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Scientific thinking  
substantive

# "What Do You Care What Other People Think?"

*Further Adventures of a  
Curious Character*

Richard P. Feynman

*as told to Ralph Leighton*

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*I HAVE* a friend who's an artist, and he sometimes takes a view which I don't agree with. He'll hold up a flower and say, "Look how beautiful it is," and I'll agree. But then he'll say, "I, as an artist, can see how beautiful a flower is. But you, as a scientist, take it all apart and it becomes dull." I think 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, I can appreciate the beauty of a flower. But at the same time, I see much more in the flower than he sees. I can imagine the cells inside, which also have a beauty. There's beauty not just at the dimension of one centimeter; there's also beauty at a smaller dimension.

There are the complicated actions of the cells, and other processes. The fact that the colors in the flower have evolved in order to attract insects to pollinate it is interesting; that means insects can see the colors. That adds a question: does this aesthetic sense we have also exist in lower forms of life? There are all kinds of interesting questions that come from a knowledge of science, which only adds to the excitement and mystery and awe of a flower. It only adds. I don't understand how it subtracts.

I've always been very one-sided about science, and when I was younger

Part *I*

A CURIOUS  
CHARACTER

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## The Making of a Scientist

I concentrated almost all my effort on it. In those days I didn't have time, and I didn't have much patience, to learn what's called the humanities. Even though there were humanities courses in the university that you had to take in order to graduate, I tried my best to avoid them. It's only afterwards, when I've gotten older and 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.

Before I was born, my father told my mother, "If it's a boy, he's going to be a scientist."\* When I was just a little kid, very small in a highchair, my father brought home a lot of little bathroom tiles—seconds—of different colors. We played with them, my father setting them up vertically on my highchair like dominoes, and I would push one end so they would all go down.

Then after a while, I'd help set them up. Pretty soon, we're setting them up in a more complicated way: two white tiles and a blue tile, two white tiles and a blue tile, and so on. When my mother saw that she said, "Leave the poor child alone. If he wants to put a blue tile, let him put a blue tile."

But my father said, "No, I want to show him what patterns are like and how interesting they are. It's a kind of elementary mathematics." So he started very early to tell me about the world and how interesting it is.

We had the *Encyclopaedia Britannica* at home. When I was a small boy he used to sit me on his lap and read to me from the *Britannica*. We would be reading, say, about dinosaurs. It would be talking about the *Tyrannosaurus rex*, and it would say something like, "This dinosaur is twenty-five feet high and its head is six feet across."

\*Richard's younger sister, Joan, has a Ph.D. in physics, in spite of this preconception that only boys are destined to be scientists.

My father would stop reading and say, "Now, let's see what that means. That would mean that if he stood in our front yard, he would be tall enough to put his head through our window up here." (We were on the second floor.) "But his head would be too wide to fit in the window." Everything he read to me he would translate as best he could into some reality.

It was very exciting and very, very interesting to think there were animals of such magnitude—and that they all died out, and that nobody knew why. I wasn't frightened that there would be one coming in my window as a consequence of this. But I learned from my father to translate: everything I read I try to figure out what it really means, what it's really saying.

We used to go to the Catskill Mountains, a place where people from New York City would go in the summer. The fathers would all return to New York to work during the week, and come back only for the weekend. On weekends, my father would take me for walks in the woods and he'd tell me about interesting things that were going on in the woods. When the other mothers saw this, they thought it was wonderful and that the other fathers should take their sons for walks. They tried to work on them but they didn't get anywhere at first. They wanted my father to take all the kids, but he didn't want to because he had a special relationship with me. So it ended up that the other fathers had to take their children for walks the next weekend.

The next Monday, when the fathers were all back at work, we kids were playing in a field. One kid says to me, "See that bird? What kind of bird is that?"

I said, "I haven't the slightest idea what kind of a bird it is."

He says, "It's a brown-throated thrush. Your father doesn't teach you anything!"

But it was the opposite. He had already taught me: "See that bird?" he says. "It's a Spencer's warbler." (I knew

he didn't know the real name.) "Well, in Italian, it's a *Chutto Lapittida*. In Portuguese, it's a *Bom da Peida*. In Chinese, it's a *Chung-long-tah*, and in Japanese, it's a *Katano Tekeda*. You can know the name of that bird in all the languages of the world, but when you're finished, you'll know absolutely nothing whatever about the bird. You'll only know about humans in different places, and what they call the bird. So let's look at the bird and see what it's *doing*—that's what counts." (I learned very early the difference between knowing the name of something and knowing something.)

He said, "For example, look: the bird pecks at its feathers all the time. See it walking around, pecking at its feathers?"

"Yeah."

He says, "Why do you think birds peck at their feathers?"

I said, "Well, maybe they mess up their feathers when they fly, so they're pecking them in order to straighten them out."

"All right," he says. "If that were the case, then they would peck a lot just after they've been flying. Then, after they've been on the ground a while, they wouldn't peck so much any more—you know what I mean?"

"Yeah."

He says, "Let's look and see if they peck more just after they land."

It wasn't hard to tell: there was not much difference between the birds that had been walking around a bit and those that had just landed. So I said, "I give up. Why does a bird peck at its feathers?"

"Because there are lice bothering it," he says. "The lice eat flakes of protein that come off its feathers."

He continued, "Each louse has some waxy stuff on its legs, and little mites eat that. The mites don't digest it perfectly, so they emit from their rear ends a sugar-like material, in which bacteria grow."

Finally he says, "So you see, everywhere there's a source of food, there's *some* form of life that finds it."

Now, I knew that it may not have been exactly a louse, that it might not be exactly true that the louse's legs have mites. That story was probably incorrect in *detail*, but what he was telling me was right in *principle*.

Another time, when I was older, he picked a leaf off of a tree. This leaf had a flaw, a thing we never look at much. The leaf was sort of deteriorated; it had a little brown line in the shape of a C, starting somewhere in the middle of the leaf and going out in a curl to the edge.

"Look at this brown line," he says. "It's narrow at the beginning and it's wider as it goes to the edge. What this is, is a fly—a blue fly with yellow eyes and green wings has come and laid an egg on this leaf. Then, when the egg hatches into a maggot (a caterpillar-like thing), it spends its whole life eating this leaf—that's where it gets its food. As it eats along, it leaves behind this brown trail of eaten leaf. As the maggot grows, the trail grows wider until he's grown to full size at the end of the leaf, where he turns into a fly—a blue fly with yellow eyes and green wings—who flies away and lays an egg on another leaf."

Again, I knew that the details weren't precisely correct—it could have even been a beetle—but the idea that he was trying to explain to me was the amusing part of life: the whole thing is just reproduction. No matter how complicated the business is, the main point is to do it again!

Not having experience with many fathers, I didn't realize how remarkable he was. How did he learn the deep principles of science and the love of it, what's behind it, and why it's worth doing? I never really asked him, because I just assumed that those were things that fathers knew.

My father taught me to notice things. One day, I was playing with an "express wagon," a little wagon with a railing around it. It had a ball in it, and when I pulled the wagon, I noticed something about the way the ball moved.

I went to my father and 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. Why is that?"

"That, nobody knows," he said. "The general principle is that things which are moving tend to keep on moving, and things which are standing still tend to stand still, unless you push them hard. This tendency is called 'inertia,' but nobody knows why it's true." Now, that's a deep understanding. He didn't just give me the name.

He went on to say, "If you look from the side, you'll see that it's the back of the wagon that you're pulling against the ball, and the ball stands still. As a matter of fact, from the friction it starts to move forward a little bit in relation to the ground. It doesn't move back."

I ran back to the little wagon and set the ball up again and pulled the wagon. Looking sideways, I saw that indeed he was right. Relative to the sidewalk, it moved forward a little bit.

That's the way I was educated by my father, with those kinds of examples and discussions: no pressure—just lovely, interesting discussions. It has motivated me for the rest of my life, and makes me interested in *all* the sciences. (It just happens I do physics better.)

I've been caught, so to speak—like someone who was given something wonderful when he was a child, and he's always looking for it again. I'm always looking, like a child, for the wonders I know I'm going to find—maybe not every time, but every once in a while.

Around that time my cousin, who was three years older, was in high school. He was having considerable difficulty with his algebra, so a tutor would come. I was allowed to sit in a corner while the tutor would try to teach my cousin algebra. I'd hear him talking about  $x$ .

I said to my cousin, "What are you trying to do?"

"I'm trying to find out what  $x$  is, like in  $2x + 7 = 15$ ."

I say, "You mean 4."

"Yeah, but you did it by arithmetic. You have to do it by algebra."

I learned algebra, fortunately, not by going to school, but by finding my aunt's old schoolbook in the attic, and understanding that the whole idea was to find out what  $x$  is—it doesn't make any difference how you do it. For me, there was no such thing as doing it "by arithmetic," or doing it "by algebra." "Doing it by algebra" was a set of rules which, if you followed them blindly, could produce the answer: "subtract 7 from both sides; if you have a multiplier, divide both sides by the multiplier," and so on—a series of steps by which you could get the answer if you didn't understand what you were trying to do. The rules had been invented so that the children who have to study algebra can all pass it. And that's why my cousin was never able to do algebra.

There was a series of math books in our local library which started out with *Arithmetic for the Practical Man*. Then came *Algebra for the Practical Man*, and then *Trigonometry for the Practical Man*. (I learned trigonometry from that, but I soon forgot it again, because I didn't understand it very well.) When I was about thirteen, the library was going to get *Calculus for the Practical Man*. By this time I knew, from reading the encyclopedia, that calculus was an important and interesting subject, and I ought to learn it.

When I finally saw the calculus book at the library, I was very excited. I went to the librarian to check it out, but she looked at me and said, "You're just a child. What are you taking this book out for?"

It was one of the few times in my life I was uncomfortable and I lied. I said it was for my father.

I took the book home and I began to learn calculus from it. I thought it was relatively simple and straightforward. My father started to read it, but he found it confusing

and he couldn't understand it. So I tried to explain calculus to him. I didn't know he was so limited, and it bothered me a little bit. It was the first time I realized that I had learned more in some sense than he.

One of the things that my father taught me besides physics—whether it's correct or not—was a disrespect for certain kinds of things. For example, when I was a little boy, and he would sit me on his knee, he'd show me rotogravures in the *New York Times*—that's printed pictures which had just come out in newspapers.

One time we were looking at a picture of the pope and everybody bowing in front of him. My father said, "Now, look at those humans. Here's one human standing here, and all these others are bowing in front of him. Now, what's the difference? This one is the pope"—he hated the pope anyway. He said, "This difference is the hat he's wearing." (If it was a general, it was the epaulets. It was always the costume, the uniform, the position.) "But," he said, "this man has the same problems as everybody else: he eats dinner; he goes to the bathroom. He's a human being." (By the way, my father was in the uniform business, so he knew what the difference is in a man with the uniform off and the uniform on—it was 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 that you've become educated about these things, there's one question I've always had that I've never understood very well."

I asked him what it was.

He said, "I understand that when an atom makes a transition from one state to another, it emits a particle of light called a photon."

"That's right," I said.

He says, "Is the photon in the atom ahead of time?"

"No, there's no photon beforehand."

"Well," he says, "where does it come from, then? How does it come out?"

I tried to explain it to him—that photon numbers aren't conserved; they're just created by the motion of the electron—but I couldn't explain it very well. I said, "It's like the sound that I'm making now: it wasn't in me before." (It's not like my little boy, who suddenly announced one day, when he was very young, that he could no longer say a certain word—the word turned out to be "cat"—because his "word bag" had run out of the word. There's no word bag that makes you use up words as they come out; in the same sense, there's no "photon bag" in an atom.)

He was not satisfied with me in that respect. I was never able to explain any of the things that he didn't understand. So he was unsuccessful: he sent me to all these universities in order to find out those things, and he never did find out.

Although my mother didn't know anything about science, she had a great influence on me as well. In particular, she had a wonderful sense of humor, and I learned from her that the highest forms of understanding we can achieve are laughter and human compassion.