From Space Travel to Social Justice

An Interview with Freeman J. Dyson

with Timothy Lesle '01

Freeman Dyson has, for years, been a major voice in areas ranging from space exploration to the potential for science to help society. Originally from England, he studied mathematics at Cambridge with Godfrey Hardy before World War II brought him to work in the Royal Air Force. After the war, Dyson came to America and worked at Cornell University's department of physics with such luminaries as Hans Bethe and Richard Feynman. Dyson eventually settled in Princeton, where he worked as a professor at the Institute for Advanced Study. Well into his career as a physicist, Dyson embarked on another, this time as a writer. He has since written several books, as well as articles that have been featured in both professional and popular magazines. He has also been involved in a number of public and governmental organizations. The span of Dyson's work has been informed by a strong sense of humanity that crops up in his writing and is clearly evident in conversation. Dyson has six children, of whom he is very proud.

In April, Dyson was invited to Dartmouth as a guest of the Humanities Center. His talk, "Ten Tales for Technophiles: Technology and Social Justice," was concerned with the appropriate methods for using technology to bring about social change. The night before, he sat down with an editor from DUJS to talk about that, as well as the myriad subjects that he has been involved in. The interviewer found him to be friendly and accommodating, possessing a sharp wit and a quick laugh.

Timothy Lesle: When you were in college, you worked in the Royal Air Force for two years as a civilian. Did the war affect your science in any way?

Freeman Dyson: It didn't affect my science, but it affected my life.

I've always been involved with the political aspects of weapons and war and social consequences of science. I very quickly became involved in an organization called the Federation of American Scientists. (It's still going strong.) Scientists were traveling all the time to Washington, lobbying, having conversations with senators and congressman, just to educate them about the facts of life and what nuclear weapons could do. The main point we had to get across was that this couldn't be kept secret. The politicians at that time had their little volatile American secret, and all we had to do was to keep it secret and the rest of the world would never find out. It's the same problem we have now with this persecution of Wen Ho Lee.

They imagine that Wen Ho Lee gave some tremendous secrets to China, and they've been making life miserable for him. And, in fact, there are no secrets. The Chinese can build bombs just as well as we can. It's idiocy to think that they have to learn that from us. So that was what we had to try to convince these politicians: that we had to talk to the Russians. And unless we had an agreement with the Russians, we were going to have a disastrous arms race, which is what happened. We were lucky to survive those fifty years. The nuclear arms race as it developed was totally stupid. We have now 50,000 nuclear weapons which nobody knows what to do with. That was a consequence of not getting together with the Russians at an early stage, before the huge production began.

T.L.: In light of this interaction between government and scientists, how do you feel about the role scientists should take in terms of being outspoken, or even going into politics themselves? I know that from the Princeton area there's Rush Holt, who won a seat in Congress.

F.D.: Yes, I'm very proud of the fact. It was a great victory of course, and he's done very well as a congressman. He was a physicist and we never expected him to win. He was up against a strongly Republican district. Fortunately his opponent was a total fool, so he managed to

squeak in. But it will be harder next time because they won't be running the same fellow again. The Republicans will have a better candidate next time. But it's great that he got in.

As far as scientists doing politics is concerned, you have to choose between two ways: you can either work on the inside, or you can work on the outside. You really can't do both at the same time. Some of my friends are very effective on the inside. To be effective they have to keep quiet. The rule of the game is that either you get something done, or you get the credit for it, but not both. So if you go that route, you have to be invisible. But the other way is to go out and speak in public and organize things like the Federation of American Scientists. You have to choose.

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On the whole, I've worked mostly on the inside. I've not been politically active, but I do advise the government. Occasionally they may take my advice, but you never know. If something good happens, then the whole point is you give them the credit for it. The ideal thing is to make the President believe that he thought of it himself.

T.L.: Your father was a musician, your relatives had wide interests. How is it you chose mathematics?

F.D.: Certainly because I had a gift. It's something you have no control over. It was, in a way, against my better judgment. I was much more interested in medicine and biology. Even as a kid, I wanted to be a medical doctor. I didn't want to be a mathematician. I had an uncle that was a medical doctor that I admired very much. But to be a medical doctor I had to do biology. And I remember one of the saddest experiences in my life was that I decided I wanted to be a biologist. So I went and caught a crayfish in a neighboring stream and brought it home and tried to dissect it. It was a bloody mess, I didn't succeed. After a while, it began to stink. I didn't have the skills to do that, so it was a complete failure.

But from about three years old, I had a gift for mathematics and so always at school I was number one in mathematics. I sort of drifted into mathematics as a career, because that was what I could do, and that's remained so. All the real work I do is always mathematics, although it may be applied to physics. I apply it to all kinds of things. Basically, what I do is scribble equations, and that's always been so. If you have the gift, it's sort of pointless to try to do something else, really. Except for writing, I have also a gift for writing. So that was a change of career when I was about fifty. I decided to divide the time between science and writing. Since then, I've become sort of fifty-percent scientist and fifty-percent writer. I find writing just as much fun as science. This book about origins of life: that's my only serious effort in biology. The origin of life of course, is a good field for an amateur because nobody knows anything about it.

T.L.: You didn't take a Ph.D., and then you went on to work at Cornell and the Institute for Advanced Studies. Could you tell us what your argument against the whole system is? What is your opinion of that sort of specialization?

F.D.: Yes, I'm not against specialization. I think for young people, to be specialized makes sense because you want to get deep into a subject and actually do something before you try to learn everything. There's a lot to be said about being specialized when you're young.

I detest the Ph.D. system because it's applied to everybody in this brutal way. It forces you into this very narrow specialization and it keeps you there for five or six years. And it's totally inappropriate for most of the people who don't want to become academics, who don't want to become scholars for the rest of their lives. They're forced to take the Ph.D. because it's a sort of union card to doing any sort of technical chore. That is, I think, a disaster. I've seen it actually destroy people. That's why I'm so violent against it.

I contrast that with the old times, before this became such a rigid system, when people could move much more freely between one profession and another. So I'd like to give everybody a Ph.D.

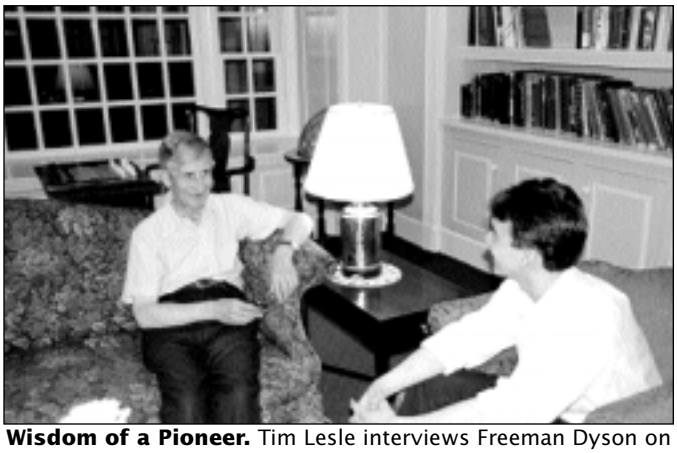
at birth and make the thing completely trivial. Get it out of the way.

T.L.: Could you describe your experience with Project Orion [developing new spacecraft propulsion]? You had a lot of ideas brewing in your group, which was made up of young scientists.

F.D.: This Orion Project was a crazy idea. I think it could have worked, technically. It would have covered the globe with radioactivity, so that wasn't such a good idea. And I could see that from the start, that this problem with radioactive fallout would be the showstopper in the end. It wouldn't fly because of the fallout problem. But still, apart from that, it was a great idea.

T.L.: And this was…

F.D.: It was a bomb-propelled spacecraft. It would be a big spaceship built like a submarine. It would be comfortable living for a dozen people or so to cruise around the solar system to the various planets and satellites. It would have really opened the whole solar system for human travel in a way that chemical rockets just can't do. We worked very enthusiastically on this in 1958, just after the Russian Sputnik went up. The government was willing to support crazy schemes like that, and so we got a few million dollars and built small models and flew them and designed the big ship. We worked out all the science, and it worked pretty well, I think, technically. But, when it came to actually doing bomb tests, which you need to do, we never got the green light. The thing always got stuck because we needed to do a real nuclear test, and no one would give us that.



Wisdom of a Pioneer. Tim Lesle interviews Freeman Dyson on April 24, 2001.

T.L.: You've written about other potential technologies, such as laser propulsion. Do you see our space program going in that direction at all?

F.D.: I think NASA has done a miserable job supporting anything you might call any sort of new technologies. They've been deathly afraid of anything that might compete with the shuttle. At NASA for the last thirty years, the political imperative has been the shuttle. That's been a complete roadblock. I don't have much hope for NASA doing this. But the nice thing is that, after all, the world is a big world. There are many countries now involved in space. The Europeans are doing very well; the Japanese are doing well. Now the Indians and Chinese are beginning. There are lots of private companies also and there's a good chance somebody will do this.

T.L.: I first heard your name in reference to the "Dysonsphere," the civilization covering an entire star. Can you clear up what you had originally said about that, versus what is popularly perceived?

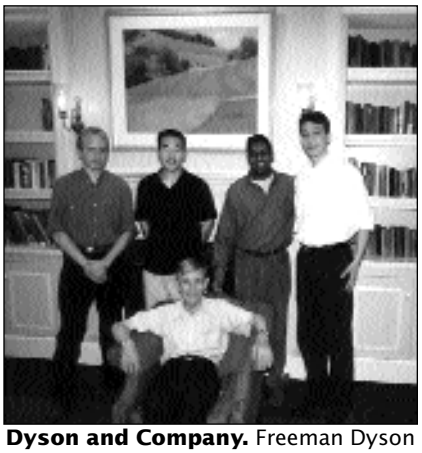
F.D.: Sure, that's easy to do. Cocconi and Morrison who were two Cornell physicists proposed listening for radio signals from aliens, which was a brilliant idea. They calculated with existing transmitters and receivers—radio communication is wonderfully sensitive, even over huge distances—that you could have aliens transmitting by radio from thousands of light-years away, and we could actually hear the signals on earth. If they wanted to communicate with us they could. Frank Drake, then, who is an astronomer still active in the business, actually did a search with a radio telescope. That happened in 1959, I think.

And it occurred to me that, after all, aliens might not want to communicate. And suppose you have aliens that don't communicate, then could you detect them? I thought about that, and the answer was very clear. Whether aliens want to communicate or not, if they're a highly developed civilization with a lot of technology, a lot of machines, a big population, they have to process a lot of energy. And the laws of thermodynamics say if you use a lot of energy, you have to radi-

ate it into space. There's no other way of getting rid of it, which means infrared radiation: That's where I started.

I wrote a little one-page article in *Science* magazine, with the title "Search for Artificial Sources of Infrared Radiation." I proposed this way of searching, and unfortunately I used the phrase "artificial biosphere" to describe the thing we were looking for. I used the phrase artificial biosphere to mean the habitat where these creatures are living, and the outside surface would be warm and radiating all this infrared.

Actually, what I had in mind was a cloud of orbiting objects around a star, which would be picking up starlight and using that to live on them and radiate away the waste heat on the outside. So that was the picture, but I didn't have any particular shape in mind for that. Anyway, the science fiction writers, Larry Niven in particular, picked up this idea. They thought of the artificial biosphere as being a big round ball. That was fixed in their minds and they called it that the "dysonsphere," and that's what you see on Star Trek. It's not at all what I had in mind.



Dyson and Company. Freeman Dyson with some members of the DUJS Board.

It's actually a physical impossibility to build a ball of that size. It'd be gravitationally unstable and collapse under its own weight, and doesn't make any sense. It's got to be orbiting, and of course if it's orbiting, it couldn't be a sphere.

T.L.: Well, now we know.

F.D.: That's the explanation. And in the meantime I got to be famous, which is always fun.

T.L.: You're very interested in biology and you talk about genetic engineering, the Genome Project. You have mentioned two specific applications of genetic engineering. One is using viruses to test cells—using stimuli to understand the workings of the cell. A second is sending chickens into space?

F.D.: That's also a joke, of course. I was talking about the way to do space exploration with biotechnology, which I think is very likely the way to make it very cheap and effective. So you'd picture something like a bird, with a really effective brain, which would be engineered to be at home in space. You can imagine a creature that's living in a vacuum, and it's a combination plant and animal, so it uses sunlight as a source of chemical energy. And instead of breathing air, it just manufactures oxygen in its wings. It functions as a combination plant and animal, and it has a brain and it flies around like a sailing boat in space. It has big solar sails instead of wings. It could do everything that an explorer needs to do, very much more flexible than anything we have today. I actually didn't have a name for this. I gave a talk about it in Australia, in Adelaide, and somebody in the audience shouted, "Oh you mean this is an astro-chicken." It makes it clear that this is really a joke, and not a serious scientific proposal.

I think it's a sensible idea, but one shouldn't take it literally. We don't have the science yet; we don't have the technology. It would be a disaster if NASA tried to do this in the bureaucratic NASA style.

T.L.: You are rather critical of the Genome Project because of cost. You're obviously a big supporter of cost reduction.

F.D.: I don't say we shouldn't have big, expensive projects. You have to have big, expensive projects. The point is they shouldn't dominate. It's like in ecology, where you have a top predator, which is the biggest animal, and under that you have the much larger population of herbivores. The same thing should be true in science. Have a few very big projects, but they should only be used when there isn't any other way. In biology, it isn't bad. The genome project isn't that big compared with the whole range of projects. It's a big project, but it's not dominating biology.

Their mistake, which I'm sorry about, is they haven't tried to develop technology to do it 1000 times cheaper. I think it is feasible. I can imagine a physical method of sequencing where the DNA molecule is somehow suspended in a vacuum one molecule at a time and you just go zap-zap-

zap-zap down the molecule with a mass spectrometer or something to weigh the individual bases as they come off the end. You can imagine doing an individual genome at the rate of a thousand bases per second or something like that, by using physical tools. And it could be vastly cheaper and vastly quicker. But they haven't put much effort into doing that. Instead they're using the same old chemical methods invented 25 years ago. They work, but they are very labor-intensive and slow. So this means every genome that's done is a major project. They've decided to do the mouse and the chimpanzee, and each one of them is a big deal. If it were a thousand times cheaper, we'd be doing all of these things, and it wouldn't require big fund-raising to do them.

T.L.: In a broader sense, how do you see science today helping people in general? How do you see science reaching everyone, not just those who can afford it?

F.D.: Well, this is very difficult and we don't know all the answers. I wrote this book *The Sun, the Genome, and the Internet* about that question. I do believe very strongly in biologically engineered plants as enormously helpful. I'm very cautious about applying genetic engineering to humans, but I think there's enormous potential in applying genetic engineering to plants, for energy production in particular.

One of my dreams is that wealth moves from the city to the countryside all over the earth, because we're using solar energy as a source of power and chemicals. Solar energy has this wonderful property: that it's well distributed over the earth, especially in the tropics, where most people live. So people can generate wealth, industries, fuel, everything they need for modern life locally, wherever there's sunshine.

And to do that you need a crop plant that converts sunlight directly into liquids. Most trees convert sunlight just into cellulose. You have to chop trees to harvest the cellulose, and it's a messy and disgusting operation. You could avoid all that, if you had trees that produce liquid fuel and pipe it down directly into pipelines into the ground, and if they could be more efficient than existing trees.

The third item in the trio is the Internet. If you have all these people living in the countryside, and they have good communication with the rest of the world, they are part of the modern economy.

T.L.: This leads to this idea of social justice, which you discuss often. How do you define social justice? Particularly in terms of sharing technology: do you want everyone to be on the same level?

F.D.: I certainly don't want to make the world into some sort of uniform, homogenized mass. That would be horrible. I'd like to preserve local cultures as much as possible, preserve languages and differences between people. The point is to give people, more or less, the same opportunities. That was the way it was supposed to be in this country, but isn't really. The chance to get ahead in the world—that's what I call social justice. Not to abolish poverty, I don't think that's possible—I think there will always be some difference between rich and poor. But to make them less extreme, so every African village is living at a reasonable level of prosperity, so the kids have a good education and can travel and choose whatever professions they want. I think that's my ideal. Of course, there are all sorts of obstacles in the way. I'm not pretending that we can actually do that; all I'm saying is that's what we should be striving for.

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T.L.: You have mentioned your daughter, a cardiologist, who had the hard choice of staying at a public hospital, helping more people who had less money, or going to a private practice and being able to give better service only to those who could afford it. You say society should have been set up to avoid that question in the first place. You also mention the case of Bob Freling and the Solar Electric Light Fund program, almost

a one-man show. Do you see positive change as something that has to take hold on the individual level, a grass-roots operation? Or do you see this as more of a top-down situation?

F.D.: Well, those are two very different questions. You talk about public health service—the choice my daughter had to make in California. That's simply because there is no decent public health service in this country. In a country with good public health service this problem doesn't arise. So that's something that has to be done from the top down. To lack a national health service is something that I find is the worst feature of this country from my point of view. Most other countries in the world do better

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On the other hand, the thing Bob Freling is doing in Africa is bottom-up. He's working in individual villages to introduce computers into the high school to educate the kids. That's something you can only do locally. So you need both.

T.L.: Do you think that society is moving in a direction that is conducive to your idea of social justice? Or do you think changes need to be made?

F.D.: I'd say it's going in the opposite direction in many respects in this country. The rich are getting richer and the poor are getting poorer. This global economy is definitely making the rich richer almost all over the world. The people who benefit are the people who are already in business. The local farmers and small business people tend to be worse off as a result. They can't compete. It's polarizing things more and more. I think we're definitely sliding backwards.

One of the things that could help is genetic engineering applied to plants. I was at this meeting in Switzerland this January, the World Economic Forum. There was this interesting confrontation there between the Europeans and the Africans on the question of genetically modified foods. The Europeans are sort of ideologically opposed too these foods. They regard them as unacceptable, so they close their borders to any imports of genetically modified foods. On the other hand, the Africans desperately need genetically modified foods because their crops are doing poorly, in most of Africa they have poor soils and bad climates. They desperately need these improved crops in order to survive. And they'd also like to sell their produce to Europe, so there's a direct confrontation between the Africans and the Europeans. And of course, I'm 100 percent on the side of the Africans. It's absolutely immoral, the way the Europeans are behaving on this issue, and the United States is somewhere in between. I think the world needs this very badly, and to oppose it on grounds of ecological purity—that's just a luxury for the rich. It's something the poor shouldn't have to suffer for.

T.L.: We've talked about a number of things, and I really need to ask this very basic question: how do you get involved in all of this?

F.D.: I've been so lucky, because through becoming a writer I've broadened my contacts enormously. I meet many more different kinds of people. I'm invited to all kinds of meetings, like that World Economic Forum. So it's a kind of autocatalytic process….

T.L.: When you were at the world economic forum, you participated in three debates. The third was against Brian Greene, the particle physicist—

F.D.: "When will we know it all?"

T.L.: When *will* we know it all?

F.D.: I think science is essentially inexhaustible. Every time you solve one problem, you find two others. So I don't think we'll ever know it all. I hope not: That would be very boring. ■

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