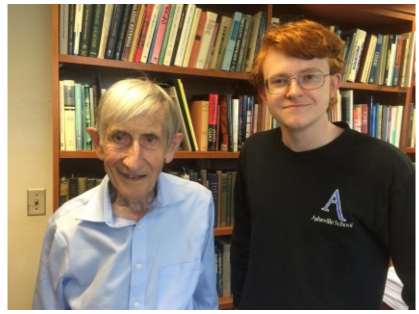
Maker of Patterns: An Interview with Freeman Dyson

by Austin A. Morris

"I will squeeze the dry orange once more and hope to find a few drops of fresh juice," the nonagenarian scientist says.



Soon to be ninety-five years old, Freeman Dyson may well be considered the grand old man of modern physics. His life has been diverse and steeped with controversy. A pure mathematician and theoretical physicist deemed prodigy, he unified three competing theories of quantum electrodynamics and was consequently given a lifetime appointment to the Institute for Advanced Study by Robert Oppenheimer, father of the atom bomb. During the 1950s, Dyson spent a year working on Project Orion, a secret study to design a nuclear-powered spaceship. He afterwards qualified as a member of the elite government advisory group called JASON, which he has served for more than five decades. Aside from being a great scientist, he has written many books on ethics and being a good human being. His most recent book titled Maker of Patterns recounts signal moments of his life spanning forty years of letters sent to his parents.

I conducted the following interview with questions posed by students from the University of Edinburgh. The last two questions come from Alumnus Richard Henderson and Honorary Professor Michael Atiyah, Nobel Prize and Fields Medal recipients, respectively.

What do you think was the greatest scientific achievement of your lifetime? What was the biggest setback? -Vedant Bhargava

My most important contribution was the unification of the Feynman-Schwinger-Tomonaga versions of quantum electrodynamics. My biggest mistake was claiming that weakly-interacting charged bosons could not exist because they would contradict the stability of matter. This claim was demolished by the discovery of the W and Z particles a few years later.

[The 1965 Nobel Prize in Physics would have almost certainly been awarded to Dyson if it had not been for the three-person limit, which still exists today. The prize was shared between Feynman, Schwinger, and Tomonaga.]

Do you think there is any scientific theory that should be abandoned, i.e. one that is not supported by observations (e.g. supersymmetry)? -Christos Kourris

No scientific theory should be believed as permanent truth, and no theory should be abandoned as unsupported by observations. All theories are uncertain and all might turn out to be useful. Example of a theory that was like supersymmetry for a long time but turned out to be useful: Lie Algebras. Only after the invention of quantum mechanics did Lie Algebras unexpectedly become the language of particle physics.

A wicked problem is an intractable global problem with seemingly no satisfactory solution. Are there any wicked problems today that you would like to see addressed? -Ethan van Woerkom

The wicked problem that affected me most directly was the wartime socialist ethic that prevailed in England during World War II. The socialist economy and the socialist ethic that allowed it to flourish are remembered by survivors of my generation as a magic time when we all shared the hardships and money was unimportant. The wicked problem is, why do we have to have a war to make socialism work?

Your mentor, GH Hardy, in his 1940 release "A Mathematician's Apology", revealed an antipathy for applied mathematics as compared to pure mathematical endeavors. His example of number theory as an innocent pursuit ironically backfired when it was used during the war to crack German enigma codes. You were influenced by Hardy, whose preference was to stay in the ivory tower. You, on the other hand, became a statistician during the conflict, applying mathematical principles to flight formations for the RAF. Was this a difficult decision for you to make?

I am not sure whether the code-breakers in World War II used number theory to crack codes. I think the use of elliptic curves in cryptography came later. The enigma operations probably had nothing to do with pure mathematics in the style of Hardy.

My own job at Bomber Command had nothing to do with mathematics, either pure or applied. I was put into the job by the novelist C. P. Snow, who was then a bureaucrat responsible for placing young scientists into wartime jobs. My job was collecting intelligence about bomber losses, trying to find out how the Germans were so successful in shooting our bombers down. My most useful source of information was talking to the one per cent of bomber crews who survived being shot down and walked home through France and Spain. I had no difficulty in accepting the job. The job was frustrating because our boss Basil Dickins never told our Commander in Chief Arthur Harris anything that Harris did not want to hear. The obvious way to reduce bomber losses was to stop flying deep into Germany in poor weather when we could not expect to do much damage. But Harris did not want to hear that.

Hardy was sixty-seven years old when he lamented in the Apology that his creative talents were passé. You are ninety-four. Did you at some point in your life experience a similar epiphany? Is your recently published book, Maker of Patterns, in any way analogous to the Apology, or is it more akin to the playful musings of Richard Feynman?

Like Hardy and other mathematicians, I encountered a mid-life crisis around age forty-five, when I saw that I was no longer as smart as the young people around me. I needed another line of work besides doing research. Following Hardy's good example, I started to write books. For the second half of my life, I spent half of my time doing science and half writing books. I wrote books in a totally different style from Hardy. My style was personal, addressed to the general public and telling stories about people I happened to know and historic events that I witnessed. Hardy's style was impersonal, addressed to students and professional mathematicians, except for one book, "A Mathematician's Apology", written at the end of his life. The Apology is addressed to the general public but is still impersonal, talking mostly about mathematics and not much about himself.

My most recent book, Maker of Patterns, takes its title from Hardy but has no resemblance to Hardy's Apology; it also has no resemblance to the personal writings of Feynman. Maker of Patterns is a collection of letters written long ago with no thought of publication. I published it as a family chronicle, to give my children and grandchildren a better awareness of their roots.

Do you think private entrepreneurship could result in cheap and commonly beneficial colonisation projects in space, and will nuclear rockets ever supersede conventional chemical rockets? -Myles Khela

The age of private entrepreneurship in space is already here. A few days ago I heard a television talk by the chief of a private company called Planet Lab in San Francisco. Planet Lab has 300 spacecraft already in orbit around the earth, Cube-sats with high-quality cameras taking pictures of the earth all the time, covering the whole earth with five-meter resolution every day. The pictures are distributed every day to his customers as needed. The customers are farmers, forest managers, fishing-boat owners, traffic managers, environmental monitors of all kinds. They pay a modest fee for his services. He says it costs him more to distribute the information than to collect it. The cube-sats are amazingly cheap since they are a by-product of the commercial cell-phone camera industry.

He ended his talk saying he had bad news and good news. The bad news is that he just lost twenty cube-sats on the launch-pad when the launch-rocket exploded. The good news is that the loss does not affect his business. The twenty cube-sats are quickly replaced, and the flow of information to the customers is not interrupted.

Of course Planet Lab is not a colonization project, but the style of Planet Lab will certainly be adapted to colonization before long, with big advantages in cost and flexibility.

The answer to the question whether nuclear rockets will supersede chemical rockets is no. Different missions need different types of propulsion. Chemical rockets will be good for local missions. Solar electric propulsion is good for longer-range low-acceleration missions. Laser propulsion and microwave propulsion will be good for high-velocity missions. There does not seem to be any type of mission that is well matched to nuclear rockets. Nuclear rockets are too heavy for local missions and too slow for high-velocity missions.

To follow up on the nuclear rocket question: would a doomsday asteroid deflection scenario warrant an [Project] Orion reboot? From what I understand nuclear propulsion offers tremendously more payload, thrust, and blowback power than a chemical rocket.

I say no to Orion reboot. Asteroid deflection requires momentum, not energy. A slow push is far more effective than a quick jolt. The best way would be a mass-driver landing on the asteroid and throwing off mass at low velocity. This could be done as quickly as an Orion reboot, and with much higher efficiency. Of course you can make up a story with Orion doing the job quicker, but in the real world this seems unlikely.

[The Project Orion nuclear spaceship would require more than eight hundred atomic bombs of varying charge momentum to reach orbit. Propelled by successive nuclear explosions, the ship would be jolted upwards, protected at its base by a blast-proof pusher-plate. Because of its massive payload, the rocket could be fitted with nuclear cannons capable of razing entire continents. Then President John F. Kennedy, who had been through one nuclear standoff already, dismissed the notion of producing such a device.]

I received several questions related to the Dyson Sphere, which you say is a misnomer. What was your original conceptualization of an artificial biosphere and how might an advanced civilization go about building one (e.g. homopolar generator acting on a planet)?

The 'Dyson Sphere' arose out of asking the question, "How could we detect an advanced civilization that does not wish to communicate?" To be detectable at a big distance, the civilization must emit big amounts of energy, comparable with the total output of a star. The star must be surrounded by some kind of shell where the aliens live at a comfortable temperature; the shell will absorb most of the starlight and emit thermal infrared radiation from its warm surface. We detect the infrared emission.

This statement so far is correct and uncontroversial. Unfortunately I went on to speculate about possible ways of building a shell, for example by using the mass of Jupiter. Jupiter could be spun up to rotate much faster, and mass would move out from Jupiter's equator to form an orbiting ring. The mass in the ring could be moved away from Jupiter to form a shell around the star. This could be done in a few thousand years using the energy from the star. These remarks about building a shell were only order-of-magnitude estimates, but were misunderstood by journalists and science-fiction writers as describing real objects. The essential idea of an advanced civilization emitting infrared radiation was already published by Olaf Stapledon in his science fiction novel Star Maker in 1937.

When will any sort of life be discovered on another planet (e.g. Mars), and when will intelligent life be discovered anywhere else in the universe? Note that Francis Crick published a book in 1981 called 'Directed Panspermia'. -Richard Henderson (Nobel Prize recipient 2017)

I have made a bet long ago that the first extraterrestrial life discovered will not be on a planet. The bet is still open. It makes no sense to guess when this discovery might happen. The whole point is that discoveries are unpredictable and nature is always ready to surprise us. This statement applies equally to unintelligent and intelligent life.

[Readers should here be warned that Dyson once told a young Francis Crick not to leave physics for biology. Dyson's bet was wrong and Crick went on to win a Nobel Prize for his work in the discovery of the double-helix structure of DNA. In this case, Richard Henderson does not need any reassurance. He left physics for biology and has already won a Nobel Prize. For those of us that have not: look no further than Dyson's last line (above).]

Now a question from Michael Atiyah. He claims to have recently proven the Riemann Hypothesis, the million-dollar problem of mathematics. Literally. **Is the proof of the Riemann Hypothesis hidden inside a black hole?** -Michael Atiyah (Fields Medal recipient 1966)

I would prefer the question to say: is the proof of the Riemann Hypothesis hidden inside a quasi-crystal? I see no plausible connection between the Riemann Hypothesis and black holes. Now I am waiting for Michael Atiyah to reveal his magic, to prove me wrong and Riemann right.

[I have since shared this answer with Michael Atiyah. He insists there is a connection between the Riemann Hypothesis and black holes. "Dyson is ninety-four years old," Atiyah said, implying age to be a factor. "Careful, Dr. Atiyah. If Dyson hears about this he might investigate your proof and end up proving it himself." Atiyah laughed, then got serious. I could not read his lips but I think he said something like: "game on."]

Freeman Dyson and Michael Atiyah have known each other since meeting at the Institute for Advanced Study in the 1950s. Atiyah recalls a story from Cambridge when Dyson, then a pure mathematician, told Harish-Chandra he was going into physics. "Why are you going into physics? It's a mess," Harish-Chandra said. Dyson responded, "I am going into physics because it's a mess." A maker of patterns he is. Freeman Dyson went into physics to clean it up, and that is exactly what he did.