Freeman John Dyson, FRS*

15th December 1923–28th February 2020

Freeman Dyson was indubitably great
with creativity eternally at spate.
A physicist and a mathematician as much
who resolved mysteries with a magical touch,
and didn't even need a doctorate!

Using original ideas which were deft, he
polished off problems considered hefty.
Feynman, Schwinger or Tomonaga,
Dyson showed were equivalent saga,
thereby throwing light on QFT!

Dyson's name comes immediately to the mind when we think of the legacy of the mathematician-cum-physicist Hermann Weyl. Dyson also contributed extensively to both physics and mathematics. His books and talks are testaments to his prolificity in writing widely on the world at large and on science and mathematics in particular. To name a few of his books, he has (talked and) written on Bombs and Poetry, Imagined Worlds, Origins of Life, and Birds and Frogs.

As a testament to his precocity during childhood, his older sister Alice remembered him being surrounded by encyclopedias and furiously calculating on reams of paper; at the age of 4, he tried to calculate the number of atoms in the Sun. Dyson started his undergraduate studies at Trinity College, Cambridge, England, under the influence of the analytic number theorist G H Hardy (while playing billiards together). Apart from number theory, Dyson was interested in mathematical facets of theoretical physics and published papers on them. During that period, some questions at the forefront of the study dealt with the renormalization theory associated with quantum field theory that tries to control tricky infinities that came up in the physical predictions. Having gotten interested in these aspects, Dyson went to Cornell to study with the physicist Hans Bethe for his postgraduation as a Commonwealth Fellow. After spending the year 1948–49 at the Institute for Advanced Study (IAS) at Princeton, he returned to the UK as a Research Fellow at the University of Birmingham during 1949–1951. In 1951, he was invited to accept a faculty position at Cornell, and amazingly, he did not have a doctorate! In December 1952, Oppenheimer, who was the Director of IAS, Princeton offered Dyson a

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lifetime appointment at the Institute. He remained at the Institute throughout his career. Dyson grabbed the attention of the physicists' world first for his proof that the approaches to quantum electrodynamics by Feynman through his path diagrams and by Schwinger by his operator method were completely equivalent. In fact, it is said that initially Oppenheimer did not accept Dyson's assertion that these diverse approaches were the same, and after getting convinced of the correctness, Oppenheimer offered Dyson the position at IAS quipping, "for proving me wrong."

Dyson's seminal work on partitions in the 1940s was enormously influential. In it, he defined the notion of the rank of a partition to explain Ramanujan's congruences. One family of congruences still did not come under its ambit for which Dyson defined a hypothetical notion called the crank of a partition. He defined what properties it must possess if it were to exist. In that paper, he says, "Whatever the final verdict of posterity may be, I believe the "crank" is unique among arithmetical functions in having been named before it was discovered. May it be preserved from the ignominious fate of the planet Vulcan!"

Dyson was not only a leading scientist and mathematician, he was a humanist in a deeper sense of the word, and wrote copiously on all aspects of life. On the origin of life, he propounded a dual origin theory, towards which there is no direct evidence as of now. The nomenclature "green technology" is due to Dyson. In his book, *The Sun, the Genome and the Internet* published in 1999, he envisaged designing of new species of plants and other organisms to meet human needs. He thought of solar energy as powering these technologies, and vociferated that genetically engineered crops could help alleviate rural poverty, and lead to an equitable distribution of wealth. In his words, "with all three components (those mentioned in the title) in place, every village in Africa could enjoy its fair share of the blessings of civilization." Dyson thought of a genetically modified tree (now called Dyson tree) that could grow on comets which could be engineered to have hollow spaces of atmosphere to breath, so that humanity could have a self-sustaining habitat outside the solar system as well.

During 1957–61, Dyson worked on Project Orion, which was a programme to directly propel spacecrafts through atomic explosions behind the craft. The prototype had also been tested. However, the Partial Test Ban Treaty (PTBT) of 1963, which bans testing in outer space (which Dyson himself supported), led to the shelving of Project Orion in 1965. In fact, Dyson became a part of a team (called TRIGA) in 1958 to design safe nuclear reactors for producing medical isotopes in hospitals.

The contributions of Dyson are so numerous that only a few can be described in some detail in a publication like *Resonance*. In this issue, there is one article by Patrick Dasgupta outlining Dyson's manifold contributions to physics and one on his mathematical contributions by the

author. Dyson himself remarks in an article titled 'Missed opportunities' how the mathematician Dyson and the physicist Dyson were not in talking terms for quite some time (leading to missed opportunities of a collaboration). One of the most topical mathematical themes to which Dyson's brilliance contributed to is the random matrix theory, providing a serious approach to the holy grail of mathematics—the Riemann hypothesis.

Many notions have been named after Dyson. Dyson envisaged genetically engineered trees that could grow on comets; they came to be called Dyson trees. We also have the Dyson sphere, an artifact lending shape to his speculation that an extraterrestrial civilization that may be technologically advanced would probably be found occupying an artificial biosphere which surrounds the parent star. A beautiful idea in combinatorial number theory called the Dyson transform was crucial in a proof that every even number is expressible as a sum of at most 6 primes. A series solution of a time-dependent Schrödinger equation found by iteration is known as the Dyson series. The notions of rank and crank of partitions are due to Dyson and are named after him.

Freeman Dyson was honored with several awards and prizes. The list is long, and we mention only a few. He was elected a Fellow of the Royal Society (FRS) in 1952. Medals named after Lorentz and Max Planck were awarded to Dyson in 1966 and 1969 respectively. Dyson was also elected an Honorary Fellow of Trinity College, Cambridge in 1989. Finally, he received the first Presidential Science and Humanism Award from the American University of Beirut in 2018.

In 2018, Dyson published his autobiographical work based mostly on his letters to others. This is titled *Maker of Patterns* (as Hardy would describe a mathematician), and is a compelling narrative tracing the history of science and mathematics in the background.

Although Dyson received several scientific awards, he did not win a Nobel Prize. Nobel laureate Steven Weinberg is said to have commented that the Nobel committee "fleeced" Dyson. However, Dyson himself spoke about it in 2009 and said "I think it's almost true without exception if you want to win a Nobel Prize, you should have a long attention span, get hold of some deep and important problem and stay with it for ten years. That wasn't my style."

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