a difference between myself and the other students.

Weiner:

By this time, your friend wasn't with you in high school?

Feynman:

Yes, he was. Leonard. Not Bernard Walker, but Leonard Mortner had come from Cedarhurst and had moved to Far Rockaway, fortunately, and was with me in high school.

Weiner:

That's really coincidence, isn't it?

Feynman:

Yes, it is. Pure coincidence — ever since. He was at MIT with me. He's out here now. It's very interesting, a series of coincidence.

Weiner:

So you were with him in high school again.

Feynman:

Yes. Now, during the high school years, in the mathematical world, I had another few things. I wanted to learn calculus. I'd heard that calculus was big stuff, after algebra. I can't get the timing right. There's another thing in geometry that comes first. When we were first starting geometry — I don't remember; that must be the second year of high school, because I think you take algebra first — my friend and I, Mortner and I, went into the geometry class the first day or two. And we had heard — my father had told me — that it's impossible to trisect an angle. My father had first told me, it's impossible to trisect a triangle — that is, to find three pieces which are the same area as the original triangle, for an equilateral triangle, and I had done it. For a not equilateral triangle. I had figured it out. That's possible. But they weren't the same shape, and he said, "No, the problem's to make them the same shape, and they must be three triangles." But that seemed to me trivially obvious, that you can't put three triangles together to make a triangle, you see, so I knew that he didn't have it right, and I kind of pushed on him, and he remembered then that it was to trisect the angle. So he had taught me the problem, first incorrectly. So I told Mortner, or he told me, that it's impossible; so we decided we were going to try it after all. So we started to work on trisecting the angle. Well, we knew that bisecting the angle could be done by bisecting the cord that goes straight across, in the isosceles triangle. So, incorrectly, we supposed that the problem was to trisect that line across the face of the angle. We had converted to trisecting a line. OK? You understand?

Weiner:

Yes, I visualize this.

Feynman:

Yeah, but it isn't really true that if you trisect the straight line you really trisect the angle, but we didn't notice that. So we had converted the problem to trisecting a line. Then we started to work on it, and we played around and we played around, and we discovered, empirically, by drawing pictures, that an equilateral triangle, if you drew the three altitudes, that the point where they met, in the dead center of the equilateral triangle, is one-third the way up the altitude. It seemed like. So we made it very carefully, on a big piece of graph paper, a very careful equilateral triangle, measured it as accurately as we could, and sure enough, it's one-third of the way up. We couldn't prove it but we knew it was one-third of the way up. Therefore, we had the solution, provided that we could construct the equilateral triangle in the right place, so that this line would be the altitude, you see. So the problem was — we thought the problem was — to find an equilateral triangle, to put an equilateral triangle, at a given altitude. And that took us a day or two

to figure out. It's possible, of course. We finally got that. While we're getting it, we're thinking. We're riding around on our bicycles — boy, it'll be in the papers! You know, two high school students, hardly starting out geometry, solve the trisection of the angle! I remember riding our bicycles, as we were riding, we'd stop suddenly. You know, we were talking about it — we'd suddenly stop and get off and draw some pictures, and so on. A very exciting week. Then, I had this thing. I went home, and I was drawing it up — you know, making some constructions for angles, to look good. Then I said what about big obtuse angles? So I made a very obtuse angle, and I went through the whole construction on the paper, and looked at the angles, and it was very poor. Then I suddenly realized — horror of horrors!— that we hadn't trisected the angle at all. But of course we had learned a lot of geometry.

Weiner:

These expectations of the newspaper headlines —

Feynman:

Yes, that's always with me. Whenever you do research, and got a partial solution, or think you're getting a solution — or get a partial solution, or think you're getting a solution — or at least, me — I always imagine a kind of a daydream, an exaggerated daydream, of the impression.

Weiner:

Upon what?

Feynman:

Well, colleagues, or something. That you write the paper in the PHYSICAL REVIEW, you see. Or you imagine that the paper — but the paper is very simple, you see. Or you imagine that the paper — but the paper is very simple, you see. For instance, we don't know why E squared over HC is 137, you know. So you daydream. "It is apparent that" — tatata, one paragraph of idea –- "so [garbled…] function we obtain" — tata! Just two paragraphs! Send it in to the PHYSICAL REVIEW. Great discovery! A dream. You know? Crazy dreams. Just daydreams. Not serious, just a fun idea, the same as the two kids and the newspaper. The very same idea. "Two children in high school first learning geometry solve the age-old problem of the trisection of the angle." But we didn't realize in fact at that time what a fantastic sensation it would have been!

Weiner:

That was your first day in class, when you walked into class, you mentioned the challenge that you felt for the geometry class.

Feynman:

Geometry. Yes. We knew that was geometry, and I knew that one of the great problems of geometry was trisecting an angle. So the heck with learning all these little bits and pieces, we would go ahead and do the big problem, you see! That's a way to learn, though — I'm telling you.

Weiner:

He was older than you. Were you in the same class?

Feynman:

Oh — no, I guess he was the same age, then.

Weiner:

Because we were trying to establish that earlier. We weren't quite sure.

Feynman:

He must have been the same age.

Weiner:

He was in the same class?

Feynman:

I'm sure he was. We did not have more knowledge of the subject than I did at that time. Definitely not.

Weiner:

It's possible you took the course later, in sequence —

Feynman:

— it must have been the same age. It must have been the same age, because I just know that he didn't know more than I did about it, or vice versa. We did it together. It was the same age.

Weiner:

What other mathematics did you have in high school?

Feynman:

Well, what I had in the classes — ultimately, through the whole high school, I took later solid geometry and trigonometry. In solid geometry was the first time I ever had any mathematical difficulties. I don't know why it was, but in the beginning the solid geometry class was complete and absolute chaos, and I couldn't understand anything. It was my only experience with how it must feel to the ordinary human being. Then I discovered what was wrong. The diagrams that were being drawn on the blackboard were three-dimensional, and I was thinking of them as plane diagrams, and I couldn't understand what the hell was going on. Suddenly I understood what was going on. Then it was child's play again. It was a mistake in orientation.

Weiner:

And in the question of your spatial perception, really.

Feynman:

No, I mean, once I understood it, it was easy. It was just that I didn't think there might be diagrams in three dimensions. Just crazy. In fact, it's dumb, because the subject was called solid geometry, but somehow or other I was trying to understand what he was talking about, when he would draw pictures, and I would see a parallelogram, and he called it a square, because it was tilted out of the plane, you know. And I -– "Oh God, this thing doesn't make any sense! What is he talking about?" I caught on after about two weeks, or three weeks, but it was terrifying, for a while. It was a terrifying experience. Butterflies in my stomach kind of feeling — here, this subject, completely un-understandable. And I'd never had any trouble with mathematics. This was terrifying. But it was just a dumb mistake. I suspect that this kind of a dumb mistake is very common, to people learning mathematics — that dumb mistake, the same kind of a mistake my cousin made — he understood the idea but he didn't understand the idea, and then, he doesn't know what he means, "to do it by algebra," and he can't ever understand the subject and always feels that there's a missing piece. But part of the missing understanding is to mistake what it is you're supposed to know.

Weiner:

Doesn't solid geometry imply the development of special perception — that is, to be able to see things in depth.

Feynman:

Well, you can. That wasn't my trouble. That's no trouble. I don't have any trouble —

Weiner:

— no, until you recognized —

Feynman:

I was misreading the diagrams, that's all. He would call a square — you draw a parallelogram on the blackboard and call it a square? OK. But I didn't understand what he means. It's a square out that way. It's not that I can't visualize, it's that I didn't know what he meant. I had no trouble visualizing. In fact, I'm good at it. In fact, I could almost visualize four dimensions. I can tell you properties of four dimensional geometry because I exercised for the purpose, to see if it was possible. I practiced, and I got some vague way of seeing, not very clearly, but usually can tell you things in four dimensions that are right, by a half-visualizing — very poor, very coarse, but not impossible. No, I had no trouble with special visualization. That wasn't the trouble. We also had trigonometry. But when I was in Miss Moore's 2X class, I got interested in calculus. As a matter of fact, I got interested in calculus earlier than that. A new set of books had come into the library, the public library. The public library had nothing. It had the ENCYCLOPEDIA BRITANNICA. It had a few books that were interesting — the ABC OF RELATIVITY. MATHEMATICAL PHILOSOPHY by Russell was the most wonderful book — it was deep — that I studied.

Weiner:

When did you read it?

Feynman:

In the high school era. Exactly when, I don't know. But then they got a series of books called ARITHMETIC FOR THE PRACTICAL MAN, which didn't interest me because it was insurance rates and so on — ALGEBRA FOR THE PRACTICAL MAN, which I read very easily — TRIGONOMETRY FOR THE PRACTICAL MAN, which I read through and then forgot. This was before I got to trigonometry in high school, long before, and I didn't find it useful or interesting. And CALCULUS FOR THE PRACTICAL MAN, which I also got. I remember this time, because I had to lie, and I was a very honest boy. I'd been trained to be very honest. But I went to take the calculus book out, and the teacher — sorry, the librarian — said, "Child, you can't take this book out. Why are you taking this book out?" I said, "It's for my father." And so I took it home, and I tried to learn a little bit. My father looked at the first few paragraphs and couldn't understand it, and this was rather a shock to me — a little bit of a shock, I

remember. It was the first time I realized that I could understand what he couldn't understand. I can't remember exactly now, but I did study calculus one time, and forgot the whole thing, I believe. But at least I studied trigonometry and definitely forgot the whole thing. But some time later, when I was inventing the solution of a certain kind of problem (dopey problem — problems of the kind you're given, that the hypothesis is a certain amount of more than the one side, you see and stuff of this kind — problems like you have a flagpole, how far out will the string be if you hold it taut? You see) — Incidentally, I remember now, everything I would do like this, I would always have a practical problem to exemplify it. I have always thought the thing was no good unless you could use it somehow. I realize now.

Weiner:

Would you try the practical problem?

Feynman:

I would use it to make up these problems, to illustrate the power of my inventions, you see. I'd invent a method of solving such a problem. Then I would illustrate it with practical problems which I would invent, like the flagpole and the string, see.

Weiner:

But you didn't feel the need to erect the flagpole and —

Feynman:

— oh no, no, no — I didn't mean that way. I meant I'd get examples from my mathematics. Anyhow, I was fiddling around with such theorems and developing a number of theorems about triangles of this kind. And I had known the definition of a sine, co-sine and tangent, from the old days. I discovered what corresponds to sine over co-sine is tangent. It's very simple. I also discovered, sine squared plus co-sine squared equals 1. I discovered again, you know. I didn't remember them. But what I did remember, that was trigonometry, was the relationship of the sine, co-sine, tangent, and there were things like cosecant, secant — I remembered that, and there were a lot of relations of some kind. Then there were things with double angles and sums of angles and everything else, all of which I couldn't remember, but I know what the subject was about, you see. So I started with sine, co-sine and tangent, found these relationships, and discovered that I could express each one in terms of the others, in terms of one another. I made a big table — how you express a tangent in terms of sine, or co-sine. See, I worked the tables out. Then I began to work with double angles and proving theories — that the sine of twice an angle is twice the sine times the co-sine. You might be amused at how I ever did that, but I did it, one way or another. I proved all the theories. I found the formula for sine of the sum of two angles and the co-sine, and all these things, and

all the trigonometry formulas, and developed them quite a bit. And each one had its own ingenious proof, which was personal and my own, because I've seen them, and some of them are very clever, much better than in the book. And some of them are also dumb. They go all around Robin Hood's barn to come around here. You can see a shortcut immediately, through here. But that was the character of it. I think I can find that notebook. I'll see if I can find that notebook.

Weiner:

That would be interesting. Were you aware that such tables existed?

Feynman:

Of course, I knew that in trigonometry, that this was the subject. But I was working it out for myself. I didn't care to know what the answer was; I wanted to see if I could do it. It was always the pleasure of doing it. In fact, after I had developed enough formulas for the sine of an angle, sine of a double angle, like five degrees, I could work out the sine and co-sine of 10 degrees and so on. I could make the whole table of sines, every five degrees. So I opened a book and picked up the sine of 5 degrees. I shouldn't have even had to do that, of course, but I did that. I remember the book. It had the sine of 5 degrees, and that was in a square. All the other numbers were worked out by calculations. So I was always interested in the power of the formulas, what they could really do. So I worked out the whole table of the sine. I had a table of sine, co-sine and tangents, in my notebook, worked out, that I worked out from knowing only the sine of 5 degrees. Just games.

Weiner:

This must have taken up quite a bit of time.

Feynman:

Oh, yes. I did a lot of playing around.

Weiner:

This was at home, and in your playing time.

Feynman:

Yes. So when I really got to trigonometry class, it was almost a waste of time. You see, most of the classes that I was in, I would only do the things just, you know, on the side. I didn't are. It was easy.

Weiner:

Well, did you get grades in them?

Feynman:

Oh yes, I got very good grades in them. But I already knew almost everything that was in the sciences and mathematics in my school. I never learned anything in the class — or practically nothing. The teacher of the trigonometry class was Mr. Ogsberry, and by this time I had met another man, whose name was Herbert Harris, who was very clever in mathematics, and we were friends there. Mr. Mortner had gone away, to some other place. Harris and I were in the trigonometry class. I believe Harris was a year older, but because I was good in arithmetic I was higher. Well, Mr. Ogsberry in the trigonometry class said — or maybe it was permutations and commutations — advanced algebra, we also had advanced algebra — in that class he said that he has two problems which from time to time he has given to students, and they have never solved them. This is his great challenge. He thinks that he would like to give them again. He'll give one, and if we solve it, he'll give the other. See? It was a big dramatic business. The first problem he gave was: you're given a parallelepiped, and the angles of the three faces, in the corner, the angles, the face angles, and the lengths of the three sides that make up the parallelepiped. I don't remember whether it was a parallelepiped or a tetrahedral. It was only a factor of three. Problem: what's the volume of the parallelepiped, in terms of these things? So we went home, and we worked for two or three weeks. We developed theorems. We worked together, developing theorems and methods and so on and gradually worked out a formula, the formula for the volume — which in fact is very beautiful. Its square root is beautifully symmetrical. It's the square root of a complicated thing, but it's beautifully symmetric, in the angles, alpha, beta, gamma, A, B, C. But our method was very unsymmetrical. We dropped perpendiculars, and we laid it out from one particular side, and did all kinds of things. Anyway, we worked it out, and we brought it in, and he was very impressed, and he gave us the other problem, which is to find the formula between — maybe he gave us both problems at the same time — to find the formula relating the dihedral angles in regular solids, to the number of the polygon and the number of sides of the polyhedron, or something. Then we worked that out too. As a matter of fact, we used much of the same theorems. And he was very impressed. Nobody had ever solved them before, and we had solved them. So that was a very exciting challenge. They were really good problems. They were good, substantial — I mean, it's not dishonest. For a kid in high school, they were really excellent challenges. They were very good challenges. It's not at all self-evident how to do it, and it was a real excitement to gradually work it out, to get closer and closer to working it out.

Weiner:

When you got the solution, which you now describe as beautiful in its symmetry, did you

think of it in those terms?

Feynman:

Oh, I think so. Oh, yes, because, you see, I think we were delighted with the answer. I don't remember.

Weiner:

Delighted with getting an answer —

Feynman:

— no. The answer. Because they were so kind of simple. I can't remember it now. I can work it out much quicker now. In fact, I did it the other day, when I was taking a shower, because I thought of that old problem. It was — oh, it must have been two or three years ago, when I was taking a shower. But now that I'm an advanced super-expert at mathematics, suppose I had to do that problem. In my head, in fifteen minutes, I worked it out. But I can't do it right now, in two minutes. It was beautiful in the sense of the symmetry, you see. The A, B, C, of the sides and the alpha, beta, gamma of the opposite angles. Actually it's not symmetrical. And we probably checked, because I was wise in those days, that when one of the angles was zero, it gives zero, and if two of the sine's, if all of the angles are right angles, it gives A, B, C, and other things like that. It's a kind of beautiful thing to be able to do all these things, you know? It looks symmetrical. I'm pretty sure that we appreciated the formula. The other one, I never appreciated as much. I remember at the time I didn't appreciate it, because it was given in terms of the number of sine's on the polygon and the number of polygons that meet at a point. And there's only five possible solids, so although it's given in terms of M and N, it's not really a general formula for any M and N, because the only values of M and N, there are only five of them, so you might as well have just worked out five angles, and list them. See, if hasn't got the beauty of the other thing. I remember that definitely, at the time. I didn't care for that problem because that was like asking for five angles, and who cares? Although it was expressed in terms of M and N, it looked quite general, but there's only five cases allowed, so the whole thing was kind of an unbeautiful thing. It wasn't general. What I mean, none of the angles for the cube and tetrahedron, and there's five or three others, and it's not very interesting.

Weiner:

So by this time you had developed some mathematical tests.

Feynman:

Apparently. What I'm telling you now is not what I feel now about the problems. I

remember definitely not liking the second problem, and thinking the first problem was a wonderful problem, and the second problem was not so wonderful. Not that it was easier, but I had a taste, as you say, as to what I liked. Yeah. I remember distinctly the idea, I discussed it with my friend, that there's only five numbers, and what the hell, there's five angles, you might as well work out each one separately and give the five angles in a list and you've done the whole problem. It isn't like an abstract formula, in terms of M and N.

Weiner:

By this time, here you are working out these problems, and it's apparent to you that you have special ability in this area. Had you any thoughts on what you might do with this, whether you wanted to —

Feynman:

I knew I'd be a scientist somehow.

Weiner:

You knew. What was the earliest you —?

Feynman:

I don't know. It was just sort of always that I wanted to do this, for the rest of my life.

Weiner:

Scientist in the general sense of scientist, or did you have any specific area that you —?

Feynman:

No, I had no idea particularly, because, you see, it was like this — like my father would come one day and tell me electrochemistry was the big and important thing, and I would have faith that I would be a great electrochemist. So I'd piddle around with the wires, with the salt, probably to find out what happened, and partly with the daydream that electrochemistry is the coming field. (It wasn't.) But that electrochemistry is the coming field, and that I'm going to be prepared for the coming field-half. And half the interest was this business. So it was always that way. I mean, when he would tell me something, there was always the feeling that this was part of me. Like a little boy wants to be a fireman — his father's a fireman. Although my father wasn't a scientist. No I guess it's not quite the same, but… Anyway, I can't remember distinctly a day when I ever said, "By golly, you know what I think I'll be?" I don't remember anything like that. Nor do I

remember, at that time, any consciousness that I ought to study this or I ought to study that in order to prepare myself for something. Whether there's more money in chemistry than there is in physics, or any such question. It never was a question how I would earn my $5000 a year. Not that I was confident that I would, but I would somehow or other work at that. It was much more important to do the science, somehow, than it was to choose such a thing. That I'm clear on. I mean, I know, it was not in high school career minded, in the sense of thinking of, where's the best opportunity? Not a whit of it. I was only interested in the stuff. When this man would give me this challenge, it wasn't because I was going to find out if I'm good enough to be a something or other. It was because it was a challenge, for its own sake — completely, always, for its own sake. It was the excitement, the fun, of working this thing out. A certain conceit, in showing off that you can do it, showing to other people as well as to yourself.

Weiner:

And you associated mathematics with science. This was part of science, as far as you're concerned.

Feynman:

Very definitely. Very definitely.

Weiner:

How did that come about, this association?

Feynman:

It came about this way. I had this laboratory, which. I told you about, when I was in grammar school, and by the time I was in high school I still had it, and it was developing further. And I would repair radios in the neighborhood, to make a little money, to get the money to buy junk for my laboratories. I had a photo-electric cell. I made amplifiers — not good ones. Nothing really worked well for me, but I struggled with it. I had lab banks and voltages and batteries and old radios and motors and so on. Electrical stuff. It had really developed from a chemistry laboratory to an electrical laboratory. Now, in this business, I had read in one of my friend's (Bernie Walker's) books, some years back — what year I can't remember exactly — he had one of these, BOOK OF KNOWLEDGE or some book. But there were a number of other books that interested me. It might be interesting. One of the books that interested me very much was a book called THE BOY SCIENTIST, by A. Frederick Commons, and it had a big circle in front, "Knowledge is Power." Then it had arches out which said, you know, "chemistry," "Electricity." I was very impressed with this whole business.

Weiner:

Was it a book from the library?

Feynman:

No, it was my own book somebody gave me. It had little experiments to do and so on. Then there was another book, THE BOY ELECTRICIAN that I got a hold of. It wasn't as good.

Weiner:

Was this during the high school period?

Feynman:

Earlier. Anyway, my friend had a book, and in that book it had a formula for the power that a resistance takes, and also the resistance voltage relation. The ohms are the volts divided by the amperes. The volts are the amperes times the ohms. The watts is the volts times the amperes. The watts are the amperes squared times the ohms, and so on. It has eight formulas or something. And I looked at them. I remember very well, this. I looked at them and I said, "You know, I think that these are many of them, really restatements of the others. They're not independent things." And so I began to piddle around to get the connections, and of course I knew enough mathematics to understand a little bit, but I'd never — you see, you have to learn someday, and it's not taught in school, that you can use X for the amps, you see. It's not taught well — the connection between mathematics and the use of the letters for some quantities in physics. I had to teach myself that, and that these relations were only mathematically interchangeable formulas. You could derive one from the other. So I got interested in the relation of the mathematics to the physics. Then, much later, when I was in high school, I found the formula for the frequency of an oscillating circuit in some book that I read. I was making oscillators and radio receivers and stuff. And it said "2 pi times the square root of LC." I remember this distinctly. And where did the "pi" come from? You see, I had been taught that pi was a golden circle. And here's a pi! Frequencies. See, the watts is the volts times the amps, that's a childishly simple formula. But the frequency — 2 pi times the square of LC — that bothered me. Where does the pi come from? And I worried about it. Then one day I realized that of course, the coils, the inductances, the coil's a circle. That's where the pi comes from. That's where to find it. Then, later, when I was looking at the formula for the inductance of a coil, one day, later, I found a pi in that. They had a list from some handbook — inductances of square coils, inductances of round coils. My mind got to work again. The inductances had nothing to do with the shape of the coils. A square coil could have an inductance too. Whatever the inductance is, the pi still comes. It fascinated me, this pi, and the relation of mathematics to physics, then. And so I got more and more interested in mathematics, but always with some relation to physics.

As far as I can tell, I still don't understand that pi! That beautiful pi — having to do with the relation of the slope of a sine wave and how long it takes to come back.

Weiner:

This ties in with what you said earlier about the — always trying to find an illustration of the mathematical formulation that you worked out; that really is the relationship of mathematics to physics.

Feynman:

Yeah, I'm always interested in the relationship, the practical business — that the thing does not mean anything really unless there's some way to make something go.

Weiner:

It's of a piece, then, the mathematics and the science.

Feynman:

Yes. Yes.

Weiner:

We're resuming now after a brief break for lunch. When we left off, we were in the high school period, Far Rockaway High School, discussing the mathematical learning there and some of the developments in your own thinking on that. Let's get on, now, to some of the science courses, and take it from there.

Feynman:

Well, the first science course I took I think was general science, meaning biology mostly. Or maybe it was called biology, I don't remember. I don't remember much of that, or finding it particularly exciting. I remember only some experiments in which egg white was dissolved in stomach enzymes, or whatever it was. It was interesting, because it always looked to me like egg white would never dissolve in anything, and to see it dissolve was interesting. But really it was not very interesting. The osmosis was an interesting process, the explanation of it in terms of the atoms, but the biology itself was not very interesting. That wasn't because I wasn't interested in living things, because my father had very much interested me in plants and animals and so on, and processes and life. But somehow the course never did anything. I don't remember much of it, so I might as well cancel it out. Then I took chemistry and physics, and in those courses I learned a little bit. But I knew a considerable amount, so I didn't learn much directly in

the course, in the normal fashion. But we had several things. We had, of course, clubs — Chemistry Club and Math Club and Physics Club and so on, where the kids would stay after school who were interested in these things, and work up demonstrations of something, and we'd give a little lecture to the other kids. It was always pretty good. It was good practice, I realize, now that I'm thinking about it. I made, I forget what, phosphine or phosgene — whichever is the one that isn't a poisonous gas.

Weiner:

Phosphine?

Feynman:

Phosphine, I guess, and it explodes and burns when it comes out into the air, and makes smoke rings and flame — a flame and a smoke ring — and I made that, for a demonstration. I'm just remembering now. A friend of mine, another friend I haven't mentioned, who was a year older than I was, named Elmer Heller, I remember, in the Physics Club gave a demonstration of the properties of sand, which I remember very well. It was a beautiful lecture—that at the angle of repose, if you make the same angle; by making such piles and looking at them, projecting one against the other, you see it's the same angle; that if you had sand in a bulb, a rubber balloon, with water, and squeezed it, the water would go down, not up. You can squeeze the balloon and the water goes down, because you disorganize the pattern of the sand in the water. It's sucked into the holes between the grains. A very nice lecture. This is the kind of thing that we would do in these clubs, and the way you'd learn something, either from the other fellow, about sand in this case, or yourself in preparing a lecture. And they were pretty good, I think, some of them. So that I did. In addition, there was a special class, with a teacher, Mr. Bater, in the physics class, who noticed that I was somehow unusual, and he said to me one day, when we were discussing index of refraction, and after class he called me aside and said, "Listen, you make too much noise in the class. You make a lot of trouble." I was feeling bad, and he said, "But I know why. It's because it's all so boring and uninteresting to you." You see, what would happen in the class is something like this. The fellow would start to explain something. He says, "Because the light is bent toward, away from the normal, as it goes into the glass." So the teacher said, "What?" And the guy would say, "It's bent toward the normal." I mean, it's just a silly game of trying to remember the rules. It was a boring business. Anyway, the teacher said, "I'll give you a book to read. You go up in the back of the room, in the corner, and you read it by yourself."

Weiner:

During class times?

Feynman:

Yes, during class time. "Pay no more attention to the class. When you know everything that's in that book, you can talk again." The class didn't fill the room, so way up in the back was separated. So I sat up there. He'd given me a book called ADVANCED CALCULUS, by Wood or Woods. It's not what they call advanced calculus today, it was more what we call mathematical methods, Fourier transforms and elliptic functions, that kind of stuff — gamma functions and so on. And that was very interesting. I worked very hard on that, and learned a great deal of mathematics in high school, of an advanced kind. I had to learn calculus in the meantime by myself. I forgot to tell you the details. I'd gotten a calculus book and read it and didn't understand it. Then later I got another calculus book. My father and I went to Macy's and he bought me a book, CALCULUS MADE EASY, and I took it home and studied it and wrote a notebook which I still have, and can give you, of this book, that tells me the stuff in it. That was a way to try to get it into my head this time, instead of forgetting it. So I had learned calculus.

Weiner:

When did you learn calculus?

Feynman:

Well, it must have been before the physics.

Weiner:

It was in the high school period?

Feynman:

Yes, but the physics was in the junior year, probably. I don't remember whether I learned this advanced calculus in senior or junior year. If I could find my record and find out — I have it here, high school — then I could find out what year we did all these things. It's easy to figure out. Anyway, I learned advanced calculus, what was called advanced calculus, the determinants, Fourier series and so on. I already knew something about Fourier series from the ENCYCLOPEDIA BRITANNICA. I struggled with every article in the encyclopedia that was scientific. I could understand everything except the article on gyroscopes and the article on group theory. I remember, because I know my challenges that were unsatisfied. The article on electrostatics gave me great difficulty, but by taking a notebook for yourself of what this is all about, and go through very slowly. I went through electrostatics several times, each time getting a little further, until I really understood it. But I don't know if I have that old notebook.

Weiner:

Was that before the physics class?

Feynman:

None of this — I can't remember. The physics class was essentially irrelevant. It was something that was in the — but the knowledge in the physics class itself was nil, for me. However, this teacher, Bater, also taught me something else. One day he told me he was going to tell me something very interesting, and he explained to me the principle of least action, in mechanics — that there was a number, the kinetic energy minus the potential energy, which, when averaged over the path, was least for the true path. This is philosophically a delightful thing. It's a different kind of way of expressing the laws, as you appreciate them. Instead of differential equations, it tells the property of the whole path. And this fascinated me. That was one of the greatest things ever. The rest of my life I've played with action, one way or another, in all my work. I mean, I find that I've loved that junk. I like it. But, I'd found also in the encyclopedia — you see, after that I'd found also in the ENCYCLOPEDIA BRITANNICA a statement that the laws of electricity are such that the potential is distributed so as to make the integral of energy a minimum. And I had proved — it wasn't in the book — I had proved from the formula that in fact you would get the differential equation of electricity from that. It wasn't there. It was stated, but it wasn't there. See, I was really learning. I was getting pretty good. I mean, not to be immodest, but relatively, I was getting more and more mature. I was learning rapidly in the normal order, from a childish fiddling with arithmetic, on and on to really doing real things, at a high level already in high school.

Weiner:

Then the advantage was the extracurricular work that Bater assigned.

Feynman:

He didn't assign. He just gave me a book to look at. You know, the real problem — you have to appreciate, really, all my time in these schools and around there — was the lack of supplies. Perhaps it was good, so that I had plenty of time to worry about elementary things before I was swamped by advanced things. I couldn't get books. The library had no calculus book. When they got it, it was within a week or two, I'm sure, that I took it out—the first guy to take it out. The first calculus book that was in town. I had a thirst, you see. I couldn't satisfy it. I'd heard about vector analysis, for example, and I didn't know what it was. I looked in the encyclopedia, and there wasn't enough there. But I knew it was something useful or important somehow. And Maskett, who by this time was getting his degree in mathematics at Columbia, wrote a thesis on vector analysis. He lent me a copy of his thesis on some subject in vector analysis, and I copied out of this thing another notebook for myself, on vector analysis, and learned, vector analysis from

that thesis. There was one part of the thesis that was some complicated business of transforming coordinate systems, that I didn't think was very important and left out. So when Maskett got his thesis back and asked what I thought of it -- "It was very good, and thank you very much, but the stuff about the transforming coordinates I didn't pay much attention to." He said, "That's what the thesis about. The rest was the introduction." But I somehow had always had a wit about what was the central and what was the peripheral matter — what are the complicated details that really are not necessary and not useful, and what were the great ideas on each subject. So when I read Maskett's thesis, I paid no attention to his reciprocal coordinate systems, which was interesting, but more advanced and not very vital, which he had contributed; whereas the description of vector analysis which was in there, I knew that was worthwhile.

Weiner:

You say you've always had this feeling about it. When was the earliest that you can recall?

Feynman:

That was a good example. Later, when I was at MIT, I would read books on fields that I didn't know, like general relativity and so on — or even in the encyclopedia, when I'd pull stuff out of the article — I seemed to have a sense to pull, in electrostatics, a lot of stuff, but when it went to the calculation of the capacitance of an elliptical condenser, which was quite complicated, it didn't bother me that I didn't understand it. I knew that was not so interesting as the general theorems about the laws of the inverse square, and, you know. I had some way of knowing what was important and what was not. The courses themselves, in the physics and chemistry, I don't remember being very intrigued by them. It was a little bit of work, like exercises, to do the things. They were not difficult, so I got very good grades. It just happens that yesterday I was reading about Einstein, who was an individual who didn't like the educational system and got through without it, and I was thinking to myself, well, I went through the educational system. He talks about how it stifles the young because they're so busy doing the work for the examinations and all that.

Weiner:

Are you talking about Martin Klein's article in PHYSICS TODAY?

Feynman:

I don't know, maybe I am. Yes, probably. I was thinking — you know, you always think, what about yourself? You know — I think that the answer in my particular case, that it is really also true, that the thing is stifling, but because of the accidents, starting with my father and so on, I had always been ahead enough that the labor of doing the ritual for the schools, working out, balancing the equation for potassium permanganate, or

whatever you have to do, was relatively easy, so I could do it so easily that it didn't disturb me, you see. I didn't work at it really. I just did it, you see. It was easy enough. And then I had time to play at a much higher level. I was always like that, through the rest of education, because you can see, learning advanced calculus in high school, and calculus, and so later when I got to college it's exactly the same situation. I'm always ahead, so that I don't learn too much in the courses, and I found it relatively easy to satisfy all the necessary requirements as I go along, without it being labor, without it being hard work that would take up a lot of my time. It was relatively easy. Then I had plenty of time to do other things.

Weiner:

You mentioned the physics and chemistry courses. Was it a year of each that you had?

Feynman:

I think it was, yes.

Weiner:

Did you have any contact again with Mr. Johnson and Mr. LeSeur?

Feynman:

Mr. Johnson was my chemistry teacher.

Weiner:

So you did see him again in that capacity. Your prior experience in the laboratory must have been helpful there.

Feynman:

Oh, sure it was, but it's helpful for a relatively trivial job. I mean, the classes, the courses, were nothing. They were just dopey. I mean, they were so simple. And it was always so slow, because everybody was such clunks about it that they would try to remember the laws, and if the guy would say, "What did you say?" then they would change it the other way, because they realized they were on the wrong track, not because they understood a thing. You know. It was a rather pitiful business altogether.

Weiner:

Getting back to Mr. Bater, and the least action principle, he explained it to you? Or did

he give you some other things to follow up on? Did he discuss it subsequently?

Feynman:

No. He just explained it to me once.

Weiner:

Did he give you any references to it, for reading?

Feynman:

No. I still remember — you know, a thing like that — whenever a thing is exciting — it's a funny thing, in the mind — you remember all the subsidiary things that have got nothing to do with it. Like, I know exactly where the blackboard was, in what well — it was in the laboratory — where he was standing, and where I was standing, and everything, while he was telling me this. It was after class, in the laboratory, in the room where the lab was.

Weiner:

It was his idea, to bring this up?

Feynman:

I can't remember how it was brought up, but he told me about this thing, and explained it, by drawing curves on the blackboard of the motion of the particle, and showing the two different curves, and the one that gives the least number is the right one. He just explained. He didn't prove anything, as far as I remember. I don't remember any complicated matter. No, he just explained that there is such a principle.

Weiner:

And your reaction to it was on reflection later?

Feynman:

Oh, I think I reacted right then and there, that this was a rather miraculous and marvelous thing — see, to express the laws in such an unusual fashion.

Weiner:

When was the next time that you dealt with it, when you had an opportunity to reflect

on it again and use it?

Feynman:

That I can't say. I remember that there was a statement of the minimum principle of electrostatics in the encyclopedia, and that I worked it out. Now, there was also, in the book on ADVANCED CALCULUS, a section on how to do minimum problems, so probably I realized that was very important, because it had to do with the least action — now that I'm thinking about it. For all I know, it may have been the other way. I mean I may have been looking at the section on minimum principles and said to Bater, "What the devil is this good for? I mean, you find the size of a circle — the circle's the shortest distance to carry a certain area? Or what?" I'm only imagining. Maybe. I don't know which came first, the chicken or the egg, but I do remember a connection between the theory of what they called the [inaudible] equations, or how to find the minimum curve for certain minimum problems, and the least action. I can't really analyze bits and pieces. It seems to me all the way through this thing, it isn't the question of learning anything precisely, like the minimum principle, but of learning that there's something exciting over there. So the next time, when you look at another book, and you see some partial recognition that this has got something to do with that — this minimum principle, I know it's got the figures in it, this has got to be good, this must be useful in mechanics, that's an interesting bit — I pay attention, see. And that is the key. The key was somehow to know what was important and what was not important, what was exciting, else I can't learn anything. And by having clues — you know, from somewhere — that what's good… I think that the same thing happened with my father. My father never really knew anything in detail, but would tell me what's interesting about the world, and where, if you look, you'll find still more interests, so that later I'd say, "Well, this is going to be good, I know — this has got something to do with this, which is hot stuff" — you know? Like, nobody knows how birds migrate, so this is something about birds' migration, so it's a real mystery, see. Because I know nobody knows how birds migrate, and they're still struggling with it. This kind of feeling of what was important. Or interesting.

Weiner:

Interesting because it's a challenge, and leads to —

Feynman:

Yeah. Yeah.

Weiner:

What else on the high school? If nothing else —

Feynman:

The only thing, the other thing I can remember, now that we're thinking about it, is that there was from time to time something like, "We should have a science assembly," in which we'd try to explain to the other children and make demonstrations of how good the science is. You would think that I would have been the one to be the leader in this, but I remember, although I tried setting up some experiments and fiddling around, I'd always end up not doing anything for the rest of society, so to speak, except in the clubs. But I remember setting up and worrying about something, but not really entering. See, if we had had — (we hadn't) — things like science fairs and so on, in those days, I doubt that I would have been a big thing at a science fair. In fact, there were a few, I remember now, visiting science fairs from somewhere — students doing science things. I didn't find it interesting to make a thing to take to some children's science demonstration or something, although I would visit them. I remember in particular right now visiting a science fair, going around and seeing a boy who had made alum crystals, beautiful octahedral, and had a big demonstration of it. Then I looked carefully at the octahedral, and there was something funny about the lines, the edge lines. They didn't fit with pattern of the direction of the crystal. I looked very closely, and I realized that it was painted wood. So I said to the boy, "Is this yours?" He said, "Yeah." I said, "But that's just painted wood." "Yeah, I know," he said, "but it looks good, makes a good demonstration." I was horrified. I was very much of an idealist and a purist and so on. I thought this was so scientific, anti-scientific — it was an evil thing, you know. It bothered the heck out of me. That's not why I wouldn't enter into those things, but this was an after — I just remember this. I did have a feeling of great respect for science, a love of it, and when somebody would fiddle with it like that, it hurt me. I was hurt by this, because he was trying to fool people.

Weiner:

You thought he should have grown the crystals.

Feynman:

If he didn't, he didn't — if he'd grown small crystals, then these were nice, this is the way it is. You see, the question is "What is it?" not "How wonderful is it!" You don't have to build it up. You don't have to fake it. It's great the way it is, is the sort of feeling. This is some kind of falseness, a terrible falseness. It just bothered me. But I just remember that when I'm thinking of — that they did have fairs, because I did see this there. I didn't enter into that kind of thing. I didn't make demonstrations for other students to watch, except in my own little club. And I didn't have any feeling that I should enter into some fairs and things like that.

Weiner:

What about external influence? By this I mean journals. Did you start reading any of the literature in the field?

Feynman:

No, no. Oh, no.

Weiner:

Were there any available, any such magazines available in school?

Feynman:

I don't think there were, but I don't think — no. I couldn't read that. No.

Weiner:

How about popular accounts?

Feynman:

Oh. There was a year — way back when I was at Cedarhurst, I used to read science fiction, which, because of my love of science, I found interesting. As time went on, I got very upset with it, because often it was, anything could happen, and it got more and more ridiculous and so on. But every once in a while there would be an idea that was scientifically interesting in one of the things. But I gradually stopped that. I used to read them a lot, and then I gradually stopped.

Weiner:

Stopped when?

Feynman:

I don't remember

Weiner:

It was past high school?

Feynman:

In high school, somewhere, I probably stopped.

Weiner:

So, magazines, SCIENTIFIC MONTHLY, things of this kind?

Feynman:

No. I didn't have SCIENTIFIC MONTHLY. I don't know why. I never saw it. Oh, what I did do — when, I don't know — yes, in high school and probably earlier — was to cut out of the newspaper things that had to do with science. And one of the things was a thing called "Explore Your Mind," which was a sort of a silly thing. They would ask questions, and make some — about why, something, and then it would explain. Any articles on science. I still remember an article, "Scientists Meet, Find Atom is a Wave," and there was a picture of a diffraction pattern or something from gold. But I thought the wave was the circles of the diffraction pattern. You know — and didn't understand — but I was interested enough in science that I kept a newspaper scrapbook of science articles.

Weiner:

Whatever happened to that, do you know?

Feynman:

No, I don't know. No.

Weiner:

It would be interesting.

Feynman:

Yes. It possibly exists somewhere.

Weiner:

When you mention here the books, as far as reading goes, there were just a few instances, the Wood's ADVANCED CALCULUS and the encyclopedia.

Feynman:

And the vector analysis from Maskett.

Weiner:

The thesis, though —

Feynman:

That's his thesis. No, just the one book on calculus. Then I had to buy one. It came to the library, but I bought one.

Weiner:

So there's no consistent poring through scientific libraries.

Feynman:

No, no. There was nowhere to find it. That I knew of. I think it's just as well. I mean, I suspect — I know now — this has nothing to do with my history, but I suspect, I kind of try to imagine what would have happened to me if I'd lived in today's era. I'm rather horrified. I think there are too many books, that the mind gets boggled. If I got interested, I would have so many things to look at, I would go crazy. It's too easy. Maybe. Maybe not. Maybe this is just an old fashioned point of view. You know. There's always these things. But it does bother me a little bit that there's so many things, and it's so easy, and they're watering down. The thing that I loved was, everything that I read was serious, was absolutely — wasn't written for a child. I have never read anything that was written for a child except THE BOY SCIENTIST book, which was pretty good. But the things written for children, after a certain stage, by let's say high school stage or even the late, late era in grammar school — things written for a child were not good. Very rarely, things written for a child — there were books on the cave man, you know? Cave men living, and people who lived on trees, and there was a book with a series of families in different circumstances that I found interesting. That was obvious for children. But later on, children's things — I didn't like children's things. Because, for one thing I was very very — (and still am) — sensitive and very worried about was that the thing to be dead honest; that it isn't fixed up so it looks easy. It isn't fixed up and partly faked so that the explanation can be made more simply — for the child, you know? Details purposely left out, or slightly erroneous explanations, in order to get away with it. This was intolerable. So I ultimately had only to trust the completely mature and odd old things, even though I was only in high school. I think most kids in high school are very mature. Because I know my friends who were in literature — you know, who wrote — and my friends who wrote plays, and they would read the great plays. They wouldn't read the children's plays, you know. It's the same thing. Anybody that's any good in high school already knows that they had to look at the real stuff.

Weiner:

What about other friends in high school? We've dwelt on the ones that shared your scientific interests. What about your wider social circle and your social life, and your other than school life? Let's get that.

Feynman:

Well, first, from the school I had in high school, — earlier, I don't know, there were just neighborhood kids, but in high school, I gradually became a member of a group of about four or five guys. All friends, good friends. We used to walk around together in the street and talk about things, you know — or go for long walks and do things together, and so on. Good friends. And it was a limited group, approximately four or five. It was me, another fellow interested in science whose name was Stapler, who is very good, but (I think) because of his mother's interest and influence, he was driven out and wasn't able to continue. I was lucky. That was the only other science guy. A fellow named Harold Guest was interested in writing plays. He now writes television things for Playhouse 90 or something — Kraft Theater, I think. He's OK. He got somewhere. Then there was a literary fellow, David Leff, who was editor of the school newspaper, who was very interested in writing, but not plays. I guess that's it. There was also this fellow Elmer Heller, but he was a year older than I was, and the connection was not as close as with the other boys, although we would sometimes talk to him, go to his parties and so on. Now, we'll talk about social life outside of the science business.

Weiner:

Girls?

Feynman:

Yes, girls. I didn't have much contact with other fellows. Oh, just the ordinary thing — maybe you'd get mixed in a baseball game, that I couldn't play, kind of trying to dodge it — but you know how it is in high school, you have cliques, and other guys coming in and out of the thing. We didn't have any enemy or anything. It was not very complicated. But then, with the girls — Oh, there was another group of older kids, older people, whom I somehow got in contact with that took some sort of an interest in me, for no good reason that I know, and tried to develop my interest in girls or something. You know, they were older than I was. So there were parties among the young and so forth. There were dances. A dancing school teacher trying to make money wanted to have, on certain Friday evenings in her studio, dances, and she was a friend of my mother's, and so my mother tried to talk the children into going, and so on and so on. Now, let's see. I can tell you about my first date, but it's a sort of a silly business, anybody's first date. There were young kids around and I got the idea that, you know, I kind of liked one of the girls. I was with this older group, and one day I mistakenly, at the beach — oh, we met at the beach. We'd hang around with each other, you know? I said, "Gee, I'd like to take her out. Make a date." Which I never even thought I'd have

the courage to do — you know all this kind of thing. So they said, "Ah!" So they grabbed me by the hair, and they grabbed her, and they pushed us together, and they said, "Dick wants to ask you for a date." Very difficult situation. Anyway, we made it, and I took her to the movies. My mother taught me, said I must step out of the bus first and help her out, and all this stuff, and I worried about: what am I going to talk about? I still remember what we talked about. It's so silly, because, you know this first experience. She asked me if I played the piano, and I told her I had tried to learn, and I used to take lessons, for a little while. After I was older — after many long months of this I could only play something called "Dance of the Daisies," or fairies or something, and this didn't seem to me a very good thing, and so I didn't do piano. This and that, we talked about. Later, as we were saying good-bye, she said, "Thank you for a lovely evening." I was so impressed. I was so happy. Then I found out, on my second date, that the girl said, "Thank you for a lovely evening." On my third date, when we were saying good-night, just at the door, I said to her, "Thank you for a lovely evening," and she got paralyzed, unable to say anything, because that was what she was just about to say. So I quickly learned the formal from the truth, you see.

Weiner:

Two things occur to me here. Were you still in the house with the cousins at this time?

Feynman:

No, no.

Weiner:

When did the change take place?

Feynman:

Approximately the second year of high school, we moved to an apartment house that was only a block or so away. I brought the laboratory with me.

Weiner:

Did you have difficulty fitting into your apartment with it?

Feynman:

Well, it was a tight squeeze, in a small room, but it was all right.

Weiner:

But you still saw the cousins and they were close by.

Feynman:

Yes. Yes — about the social more, huh?

Weiner:

Well, you mentioned the music, and that raises another question — what other interests did you get into, other than science, other than school?

Feynman:

Nothing. I was not interested in sports. I was not good at writing, or making any drawing, or clay — nothing.

Weiner:

You didn't have much time for that, did you?

Feynman:

Oh, I may have had time, but I probably spent the time doing something else. I didn't have any hobbies. My hobby was to do this science stuff. I didn't do it all the time. I mean, I would run around the street with these guys and talk all the time, and discuss the world or something, or hang around the drugstore and drink sodas. I don't remember what. But I didn't have any other interests at the time that I was pursuing at all, that I can remember. Nothing. I would repair radios, but that was directly connected to my laboratory and my equipment. Everything was directly connected to it. I did — I forgot to tell you — repair radios, starting in that other house, and later in the apartment house. That must have been the second year of high school. It was in the Depression, so people couldn't afford to have their radios repaired by the regular repair man. It was discovered that it was possible they would hire a silly — even as young a boy as I, to repair their sets. The first person who did was my aunt, who ran a hotel, a resort hotel. She called me up one day and said that her radio was out of commission. Well, she had somebody else call -– "This is such and such hotel, do you know something about radios?" "Would you come and repair our radio, please? It doesn't work and stuff. I said, "But I'm only a little boy." They said, "That's all right, we understand from a good authority that you know something. Would you like to try to fix our radio?" I said, "Well, I'll try" — you know. And I came. They still laugh about it, because the "boy" came — a little boy, you know — and had a big screwdriver sticking out of his pocket. I brought the tools in my pocket. I went to the radio. They had a man, a handy man, in the hotel, who was a nice fellow, and when I went to try and figure it out, I found out rather quickly that the

switch wouldn't work right, only because the knob slipped on the shaft. When I went to fix it, I could see it couldn't work because the screw was broken or something. But the man, who was the handy man, after I pointed out what the trouble was, fixed it up. You see, he figured out a way to fix it that I might not have been able to do. He helped me. And so I was successful in the first repair job. Then, it was almost as if — I had good luck with things like this — it was almost as if a course was prepared. The next person who called me up, it was only the plug to plug in the wall had to be fixed. You understand? They got more and more complicated, in the right order. Otherwise I might have been horribly discouraged at the beginning, but by sheer luck, the jobs, — I put up a new antenna. Well, that just means climbing up to the roof. My mother was horrified. One day she's coming home, she sees me climbing around on somebody's roof. I was fixing the antenna. But gradually I got more and more difficult jobs, because people would hear, my mother's friends and so on. And finally I got jobs that were outside the family. I had a job — my friend Bernie Walker and I were working for a printer, and another printer, whom we had to deliver something to, wanted to help me out. He found out I fixed radios, so he got me some jobs, and they were completely people I didn't even know. I remember one of these particularly, just for amusement. The man got me this job. The fellow was to call for me in his car to take me to this place. He was obviously poor. The car was a wreck. We got into the car and he said, "You're only a child, how can you expect to fix —?" All the time going, he's all upset by "only a child," you know, all the time going, talking about this. I felt bad, you know, but I can't do anything about it. He's yakking all the time and he tells me, he's a guy that fixes radios, and so on. So finally we get to the place with the radio. I said, "What's the matter with the set?" He said, "Oh, it makes a noise when you first turn it on, but the noise stops and everything's all right." I thought, "How can this fellow worry about a mere noise when he's got no money?" So I got to the place, and there's this radio. I turn it on — and the noise was so blood-curdling, such a terrifying racket, such a terrible noise, that you could see it was a noise! I mean, the guy wanted to get it fixed. And then it would quiet down and everything would play right. So I turned it on, I listened to this, and I'd turn it off, and then I'd start to walk back and forth, thinking. So he says, "What are you doing? Can you fix it?" I said, "I'm thinking." This only made him make another thing. And I thought, you see. I figured out — how can there be a noise that disappears? Something is changing with time. So something is heating up before something else. So I guessed that the main amplifiers are heating up before the information is coming from the grids, from the earlier circuits, that it's picking up some kind of noise. So I figured, it was probably due to the heating of the tubes, so if I reversed the order of the tubes of the same kind, maybe it would be all right. It would heat up the other way around, you know. So I just thought that. I went to the back of the set and I changed the tubes around and put them back, see. I turned it on. Just as quiet as you please! This fellow — you know, when a man is angry at you and thinks you can't do something, those are just the guys that when you do something, they just love you. I mean, you're a god after — you know? I mean, that's the kind of person that if you do succeed, they're absolutely the opposite. He went crazy. He recommended me to everybody. He said, "This fellow's a genius! I never saw a man who repaired a radio first by thinking!" And I went back and

I changed the tubes around, that's all I did. I was very happy about that, because that was a great success of the mind, you know. I loved that. That was a big success for me, to be able to repair it, after all the things he had said. I love challenges. I always have. In fact, later hobbies at the beginning were not scientific but were always challenges. Picking locks, cracking codes, analyzing hieroglyphics that nobody knows how to translate — you see, they're all the same now.

Weiner:

Talking about these jobs — any other kind of job, more conventional in nature, in your high school period?

Feynman:

Yeah, I had this job with a printer.

Weiner:

What did you do there?

Feynman:

Just odd things. Swept the floor, put what they called the furniture away — that is the sticks of type and so on — delivered the circulars that had been printed.

Weiner:

Weekends?

Feynman:

No, afternoons. I tried to collect bills that were owed, and then I'd take stuff that was too hard for this job printer to the linotype printer, the guy I told you about before, and come back on my bicycle, about four miles, and so on. That kind of stuff. Incidentally, it's amusing how I got the job there, because Bernie Walker, my friend, and I decided we'd got to get some work, you see. So we went around from store asking if they had any circulars to deliver, because those were the days when they would advertise by hand things that you would pass around. We would have some success, but not too good. And this fellow, Bernie Walker, who later went into business, you see — you can see already the disease, I mean the methods — he said, "Hey, I've got an idea. Why do we go from store to store asking if they've got any circulars to deliver? We'll go to the printer, who makes the circulars, and we'll ask him who he wants us to deliver his order of circulars to. We will do it for nothing. Then when we come in we'll say, "We're delivering our

circulars from printer so and so. Do you need a boy to deliver them?" He said, "That's a great idea." I would never have thought of that. He had a businessman's mind, Mr. Walker. So that's what we did, and the printer was so impressed with our ingenuity that he said he needed a boy to take care of the place, and so he hired the two of us, alternately, to do this, you see. He was impressed by the cleverness of this, Bernie's idea.

Weiner:

Was this for spending money? I mean, this wasn't —

Feynman:

Yes, I think so. There was also the attitude that you should do something, work — you know, the idea that to hang around and do nothing was somehow… There was a feeling of some sort of responsibility to earn money. I can't explain it.

Weiner:

Well, it was also the Depression period. This would have emphasized it.

Feynman:

Yes. And also, to do some work like that, that's good. I don't know why, but that was the feeling — we should do it. I'm sure that if I didn't, I would have got the spending money, because it wasn't a lot of money, really. But the idea that you should get a job was somehow right. I don't know (women's tales) yeah…

Weiner:

When you were in high school, were you thinking about college? When did you start thinking about what the next step was going to be in your education?

Feynman:

I don't know when I started to think about that. I must have thought about it. I knew that I was going to go to college. In this particular high school there were two kinds of courses, one called the commercial course, and one called, I don't know, the academic course or something — I don't remember — but anyway, one was supposed to be for college and the other wasn't. There never was any question. I was not in the commercial course. It was my parents who knew I would go to college, and who in fact were saving, in spite of the Depression, as best they could, to make sure that I could to go any college I wanted, when the time came. So they were the ones.

Weiner:

Were you — (crosstalk)

Feynman:

The finances, no — although they had their problems, but the problems were not communicated to me. I was always guaranteed, you know, that — But I did have a feeling of responsibility to make whatever effort I could to help. But there was no fear that it wouldn't go through. So I never really was deeply concerned. I never had a decision, (I can't remember any) when I would go to college or something.

Weiner:

But then at one point you had to make a decision, because you had to apply.

Feynman:

Of course, because I had to apply. I then applied to the colleges. One I applied to was CCNY, I think, because of the financial thing, in case we couldn't make it. I applied to Columbia. I applied to MIT. What else I applied to, I don't remember.

Weiner:

Excuse me a minute. Did you have, at that time, the state Regents' examination?

Feynman:

Yes, we did, on all the courses.

Weiner:

Do you remember how you did?

Feynman:

Yes, I have all the records, if you want.

Weiner:

How did you do? We'll look at the records too.

Feynman:

In mathematics and science it was the absolute top, 99 percent, 100 percent sometimes, or 90, very close. In the other subjects, in the neighborhood of 80 something. I did better in the Regents' than I did in the courses themselves. You know, I was always able, if I had pressure enough, to work very hard and temporarily absorb enough information, say in German, to make a passing grade, and then forget the whole damn thing.

Weiner:

Cramming?

Feynman:

Cramming, yeah.

Weiner:

Then, with decent Regents' scores and these applications —

Feynman:

Fairly decent. Only fair. But good in the math and science.

Weiner:

You applied to these different institutions. At that time, did you know what curriculum you would choose, if you were accepted?

Feynman:

I thought I would go into mathematics, I think. I did, in fact, when I got to MIT, so I don't know exactly what I thought on that, but that's what I did.

Weiner:

Were you accepted at the other schools too?

Feynman:

I don't remember about CCNY. I was not accepted at Columbia. They said "No" They have an examination also, which I took, and lost fifteen bucks. You have to pay, apply, and take the exam. I remember the fifteen bucks. But I flunked -– somehow — I didn't get in. At MIT they had a few scholarships, which I applied for and didn't get. I just got in the regular way. I think maybe I did get a small scholarship; I'm not sure, but not the

big scholarship that I had hoped for.

Weiner:

Were there any examinations for this?

Feynman:

No, there weren't examinations.

Weiner:

Based on existing records.

Feynman:

Yes.

Weiner:

How about College Entrance Examination, Boards?

Feynman:

There was no such thing, as far as I remember. There was only this exam at Columbia.

Weiner:

I think these existed perhaps earlier, but they weren't universal.

Feynman:

Maybe. Yeah. One thing, just to put into the record, which I didn't like, at the time, about MIT, was that they required a recommendation from a former student of MIT. I didn't know any former student at MIT. So I went to this man's office. The man talked to me for ten minutes, and then wrote, "This guy's a good man." I think that's all evil, that's all wrong, because it's dishonest. I was a very honest sort of scientific — if I want anything — it's true, you know. And that the school would request such a thing, and I had to go through this falseness — it bothered me. I remember it. I just put that in. That one thing I didn't like about applying to that school.

Weiner:

Feynman:

It was supposed to be one of the best schools in science and technology.

Weiner:

How did you learn that, that it was supposed to be?

Feynman:

I don't know. My father probably knew that. My father probably thought that — you see, because I think my father and mother discussed it. MIT was more expensive than the local schools, I think. This I'm imagining, because I remember, later, say, how the two of them sat down and they tried to figure out how with the budget they could send me to the best school. They were great — you know? I mean, they were right behind me.

Weiner:

Did you have any idea who was at MIT?

Feynman:

People? Oh, no. Just that it was a good school. I didn't know in terms of people.

Weiner:

So you graduated from high school in —

Feynman:

— 1935. Right.

Weiner:

And what did you do that summer? Was that any different from any other summer?

Feynman:

That's the summer I got the job in — was it? No. What the heck did I do that summer? No. I don't remember.

Weiner:

What about other summers in high school?

Feynman:

I usually tried to work. I worked in my aunt's hotel, a few summers. One summer I was ill. Oh, that was after, when I was at MIT. I was ill from the work at MIT, apparently, over — something, and the doctor insisted that I relax that summer, so I stayed in bed and drank malted milks, and would just go to the beach — I had a great summer. But I was ill. I had gotten ill.

Weiner:

After your freshman year?

Feynman:

Yes, the freshman year. But that takes us ahead. You asked about social matters, and there are a lot of social matters to be discussed yet. Girls. We really didn't get to it.

Weiner:

In high school.

Feynman:

Yes. I don't know if you want to get into it now, or continue in this direction? I thought I'd remind you, before we get into the first year of college, that you left something out.

Weiner:

Yes, let's go back then.

Feynman:

All right. Since I had been a sissy and so on, I was a little bit worried about this relationship with girls. There were some other social things that were very good. There was a Jewish Center in town that got the idea to make a junior something — I don't know what you call it, a "junior league" or something — which was built to make the young kids of the high school happy. It was an organization that was supposed to be run by them. It had its own president and so on, but they would use the buildings that were associated with the Jewish Temple. And it was really, now that I think of it, quite a wonderful effort. They had teachers to come to help, and we were divided into units, like

there was a dramatic unit, an art unit, a writer's unit where the people who liked to write, like my friend who liked to write, would get together, and they would tell the story that they would write, and then the next week some other guy would write a story and tell it, you know. They'd discuss it. And in the art unit — which I joined, for a reason which I will explain in a minute — we started by making plaster casts of heads, of faces. You know, you lie on the floor and put the plaster on and have straws out of the nose and all this kind of thing. And then we'd try to make artistic things, for which I had no talent whatsoever. The reason I joined the art unit was that I had met a very beautiful and wonderful girl who was very, very interested in art, and she was joining the art unit. So, I didn't know her too well — I mean, as a matter of fact, I understood that she was the girl-friend of some other guy, and it was absolutely hopeless, because they were completely… But I joined anyway, you know, so I could be there, because I was dreaming of her. I don't remember the order of events, but some way I met her at a party. I think the first time I met her was at a party at which somebody was teaching us how to neck and showing us how we should kiss a girl — the lips should be at right angles, and this kind of stuff. And then we sat and practiced with some girl.

Weiner:

He demonstrated before the group?

Feynman:

Yes, with some girl. He was a little older than the others. Then we would sit and we'd try to neck. I had a girl I was practicing with. Then, just at this moment, there was a little excitement -- "Arlene is coming!" — and everybody gets excited. It was the older group I was with, you see. Everybody jumps up to great her. And I figure, nobody is that important — you know, this is not the way to behave — so I just kept on…

Weiner:

— practicing?

Feynman:

Practicing. She remembered it later, that she came in, and there was one person in the party she didn't like because he was necking in the corner. Nobody else was doing such a terrible thing. Anyway, we started out on the wrong foot. But at another party, where she was — I had seen her, and then I was really impressed with this Arlene, I understood why everybody had jumped up. I was at another party where she was. For a reason that I don't know, she sat on the arm of my chair. So there was hope. I was excited as the devil. She was with this older group, you know. She was in this junior center, so that's why I joined the art group. There was no science group, there was nothing like that in this junior center, but it was social. There were dances. It was a good thing to join, in

spite of the fact — And so therefore I got to know her, and then I got to know her boy-friend, who, it turned out, she broke up with, or it turned out she wasn't with him, and gradually I got to know her better. I took her to the dance. I told you that there was a lady with a dancing school that my mother knew, so I took her to that dance, and I introduced her to my friends, and the playwright man, by the name of Harold Gast, came up to me to tell me very carefully that "that's my girl" and he's "not interested," etc. I've since learned that that's a dead signal to watch out, when they protest too much. Anyway, he was then my competitor, after that, after his assertion that she was my girl and he would not interfere — a thing which I had not even asked for. But I learned. So he was a kind of competitor. She would go with him, or with me, all the time. When I went to MIT, we wrote letters back and forth. But the day when I really — I don't know what really convinced her, but one day that I realized that I was getting ahead of Mr. Gast was the day we graduated from high school. She was invited to our graduation. We were both graduating together. He had written a play. She sat between our parents — she was a very sensible girl. It happened that I won a lot of medals, for best in physics, best in chemistry, and best in mathematics. He wrote the play, but I was getting called to the platform every few minutes, you know -- "Now the prize for physics" -- "Now the prize for chemistry" — "for mathematics" — and so on. It was get up and get down, get up and get down, and because of a fluke — a fluke — when it came to English, because of the fluke that they had decided this thing on the Regents' grade and nothing else, which was unfair, because it could be am accident from cramming or an accident of the system — I had been relatively poor in English and these fellows had been very good. And my two friends, the playwright and the writer for the newspaper, neither of them got honors in English because they did badly on the last Regents — and I did! So this was a freakish accident. I know why I did, because for one time in my life I finally broke down in the English. Everybody, I listen to them talk; they're a kind of baloney. They don't talk direct, in English class, and I'm always trying to talk straight. In the examination, in the Regents' examination, they had things like, "Take a book and make a book review," and I would take the simplest freshman book, TREASURE ISLAND, while my friends would try something like Sinclair Lewis' book about the stockyards or something. Mine, though dull, was all right, so the dull teachers said OK — but she had objections to his interpretations of the social relations. You know, she was much more interested. But the real place where I faked it was, they gave us a list of compositions that we could write on different subjects, and for a change they had a few scientific subjects in there, one of which was "The Importance of Science in Aviation." To me this seemed incredible, that the person who had made up the title was an ass, because it was so obvious. I mean, it's such a dumb kind of a subject. But I figured for once I'm going to do what I see my friends do. So I wrote an article, in which I talked about the importance of science in the analysis of vortices, eddies, turbulence, and swirling motions of the air — all the same thing, you see. So I made these big words and I repeated myself, I did all that baloney and I got a very good — I think that's why I got a good grade in the English quiz. I did it for the first time consciously, because I thought it was so silly, nobody knows anything, so it's easy to write about these things. Anyhow, this seemed to have impressed my girl, but the thing that impressed her most was the

following: My parents, my mother — I don't know about whether my father was there, I can't remember — and Mrs. Gast went together down the hallway afterwards to talk to the teachers, after graduation, and they met Mr. Ogsberry in the hall, and he (my mother said) — They said, "I'm Mrs. Gast and this is Mrs. Feynman." He said, "Oh, Mrs. Feynman!" Just like that, you see. And then he makes her think, to try to impress her, what I had -- "Your son has something the state should support, and it shouldn't be necessary…" Big deal. He made a great speech. He was very impressed by his students. And Mrs. Gast kept saying, "What about my boy Harold?" "Oh, Harold's all right, never mind Harold — now listen, Mrs. Feynman —" What he was worried about was that the parent might not understand, and might say to the child he must get a job or something. See, he was worried, but he didn't have to worry, because my parents were aware of this. My friend Stapler's parents were not — his mother; his father was dead. She was not that kind. He had to go out to get money, because she needed money, and that was the end of him, really. So I was lucky. But anyway, this girl-friend, Arlene, was standing there, listening to all this, you see. And after that I had a little easier job against Harold Gast. Or at least I imagined that that was the reason. Anyway, I fell gradually in love with this girl, and it took me six years before we got engaged. I met her at thirteen, when I was thirteen. I was thirteen and a half, she was thirteen, something like that, and we got engaged six years later, and we were married another seven years later. I knew her for thirteen years before we got married. It was quite an unusually long situation. We were very much in love by that time. A most marvelous woman. We had a terrific relationship.

Weiner:

You were married in 1940 — something?

Feynman:

1941 or 1942, yeah. Details we'll put in when the time comes, if you want. Then, when I was at MIT — I've cut the end of the high school. Yeah, that was the best girl, the most important girl. There were a few dates here and there with other girls, but this was the most important one.

Weiner:

You won these awards. Were they honors or specific awards?

Feynman:

Well, like medals, you know. I think it was maybe the Exchange Club of Far Rockaway would give a chemistry medal, by giving the money for the medal. The Bausch and Lomb Optical Co. gave the medal for science, I think, and they probably had a policy of giving the medals to the high schools for science, to finance it. So I remember, it was Bausch and Lomb that gave that, because my father kept saying to me, "Listen, you've

got to write them a letter and thank them for doing this. I'll dictate it to you: 'Bausch and Lomb: Gentlemen…'" So we had a kind of joke around the house, "Bausch and Lomb: Gentlemen." I never wrote the letter, and he'd never dictate any further. But I remember that.

Weiner:

I think this is a fitting conclusion to the high school.