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The Pleasure of Finding Things Out

This is the edited transcript of an interview with Feynman made for the BBC television program Horizon *in 1981, shown in the United States as an episode of* Nova. *Feynman had most of his life behind him by this time (he died in 1988), so he could reflect on his experiences and accomplishments with the perspective not often attainable by a younger person. The result is a candid, relaxed, and very personal discussion on many topics close to Feynman's heart: why knowing merely the name of something is the same as not knowing anything at all about it; how he and his fellow atomic scientists of the Manhattan Project could drink and revel in the success of the terrible weapon they had created while on the other side of the world in Hiroshima thousands of their fellow human beings were dead or dying from it; and why Feynman could just as well have gotten along without a Nobel Prize.*

The Beauty of a Flower

I have a friend who's an artist and he's sometimes taken a view which I don't agree with very well. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree, I think. And he says—"you see, I as an artist can see how beautiful this is, but you as a scientist, oh, take this all apart and it becomes a dull thing." And I think that he's kind of nutty. First of all, the beauty that he sees is available to other people and to me, too, I believe, although I might not be quite as refined aesthetically as he is; but I can appreciate the beauty of a flower. At the same time I see much more about the flower than he sees. I can imagine the cells in there, the complicated actions inside which also have a beauty. I mean it's not just beauty at this dimension of one centimeter, there is also beauty at a smaller dimension, the inner structure. Also the processes, the fact that the colors in the flower evolved in order to attract insects to pollinate it is interesting—it means that insects can see the color. It adds a question: Does this aesthetic sense also exist in the lower forms? Why is it aesthetic? All kinds of interesting questions which shows that a science knowledge only adds to the excitement and mystery and the awe of a flower. It only adds; I don't understand how it subtracts.

Avoiding Humanities

I've always been very one-sided about science and when I was younger I concentrated almost all my effort on it. I didn't have time to learn and I didn't have much patience with what's called the humanities, even though in the university there were humanities that you had to take. I tried my best to avoid somehow learning anything and working at it. It was

only afterwards, when I got older, that I got more relaxed, that I've spread out a little bit. I've learned to draw and I read a little bit, but I'm really still a very one-sided person and I don't know a great deal. I have a limited intelligence and I use it in a particular direction.

Tyrannosaurus in the Window

We had the *Encyclopaedia Britannica* at home and even when I was a small boy [my father] used to sit me on his lap and read to me from the *Encyclopaedia Britannica*, and we would read, say, about dinosaurs and maybe it would be talking about the brontosaurus or something, or the tyrannosaurus rex, and it would say something like, "This thing is twenty-five feet high and the head is six feet across," you see, and so he'd stop all this and say, "Let's see what that means. That would mean that if he stood in our front yard he would be high enough to put his head through the window but not quite because the head is a little bit too wide and it would break the window as it came by."

Everything we'd read would be translated as best we could into some reality and so I learned to do that—everything that I read I try to figure out what it really means, what it's really saying by translating and so (LAUGHS) I used to read the *Encyclopaedia* when I was a boy but with translation, you see, so it was very exciting and interesting to think there were animals of such magnitude—I wasn't frightened that there would be one coming in my window as a consequence of this, I don't think, but I thought that it was very, very interesting, that they all died out and at that time nobody knew why.

We used to go to the Catskill Mountains. We lived in New York and the Catskill Mountains was the place where people went in the summer; and the fathers—there was a big group of people there but the fathers would all go back to New York to work during the week and only come back on the weekends. When my father came he would take me for walks in the woods and tell me various interesting things that were going on in the woods—which I'll explain in a minute—but the other mothers seeing this, of course, thought this was wonderful and that the other fathers should take their sons for walks, and they tried to work on them but they didn't get anywhere at first and they wanted my father to take all the kids, but he didn't want to because he had a special relationship with me—we had a personal thing together—so it ended up that the other fathers had to take their children for walks the next weekend, and the next Monday when they were all back to work, all the kids were playing in the field and one kid said to me, "See that bird, what kind of a bird is that?" And I said, "I haven't the slightest idea what kind of a bird it is." He says, "It's a brown throated thrush," or something, "Your father doesn't tell you anything." But it was the opposite: my father *had* taught me. Looking at a bird he says, "Do you know what that bird is? It's a brown throated thrush; but in Portuguese it's a . . . in Italian a . . .," he says "in Chinese it's a . . . , in Japanese a . . .," etcetera. "Now," he says, "you know in all the languages you want to know what the name of that bird is and when you've finished with all that," he says, "you'll know absolutely nothing whatever about the bird. You only know about humans in different places and what they call the bird. Now," he says, "let's look at the bird."

He had taught me to notice things and one day when I was playing with what we call an express wagon, which is a little wagon which has a railing around it for children to play with that they can pull around. It had a ball in it—I remember this—it had a ball in it, and I pulled the wagon and I noticed something about the way the ball moved, so I went to my father and I said, "Say, Pop, I noticed something: When I pull the wagon the ball rolls to the back of the wagon, and when I'm pulling it along and I suddenly stop, the ball rolls to the front of the wagon," and I says, "why is that?" And he said, "That nobody knows," he said. "The general principle is that things that are moving try to keep on moving and things that are standing still tend to stand still unless you push on them hard." And he says, "This tendency is called inertia but nobody knows why it's true." Now that's a deep understanding—he doesn't give me a name, he knew the difference between knowing the name of something and knowing something, which I learnt very early. He went on to say, "If you look close you'll find the ball does not rush to the back of the wagon, but it's the back of the wagon that you're pulling against the ball; that the ball stands still or as a matter of fact from the friction starts to move forward really and doesn't move back." So I ran back to the little wagon and set the ball up again and pulled the wagon from under it and looking sideways and seeing indeed he was right—the ball never moved backwards in the wagon when I pulled the wagon forward. It moved backward relative to the wagon, but relative to the sidewalk it was moved forward a little bit, it's just [that] the wagon caught up with it. So that's the way I was educated by my father, with those kinds of examples and discussions, no pressure, just lovely interesting discussions.

Algebra for the *Practical* Man

My cousin, at that time, who was three years older, was in high school and was having considerable difficulty with his algebra and had a tutor come, and I was allowed to sit in a corner while (LAUGHS) the tutor would try to teach my cousin algebra, problems like $2x$ plus something. I said to my cousin then, "What're you trying to do?" You know, I hear him talking about *x.* He says, "What do *you* know—$2x + 7$ is equal to 15," he says "and you're trying to find out what x is." I says, "You mean 4." He says, "Yeah, but you did it with arithmetic, you have to do it by algebra," and that's why my cousin was never able to do algebra, because he didn't understand how he was supposed to do it. There was no way. I learnt algebra fortunately by not going to school and knowing the whole idea was to find out what x was and it didn't make any difference how you did it—there's no such thing as, you know, you do it by arithmetic, you do it by algebra—that was a false thing that they had invented in school so that the children who have to study algebra can all pass it. They had invented a set of rules which if you followed them without thinking could produce the answer: subtract 7 from both sides, if you have a multiplier divide both sides by the multiplier and so on, and a series of steps by which you could get the answer if you didn't understand what you were trying to do.

There was a series of math books, which started *Arithmetic for the Practical Man*, and then *Algebra for the Practical Man,* and then *Trigonometry for the Practical Man*, and I learned trigonometry for the practical man from that. I soon forgot it again because I didn't understand it very well but the series was coming out, and the library was going to get *Calculus for the Practical Man* and I knew by this time by reading the *Encyclopaedia* that calculus was an important subject and it was an interesting one and I ought to learn it. I was older now, I was perhaps thirteen; and then the calculus book finally came out and I was so excited and I went to the library to take it out and she looks at me and she says, "Oh, you're just a child, what are you taking this book out for, this book is a [book for adults]." So this was one of the few times in my life I was uncomfortable and I lied and I said it was for my father, he selected it. So I took it home and I learnt calculus from it and I tried to explain it to my father and he'd start to read the beginning of it and he found it confusing and it really bothered me a little bit. I didn't know that he was so limited, you know, that he didn't understand, and I thought it was relatively simple and straightforward and he didn't understand it. So that was the first time I knew I had learnt more in some sense than he.

Epaulettes and the Pope

One of the things that my father taught me besides physics (LAUGHS), whether it's correct or not, was a disrespect for respectable . . . for certain kinds of things. For example, when I was a little boy, and a rotogravure—that's printed pictures in newspapers—first came out in the *New York Times,* he used to sit me again on his knee and he'd open a picture, and there was a picture of the Pope and everybody bowing in front of him. And he'd say, "Now look at these humans. Here is one human standing here, and all these others are bowing. Now what is the difference? This one is the Pope"—he hated the Pope anyway—and he'd say, "the difference is epaulettes"—of course not in the case of the Pope, but if he was a general—it was always the uniform, the position, "but this man has the same human problems, he eats dinner like anybody else, he goes to the bathroom, he has the same kind of problems as everybody, he's a human being. Why are they all bowing to him? Only because of his name and his position, because of his uniform, not because of something special he did, or his honor, or something like that.'' He, by the way, was in the uniform business, so he knew what the difference was between the man with the uniform off and the uniform on; it's the same man for him.

He was happy with me, I believe. Once, though, when I came back from MIT–I'd been there a few years–he said to me, "Now," he said, "you've become educated about these things and there's one question I've always had that I've never understood very well and I'd like to ask you, now that you've studied this, to explain it to me," and I asked him what it was. And he said that he understood that when an atom made a transition from one state to another it emits a particle of light called a photon. I said, "That's right." And he says, "Well, now, is the photon in the atom ahead of time that it comes out, or is there no photon in it to start with?" I says, "There's no photon in, it's just that when the electron makes a transition it comes" and he says "Well, where does it come from then, how does it come out?" So I couldn't just say, "The view is that photon numbers aren't conserved, they're just created by the motion of the electron." I couldn't try to explain to him something like: the sound that I'm making now wasn't in me. It's not like my little boy who when he started to talk, suddenly said that he could no longer say a certain word–the word was "cat"–because his word bag has run out of the word cat (LAUGHS). So there's no word bag that you have inside so that you use up the words as they come out, you just make them as they go along, and in the same sense there was no photon bag in an atom and when the photons come out they didn't come from somewhere, but I couldn't do much better. He was not satisfied with me in the respect that I never was able to explain any of the things that he didn't understand (LAUGHS). So he was unsuccessful, he sent me through all these universities in order to find out these things and he never did find out (LAUGHS).

Invitation to the Bomb

[while working on his PhD thesis, Feynman was asked to join the project to develop the atomic bomb.] It was a completely different kind of a thing. It would mean that I would have to stop the research in what I was doing, which is my life's desire, to take time off to do this, which I felt I should do in order to protect civilization. Okay? So that was what I had to debate with myself. My first reaction was, well, I didn't want to get interrupted in my normal work to do this odd job. There was also the problem, of course, of any moral thing involving war. I wouldn't have much to do with that, but it kinda scared me when I realized what the weapon would be, and that since it might be possible, it must be possible. There was nothing that I knew that indicated that if we could do it they couldn't do it, and therefore it was very important to try to cooperate.

[In early 1943 Feynman joined Oppenheimer's team at Los Alamos.] With regard to moral questions, I do have something I would like to say about it. The original reason to start the project, which was that the Germans were a danger, started me off on a process of action which was to try to develop this first system at Princeton and then at Los Alamos, to try to make the bomb work. All kinds of attempts were made to redesign it to make it a worse bomb and so on. It was a project on which we all worked very, very hard, all co-operating together. And with any project like that you continue to work trying to get success, having decided to do it. But what I did–immorally I would say–was to not remember the reason that I said I was doing it, so that when the reason changed, because Germany was defeated, not the singlest thought came to my mind at all about that, that that meant

now that I have to reconsider why I am continuing to do this. I simply didn't think, okay?

Success and Suffering

*[On 6 August **1945** the atomic bomb was exploded over Hiroshima.]* The only reaction that I remember–perhaps I was blinded by my own reaction–was a very considerable elation and excitement, and there were parties and people got drunk and it would make a tremendously interesting contrast, what was going on in Los Alamos at the same time as what was going on in Hiroshima. I was involved with this happy thing and also drinking and drunk and playing drums sitting on the hood of–the bonnet of–a Jeep and playing drums with excitement running all over Los Alamos at the same time as people were dying and struggling in Hiroshima.

I had a very strong reaction after the war of a peculiar nature–it may be from just the bomb itself and it may be for some other psychological reasons, I'd just lost my wife or something, but I remember being in New York with my mother in a restaurant, immediately after [Hiroshima], and thinking about New York, and I knew how big the bomb in Hiroshima was, how big an area it covered and so on, and I realized from where we were–I don't know, 59th Street–that to drop one on 34th Street, it would spread all the way out here and all these people would be killed and all the things would be killed and there wasn't only one bomb available, but it was easy to continue to make them, and therefore that things were sort of doomed because already it appeared to me–very early, earlier than to others who were more optimistic–that international relations and the way people were behaving were no different than they had ever been before and that it was just going to go on the same way as any other thing and I was sure that

it was going, therefore, to be used very soon. So I felt very uncomfortable and thought, really believed, that it was silly: I would see people building a bridge and I would say "they don't understand." I really believed that it was senseless to make anything because it would all be destroyed very soon anyway, but they didn't understand that and I had this very strange view of any construction that I would see, I would always think how foolish they are to try to make something. So I was really in a kind of depressive condition.

"I Don't Have to Be Good Because They Think I'm Going to Be Good."

[After the war Fgnman joined Hans Bethe at Cornell University. He turned down the offer of a job at Princeton's Institute for Advanced **Study.]*** They [must have] expected me to be wonderful to offer me a job like this and I wasn't wonderful, and therefore I realized a new principle, which was that I'm not responsible for what other people think I am able to do; I don't have to be good because they think I'm going to be good. And somehow or other I could relax about this, and I thought to myself, I haven't done anything important and I'm never going to do anything important. But I used to enjoy physics and mathematical things and because I used to play with them it was in very short order [that I] worked the things out for which I later won the Nobel Prize.?

*(1906–) Winner of the 1967 Nobel Prize in Physics for contributions to the theory of nuclear reactions, especially for his discoveries concerning the energy production in stars. *Ed.*

†In 1965, the Nobel Prize for Physics was shared by Richard Feynman, Julian Schwinger, and Sin-Itiro Tomonaga for their fundamental work in quantum electrodynamics, and its deep consequences for the physics of elementary particles. *Ed.*

The Nobel Prize—Was It Worth It?

[Fgnman was awarded a Nobel Prize for his work on quantum electrodynamics.] What I essentially did—and also it was done independently by two other people, [Sinitiro] Tomanaga in Japan and [Julian] Schwinger—was to figure out how to control, how to analyze and discuss the original quantum theory of electricity and magnetism that had been written in 1928; how to interpret it so as to avoid the infinities, to make calculations for which there were sensible results which have since turned out to be in exact agreement with every experiment which has been done so far, so that quantum electrodynamics fits experiment in every detail where it's applicable—not involving the nuclear forces, for instance—and it was the work that I did in 1947 to figure out how to do that, for which I won the Nobel Prize.

[BBC: *Was it worth the Nobel Prize?]* As a (LAUGHS) . . . I don't know anything about the Nobel Prize, I don't understand what it's all about or what's worth what, but if the people in the Swedish Academy decide that *x, y,* or z wins the Nobel Prize then so be it. I won't have anything to do with the Nobel Prize . . . it's a pain in the . . . (LAUGHS). I don't like honors. I appreciate it for the work that I did, and for people who appreciate it, and I know there's a lot of physicists who use my work, I don't need anything else, I don't think there's any sense to anything else. I don't see that it makes any point that someone in the Swedish Academy decides that this work is noble enough to receive a prize—I've already got the prize. The prize is the pleasure of finding the thing out, the kick in the discovery, the observation that other people use it [my work]—those are the real things, the honors are unreal to me. I don't believe in honors, it bothers me, honors bother, honors is epaulettes, honors is uniforms. My papa brought me up this way. I can't stand it, it hurts me.

When I was in high school, one of the first honors I got was to be a member of the Arista, which is a group of kids who got good grades—eh?—and everybody wanted to be a member of the Arista, and when I got into the Arista I discovered that what they did in their meetings was to sit around to discuss who else was worthy to join this wonderful group that we are—okay? So we sat around trying to decide who it was who would get to be allowed into this Arista. This kind of thing bothers me psychologically for one or another reason I don't understand myself—honors—and from that day to this [it] always bothered me. When I became a member of the National Academy of Sciences, I had ultimately to resign because that was another organization most of whose time was spent in choosing who was illustrious enough to join, to be allowed to join us in our organization, including such questions as [should] we physicists stick together because they've a very good chemist that they're trying to get in and we haven't got enough room for so-and-so. What's the matter with chemists? The whole thing was rotten because its purpose was mostly to decide who could have this honor—okay? I don't like honors.

The Rules of the Game

[From 1950 to 1988 Fgnman was Professor of Theoretical Physics at the California Institute of Technology.] One way, that's kind of a fun analogy in trying to get some idea of what we're doing in trying to understand nature, is to imagine that the gods are playing some great game like chess, let's say, and you don't know the rules of the game, but you're allowed to look

at the board, at least from time to time, in a little corner, perhaps, and from these observations you try to figure out what the rules of the game are, what the rules of the pieces moving are. You might discover after a bit, for example, that when there's only one bishop around on the board that the bishop maintains its color. Later on you might discover the law for the bishop as it moves on the diagonal which would explain the law that you understood before—that it maintained its color—and that would be analagous to discovering one law and then later finding a deeper understanding of it. Then things can happen, everything's going good, you've got all the laws, it looks very good, and then all of a sudden some strange phenomenon occurs in some corner, so you begin to investigate that—it's castling, something you didn't expect. We're always, by the way, in fundamental physics, always trying to investigate those things in which we don't understand the conclusions. After we've checked them enough, we're okay.

The thing that doesn't fit is the thing that's the most interesting, the part that doesn't go according to what you expected. Also, we could have revolutions in physics: after you've noticed that the bishops maintain their color and they go along the diagonal and so on for such a long time and everybody knows that that's true, then you suddenly discover one day in some chess game that the bishop doesn't maintain its color, it changes its color. Only later do you discover a new possibility, that a bishop is captured and that a pawn went all the way down to the queen's end to produce a new bishop—that can happen but you didn't know it, and so it's very analagous to the way our laws are: They sometimes look positive, they keep on working and all of a sudden some little gimmick shows that they're wrong and then we have to investigate the conditions under which this bishop change of

color happened and so forth, and gradually learn the new rule that explains it more deeply. Unlike the chess game, though, in [which] the rules become more complicated as you go along, in physics, when you discover new things, it looks more simple. It appears on the whole to be more complicated because we learn about a greater experience—that is, we learn about more particles and new things—and so the laws look complicated again. But if you realize all the time what's kind of wonderful—that is, if we expand our experience into wilder and wilder regions of experience—every once in a while we have these integrations when everything's pulled together into a unification, in which it turns out to be simpler than it looked before.

If you are interested in the ultimate character of the physical world, or the complete world, and at the present time our only way to understand that is through a mathematical type of reasoning, then I don't think a person can fully appreciate, or in fact can appreciate much of, these particular aspects of the world, the great depth of character of the universality of the laws, the relationships of things, without an understanding of mathematics. I don't know any other way to do it, we don't know any other way to describe it accurately . . . or to see the interrelationships without it. So I don't think a person who hasn't developed some mathematical sense is capable of fully appreciating this aspect of the world—don't misunderstand me, there are many, many aspects of the world that mathematics is unnecessary for, such as love, which are very delightful and wonderful to appreciate and to feel awed and mysterious about; and I don't mean to say that the only thing in the world is physics, but you were talking about physics and if that's what you're talking about, then to not know mathematics is a severe limitation in understanding the world.

Smashing Atoms

Well, what I'm working on in physics right now is a special problem which we've come up against and I'll describe what it is. You know that everything's made out of atoms, we've got that far already and most people know that already, and that the atom has a nucleus with electrons going around. The behavior of the electrons on the outside is now completely [known], the laws for it are well understood as far as we can tell in this quantum electrodynamics that I told you about. And after that was evolved, then the problem was how does the nucleus work, how do the particles interact, how do they hold together? One of the by-products was to discover fission and to make the bomb. But investigating the forces that hold the nuclear particles together was a long task. At first it was thought that it was an exchange of some sort of particles inside, which were invented by Yukawa, called pions, and it was predicted that if you hit protons—the proton is one of the particles of the nucleus—against a nucleus, they would knock out such pions, and sure enough, such particles came out.

Not only pions came out but other particles, and we began to run out of names—kaons and sigmas and lamdas and so on; they're all called hadrons now—and as we increased the energy of the reaction and got more and more different kinds, until there were hundreds of different kinds of particles; then the problem, of course—this period is 1940 up to 1950, towards the present—was to find the pattern behind it. There seemed to be many many interesting relations and patterns among the particles, until a theory was evolved to explain these patterns, that all of these particles were really made of something else, that they were made of things called quarks—three quarks, for example, would form a proton—and that the proton is one of the particles of the nucleus; another one is a

neutron. The quarks came in a number of varieties—in fact, at first only three were needed to explain all the hundreds of particles and the different kinds of quarks—they are called u-type, d-type, s-type. Two us and a d made a proton, two ds and a u made a neutron. If they were moving in a different way inside they were some other particle. Then the problem came: What exactly is the behavior of the quarks and what holds them together? And a theory was thought of which is very simple, a very close analogy to quantum electrodynamics—not exactly the same but very close—in which the quarks are like the electron and the particles called gluons—which go between the electrons, which makes them attract each other electrically—are like the photons. The mathematics was very similar but there are a few terms slightly different. The difference in the form of the equations that were guessed at were guessed by principles of such beauty and simplicity that it isn't arbitrary, it's very, very determined. What is arbitrary is how many different kinds of quark there are, but not the character of the force between them.

Now unlike electrodynamics, in which two electrons can be pulled apart as far as you want, in fact when they are very far away the force is weakened; if this were true for quarks you would have expected that when you hit things together hard enough the quarks would have come out. But instead of that, when you're doing an experiment with enough energy that quarks could come out, instead of that you find a big jet—that is, all particles going about in the same direction as the old hadrons, no quarks—and from the theory, it was clear that what was required was that when the quark comes out, it kind of makes these new pairs of quarks and they come in little groups and make hadrons.

The question is, why is it so different in electrodynamics, how do these small-term differences, these little terms that are different in the equation, produce such different effects, entirely different effects? In fact, it was very surprising to most people that this would really come out, that first you would think that the theory was wrong, but the more it's studied the clearer it became that it's very possible that these extra terms would produce these effects. Now we were in a position that's different in history than any other time in physics, that's always different. We have a theory, a complete and definite theory of all of these hadrons, and we have an enormous number of experiments and lots and lots of details, so why can't we test the theory right away to find out whether it's right or wrong? Because what we have to do is calculate the consequences of the theory. If this theory is right, what should happen, and has that happened? Well, this time the difficulty is in the first step. If the theory is right, what should happen is very hard to figure out. The mathematics needed to figure out what the consequences of this theory are have turned out to be, at the present time, insuperably difficult. At the present time—all right? And therefore it's obvious what my problem is—my problem is to try to develop a way of getting numbers out of this theory, to test it really carefully, not just qualitatively, to see if it might give the right result.

I spent a few years trying to invent mathematical things that would permit me to solve the equations, but I didn't get anywhere, and then I decided that in order to do that I must first understand more or less how the answer probably looks. It's hard to explain this very well, but I had to get a qualitative idea of how the phenomenon works before I could get a good quantitative idea. In other words, people didn't even understand roughly how it worked, and so I have been working most recently in the last year or two on understanding roughly how it works, not quantitatively yet, with the hope that in the future that rough understanding can be refined

into a precise mathematical tool, way, or algorithm to get from the theory to the particles. You see, we're in a funny position: It's not that we're looking for the theory, we've got the theory—a good, good candidate—but we're in the step in the science that we need to compare the theory to experiment by seeing what the consequences are and checking it. We're stuck in seeing what the consequences are, and it's my aim, it's my desire to see if I can work out a way to work out what the consequences of this theory are (LAUGHS). It's a kind of a crazy position to be in, to have a theory that you can't work out the consequences of . . . I can't stand it, I have to figure it out. Someday, maybe.

"Let George Do It."

To do high, real good physics work you do need absolutely solid lengths of time, so that when you're putting ideas together which are vague and hard to remember, it's very much like building a house of cards and each of the cards is shaky, and if you forget one of them the whole thing collapses again. You don't know how you got there and you have to build them up again, and if you're interrupted and kind of forget half the idea of how the cards went together—your cards being different-type parts of the ideas, ideas of different kinds that have to go together to build up the idea—the main point is, you put the stuff together, it's quite a tower and it's easy [for it] to slip, it needs a lot of concentration—that is, solid time to think—and if you've got a job in administrating anything like that, then you don't have the solid time. So I have invented another myth for myself—that I'm irresponsible. I tell everybody, I don't do anything. If anybody asks me to be on a committee to take care of admissions, no, I'm irresponsible, I don't give a damn about the students—of course I give a damn about the students but I know that somebody else'll do it—and I take the view, "Let George do it," a view which you're not supposed to take, okay, because that's not right to do, but I do that because I like to do physics and I want to see if I can still do it, and so I'm selfish, okay? I want to do my physics.

Bored by the History

All those students are in the class: Now you ask me how should I best teach them? Should I teach them from the point of view of the history of science, from the applications? My theory is that the best way to teach is to have no philosophy, [it] is to be chaotic and [to] confuse it in the sense that you use every possible way of doing it. That's the only way I can see to answer it, so as to catch this guy or that guy on different hooks as you go along, [so] that during the time when the fellow who's interested in history's being bored by the abstract mathematics, on the other hand the fellow who likes the abstractions is being bored another time by the history—if you can do it so you don't bore them all, all the time, perhaps you're better off. I really don't know how to do it. I don't know how to answer this question of different kinds of minds with different kinds of interests—what hooks them on, what makes them interested, how you direct them to become interested. One way is by a kind of force, you have to pass this course, you have to take this examination. It's a very effective way. Many people go through schools that way and it may be a more effective way. I'm

sorry, after many, many years of trying to teach and trying all different kinds of methods, I really don't know how to do it.

Like Father, Like Son

I got a kick, when I was a boy, [out] of my father telling me things, so I tried to tell my son things that were interesting about the world. When he was very small we used to rock him to bed, you know, and tell him stories, and I'd make up a story about little people that were about so high [who] would walk along and they would go on picnics and so on and they lived in the ventilator; and they'd go through these woods which had great big long tall blue things like trees, but without leaves and only one stalk, and they had to walk between them and so on; and he'd gradually catch on [that] that was the rug, the nap of the rug, the blue rug, and he loved this game because I would describe all these things from an odd point of view and he liked to hear the stories and we got all kinds of wonderful things—he even went to a moist cave where the wind kept going in and out—it was coming in cool and went out warm and so on. It was inside the dog's nose that they went, and then of course I could tell him all about physiology by this way and so on. He loved that and so I told him lots of stuff, and I enjoyed it because I was telling him stuff that I liked, and we had fun when he would guess what it was and so on. And then I have a daughter and I tried the same thing—well, my daughter's personality was different, she didn't want to hear this story, she wanted the story that was in the book repeated again, and reread to her. She wanted me to read to her, not to make up stories, and it's a different personality. And so if I were to say a very good method for teaching children about science is to make up these stories of the little people, it doesn't work at all on my daughter—it happened to work on my son—okay?

"Science Which Is Not a Science . . ."

Because of the success of science, there is, I think, a kind of pseudoscience. Social science is an example of a science which is not a science; they don't do [things] scientifically, they follow the forms—or you gather data, you do so-and-so and so forth but they don't get any laws, they haven't found out anything. They haven't got anywhere yet—maybe someday they will, but it's not very well developed, but what happens is on an even more mundane level. We get experts on everything that sound like they're sort of scientific experts. They're not scientific, they sit at a typewriter and they make up something like, oh, food grown with, er, fertilizer that's organic is better for you than food grown with fertilizer that's inorganic—may be true, may not be true, but it hasn't been demonstrated one way or the other. But they'll sit there on the typewriter and make up all this stuff as if it's science and then become an expert on foods, organic foods and so on. There's all kinds of myths and pseudoscience all over the place.

I may be quite wrong, maybe they do know all these things, but I don't think I'm wrong. You see, I have the advantage of having found out how hard it is to get to really know something, how careful you have to be about checking the experiments, how easy it is to make mistakes and fool yourself. I know what it means to know something, and therefore I see how they get their information and I can't believe that they know it, they haven't done the work necessary, haven't done the checks necessary, haven't done the care necessary. I have a great suspicion that they don't know, that this stuff is

[wrong] and they're intimidating people. I think so. I don't know the world very well but that's what I think.

Doubt and Uncertainty

If you expected science to give all the answers to the wonderful questions about what we are, where we're going, what the meaning of the universe is and so on, then I think you could easily become disillusioned and then look for some mystic answer to these problems. How a scientist can take a mystic answer I don't know because the whole spirit is to understand—well, never mind that. Anyhow, I don't understand that, but anyhow if you think of it, the way I think of what we're doing is we're exploring, we're trying to find out as much as we can about the world. People say to me, "Are you looking for the ultimate laws of physics?" No, I'm not, I'm just looking to find out more about the world and if it turns out there is a simple ultimate law which explains everything, so be it, that would be very nice to discover.

If it turns out it's like an onion with millions of layers and we're just sick and tired of looking at the layers, then that's the way it is, but whatever way it comes out its nature is there and she's going to come out the way she is, and therefore when we go to investigate it we shouldn't predecide what it is we're trying to do except to try to find out more about it. If you say your problem is, why do you find out more about it, if you thought you were trying to find out more about it because you're going to get an answer to some deep philosophical question, you may be wrong. It may be that you can't get an answer to that particular question by finding out more about the character of nature, but I don't look at it [like that]. My interest in science is to simply find out about the world, and the more I find out the better it is, like, to find out.

There are very remarkable mysteries about the fact that we're able to do so many more things than apparently animals can do, and other questions like that, but those are mysteries I want to investigate without knowing the answer to them, and so altogether I can't believe these special stories that have been made up about our relationship to the universe at large because they seem to be too simple, too connected, too local, too provincial. The earth, He came to the earth, one of the aspects of God came to the earth, mind you, and look at what's out there. It isn't in proportion. Anyway, it's no use arguing, I can't argue it, I'm just trying to tell you why the scientific views that I have do have some effect on my belief. And also another thing has to do with the question of how you find out if something's true, and if all the different religions have all different theories about the thing, then you begin to wonder. Once you start doubting, just like you're supposed to doubt, you ask me if the science is true. You say no, we don't know what's true, we're trying to find out and everything is possibly wrong.

Start out understanding religion by saying everything is possibly wrong. Let us see. As soon as you do that, you start sliding down an edge which is hard to recover from and so on. With the scientific view, or my father's view, that we should look to see what's true and what may be or may not be true, once you start doubting, which I think to me is a very fundamental part of my soul, to doubt and to ask, and when you doubt and ask it gets a little harder to believe.

You see, one thing is, I can live with doubt and uncertainty and not knowing. I think it's much more interesting to live not knowing than to have answers which might be wrong. I have approximate answers and possible beliefs and different degrees of certainty about different things, but I'm not absolutely sure of anything and there are many things I don't

know anything about, such as whether it means anything to ask why we're here, and what the question might mean. I might think about it a little bit and if I can't figure it out, then I go on to something else, but I don't have to know an answer, I don't feel frightened by not knowing things, by being lost in a mysterious universe without having any purpose, which is the way it really is so far as I can tell. It doesn't frighten me.