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Features

A conversation with Freeman Dyson

by Helen Joyce

Freeman Dyson has had a long and distinguished career in physics. The holder of a Professorship at the Princeton Institute for Advanced Study for more than 40 years, he did fundamental work on internal physics of stars and the interactions of subatomic particle beams. He is the author of several popular science books, advocates space colonisation and the search for extraterrestrial life, and is a passionate speaker on topics as wideranging as GM crops and the search for world peace.

He describes the way he does physics as "a sort of architecture done with equations, rather than with bits of wood and steel". A self−confessed optimist, he says that having unsolved problems is what makes life interesting.

In the summer of 2003, Dyson gave the annual Dirac lecture at the University of Cambridge, entitled Looking for Life in Unlikely Places. Afterwards, Plus spoke to him about his life in science.

You can watch, or just listen to, the interview and lecture at http://www.xscite.com/FreemanDyson.

Freeman Dyson in the grounds of St. Johns College after delivering the Dirac Lecture, June 2003.

Why do you find maths fascinating?

I've never remembered a time when I wasn't in love with calculating. One of the first memories I have was when I was still being put down for a nap in the afternoons. I was in the crib and not able to climb out, and I was calculating the infinite series, 1+1/2+1/4+1/8+1/16... and discovered that it came out to 2. I remember that very vividly. It was a big moment when I found that out. I just loved calculating. It's something you're born with − it certainly didn't come from outside as far as I know.

The kind of math that I've done all my life is old−fashioned math. I never became a modern mathematician, never learned any of the abstract stuff. What I do is really nineteenth century, and it turns out of course that that is what you need for applied math. The nineteenth century is a good place to start if you want to be useful!

Is it possible, or desirable, to do physics without maths?

Yes. Dick Feynman, who was my mentor as a physicist, had very little math. He never really thought in terms of mathematics; he had a very concrete imagination. He drew pictures instead of making calculations, and somehow got the right answers.

But of course he was really a unique character, not only in his work but also in his personality. He had this remarkable vision of things, he called it the space−time approach. It meant he could reconstruct the whole of physics from his own point of view, without much in the way of equations. Instead of writing down an equation and solving it he would just write down the answer, which other people can't do. It was combined with some sort of geometrical pictures he had in his head. There have been others like that − he's not the only one − but it is unusual.

I work completely from a mathematical point of view, I was just the opposite. I have to have an equation that I can solve. So I do it the old−fashioned way, and then of course the fun was to understand what he was doing from my point of view, which turned out to be very interesting − I was able to translate his style into old−fashioned mathematics so other people could use it.

What has your mathematical training brought to what you have done?

My main teacher as a mathematician was a wonderful gentleman called Besicovitch who lived here in Cambridge. He was an emigre Russian, he talked with a very thick Russian accent − he was a great character. My style as a mathematician was strongly influenced by Besicovitch.

He worked on the borderline between geometry and set theory, both of which are kind of nineteenth century. He did beautiful proofs which are kind of architectural. Besicovitch's style was to take some rather simple question and build up an enormously elaborate construction to show that such a thing worked or didn't work and then get a very simple answer at the end. And that's typical of the way I do physics. It's a sort of architecture done with equations, rather than with bits of wood and steel.

Freeman Dyson with Martin Rees (centre) and Douglas Gough in the grounds of St Johns College, Cambridge, June 2003.
Photo and copyright Anna N. Zytkow

In your popular books you comment on topics that are not directly related to your work as a physicist. So you obviously feel that mathematicians and scients have a wide role to play in society as commentators or guides. What motivates you in this wider search for meaning and truth?

I suppose the fact that my interests have always been very much broader than my skills! My skills have always been just playing around with equations, but there is much more to life than equations. I've been interested in big human problems, and growing up through World War II I had an acute experience of war. I was involved with the bombing campaign in World War II, so it gave me the feeling that war and peace was something we have to deal with. So that's always been a big driving force for me, coming to grips with the problems of war and peace.

Freeman Dyson with Mike Green, Martin Rees and John Barrow in the background, in the grounds of St Johns College, Cambridge, June 2003.

I think the reason why scientists can deal with that is because we have an additional qualification which is nothing to do with the technical parts of science, which is that we are operating in an international community. Science is about the most international activity there is. We have friends and colleagues all over the world, including countries that are not supposed to be respectable. It's a great tradition in science that you talk to everybody and that you all understand the same things and you all understand them in more or less the same way. So as scientists we're setting a model for the world − how to operate a global enterprise without coming into collision. I think that's something we can do much better than the politicians.

I worked for a while in the United States in the Disarmament Agency which was the part of Government concerned with arms control. That was during the Kennedy administration, so it was forty years ago. The Disarmament Agency was just new then. It was only about 100 people in the whole administration. Ten of us were scientists, and the other ninety were mostly ex−ambassadors and diplomatic types and the ten scientists were doing all of the work, not because we were experts on bombs, but because we were accustomed to talking with the Russians and the Chinese and the other people who were supposed to be bad guys, and the diplomats weren't. We really believed in coming to agreements much more than the diplomats did.

I suppose that could be true of all academics − do you think it is more true of scientists?

Well, I wouldn't say that dogmatically, but I do think it is true. Science does translate much better than, say, history or law or literature. We can read other people's literature, but that is for most people an effort; most people rely on translations, so it's very different. In science you don't need translations.

Do you feel that modern scientists have an ethical role to play in the world?

Very definitely. Of course we don't all agree about ethics, but still the ethics of science I think is extremely important to most of us. First of all, not claiming to know more than you know. That's the most important thing, that science is about uncertainty rather than about certainty. So it's very different from law where everything has to be in black and white, and it's different from religion too. This tradition of admitting when you're wrong is very important. In science when you're proved wrong you just goodhumouredly say 'well, yes, I was wrong', which other people find not so easy.

You describe yourself as an optimist − why is this?

The reason I'm optimistic is easy to see; it's because I came through the 1930s. I was a teenager in the 1930s, when things were from every point of view much worse than they are today. We had a terrible economic depression, millions of people out of work, much more than now, we had Hitler to deal with, another World War coming up, which we all expected to die in − I didn't expect to survive World War II. We all expected it to be worse than World War I, and World War I was a terrible tragedy for England.

It was really a time to despair − even little things like pollution, England was filthy then compared to what it is now. I remember in London if you put on a clean shirt in the morning it was black by the evening around the collar and the cuffs. The air was filthy, the water was filthy, the Thames was so polluted that nothing could live in it − well, it's all been improved very greatly. It took just fifty years of careful attention to detail − those pollution problems are curable. The present generation has forgotten all that, they seem to think that just because pollution exists, it's a disaster. I would say the opposite, it's an opportunity for doing better.

Freeman Dyson with the statue of Fred Hoyle in the grounds of the Institute of Astronomy, Cambridge, June 2003.
Photo and copyright Anna N. Zytkow

So there are many reasons, but I think having lived through bad times is the main reason. World War II was bad enough, but it was nothing like as bad as we expected. We had read Aldous Huxley's *Brave New World* and he starts out with anthrax bombs − well, we expected anthrax bombs, there's nothing new about anthrax. It never happened, so we were lucky.

In all sorts of ways we were lucky; of course England had a better war than many places. But still, it was a tough war and nevertheless we survived, so, having lived through that, I can't take the present problems so seriously. I think none of the present−day problems are as bad as what we faced then.

And you see science and technology as being part of the solution?

It has been, yes, especially if you go to China and countries in Africa. They have a very different view of science because they know they absolutely need it. You can't imagine China in its present state of economic growth without modern technology, and of course China has got enormously more prosperous just in the last ten years. They have a very positive attitude toward technology, including genetic engineering.

The same is true of the people I know in Africa. For them, science really is a necessity of life. They don't have such mixed feelings about it.

Do we have a job to do as scientists here in the rich world, to persuade people that the doomsaying isn't necessarily correct?

Yes − but I don't try to impose my views on everybody. It's quite good to have some people to go around preaching gloom and doom, but I don't happen to agree with them. And I think it's unfair if we try to impose those views on the Chinese and the Africans.

What have you found fun about being a scientist?

The thing I have found most delightful is having friends all over the world. I just spent a couple of weeks in China. You are greeted there as a friend and colleague, and immediately you talk the same language, even if it is not Chinese! I don't have a word of Chinese, but still we could communicate pretty well.

Without the science I would just be a tourist and it does make a huge difference, having a professional contact. Of course, there are other professions which have the same kind of international spread − if you're a musician it's the same − but not for most.

And what about the actual doing of science?

That of course is always fun, because, especially being a theorist, I am free to jump around. I don't have to deal with apparatus, so if I get bored with a problem I can just scrap it and start on something else, which is what I frequently do. So I have great freedom, and especially in astronomy, we're never running out of problems.

At the moment, the two most vigorously active branches of science are astronomy and biology, and in both of them there is no shortage of interesting things to do, and not likely to be for the next hundred years.

There is a theorem proved by Kurt Godel in 1931, which is the Incompleteness Theorem for mathematics. The theorem says that if you have any finite formulation of mathematics, that is, a finite set of equations and a finite set of rules of logical inference, then you can write down statements within the language that is defined that way, and you can prove that they cannot be proved and that they cannot be disproved.

So given any finite system of mathematics, there are statements within the system that you can't decide whether they are true or untrue by using the rules, which is a very powerful and profound result. It means that any formulation of mathematics is incomplete; there are always questions that you can't answer within the system.

In fact it means that mathematics is inexhaustible − given any particular set of rules there are questions that you can't answer. You always have to invent new rules in order to decide new questions. So it's guaranteed that mathematics will never come to an end, which I think is a delightful set of affairs! It came as a big shock to the mathematicians in 1931, because they had had dreams of solving all the problems. The fact that you can't solve all the problems I think is much better.

The question is does that also apply to physics and I think it does, because in some sense physics includes mathematics, and anything you can say about the physical world you can say in terms of mathematics. Therefore if mathematics is inexhaustible then physics is also inexhaustible. I think that's also consoling to physicists, or it should be, that they won't ever come to an end of problems either.

I think you finding that consoling is probably the definition of being an optimist!

The point is that having unsolved problems is what makes life interesting. To me the idea of solving all the problems in science or in anything else is the most gloomy prospect I can imagine.

About this article

Professor Freeman Dyson is now retired from his Professorship in Physics at the Institute for Advanced Study in Princeton, where he spent most of his working life. On 16th June, 2003, he gave the annual Dirac Lecture at the Centre for Mathematical Sciences in Cambridge. His talk, entitled "Looking for life in unlikely places: reasons why planets may not be the best places to look for life", was recorded and edited by Bjorn Hassler and Adrian Cullum−Hanshaw of the Department of Applied Mathematics and Theoretical Physics at Cambridge.

You can watch, or just listen to, this interview and the Dirac Lecture at http://www.xscite.com/FreemanDyson.

Dr. Anna N. Zytkow of the Institute of Astronomy in Cambridge very kindly allowed *Plus* to use photographs she took during Professor Dyson's visit to Cambridge in June 2003.
