A MAN WHO CHANGED THE WAY WE SEE THE WORLD

The Centenary of Sir Fred Hoyle (1915-2015)

Kamala Wickramasinghe

He strode the scientific stage of the 20th century like a colossus inspiring a whole generation of scientists but also reaching out to millions with his lectures and his science fiction works. Throughout a career spanning six decades, he sought answers to some of the biggest questions posed by physics and astronomy and was a tireless and creative pioneer, the latter often leading him to being at odds with the mainstream of science. He invented the Steady State theory, was the founder of astrobiology and he discovered how the chemical elements, which are the basis of all life, are formed. His legacy to modern science is arguably unparalleled and his more radical theories about the origin of life are finally on the brink of being accepted.

Sir Fred Hoyle was a regular guest at my family home during my childhood and early adulthood. His visits were owed to his long scientific collaboration with my father on the cosmic origins of life. Yet Hoyle's pursuits were not confined to this area. Not only did he have a knowledge of astronomy that seemed encyclopaedic but he was also able to apply his intelligence and creative thinking to a wide array of disciplines. During his visits, he used to engage myself and my siblings in various discussions ranging from Shakespeare to politics to food and of course science. He had a passion for music and walking and used them as tools to aid his creativity. His mother had studied piano at the Royal College of Music and had imbued in him a deep love for the piano. I myself had studied the piano to a high level and Hoyle would often ask me to play whilst he and my father were attempting to unravel the unanswered questions posed by the Universe.

In 1983, prior to one of Hoyle's visits to our home, I overheard my parents discussing the fact that a Nobel prize had been awarded to Hoyle's friend, the scientist Willy Fowler, for work in nuclear physics that had been led and essentially carried out by Hoyle. Hoyle had been the originator of a theory of the natural history of our known chemical elements and went on to lead the team that resulted in its proof in the 1950s.

For many hundreds of years philosophers and alchemists had puzzled about how the different chemical elements in the world came to be. The elements that all life depends on seemed to have an origin which eluded discovery until Hoyle led an investigation which unlocked this great mystery of the natural world.

By the 1940s, it was already known that the process by which energy is generated in stars involved nuclear fusion - the conversion at very high temperatures of the simplest element hydrogen to helium. But the precise link between such processes to the evolution of stars, and the formation of carbon, nitrogen, oxygen and other elements was yet to be discovered.

Fred Hoyle began to link the evolution of stars to the origin of the chemical elements heavier than helium. As the hydrogen fuel in a star like the sun becomes exhausted, its central core contracts to become hotter and this permits the helium to be transformed into carbon, nitrogen and oxygen.

At this point in the chain of reasoning Fred made a profoundly important scientific discovery. Using the science of nuclear physics he calculated that in order for carbon to be produced in this way, the nucleus of carbon must possess an "excited state energy level" that was not known to exist at this time. Convinced that carbon in the cosmos had to be produced in this way, Hoyle thereupon approached Willy Fowler, Director of the Kellogg Radiation Laboratory at Caltech and asked him to use his laboratory to look for carbon. It was found to be present.

In the early 1950's Fred Hoyle entered into his historic collaboration with Willy Fowler, and astronomers Geoff and Margaret Burbidge which culminated in a game-changing B2FH paper in Physical Reviews. In this paper Fred and his team showed convincingly how stars evolve over time and in the process synthesise all the known chemical elements through nuclear processes (first fusion, and later addition of neutrons). These chemical elements are eventually scattered back into interstellar space in exploding stars called supernovae, so producing the raw materials of life.

The reason that Hoyle was excluded from the Nobel Prize for this work remains a topic of speculation but was not one which he himself talked about much. Interestingly Willy Fowler had, in the months preceding the award, been asked by Hoyle's granddaughter to write an article for her school magazine. In the article, Fowler had stated that Fred was the pioneer of the work and its main driving force.

Despite holding prestigious posts - Hoyle was Plumian Professor at Cambridge and founder and Director of the Institute of Astronomy in Cambridge - he was often viewed as being anti-establishment. He did not allow himself to be confined to hypotheses which upheld the status quo of mainstream science, often looking for solutions in unsuspected places. Throughout our history all revolutionary advances in science have sprung from ideas that were outside the realm of conventional belief systems and, sadly, throughout our history the originators of these ideas have been viewed with suspicion.

Although Fred Hoyle's contributions extend across most of astronomy, he is perhaps best known as the inventor of the Steady-State theory of the Universe. Edwin Hubble's discovery of the expansion of the Universe in the 1930's had led to a widespread belief in the so-called Big-Bang theory of the cosmos which was readily assimilated into the establishment, not least perhaps for its fit with religious views of creation.

 During the 1950's Hoyle and his collaborators began to challenge this theory. They postulated that despite the observed expansion of the Universe - galaxies getting further apart with time - the Universe could be in a steady state if new matter and new galaxies formed continuously in the space vacated by the expansion. The theory led to many definite predictions. Supporters of the Big-Bang theory (a term coined by Hoyle as a disparaging appellation) were quick to devise experiments that sought to disprove the predictions of steady state cosmology, and by the early 1960's such predictions appeared to be going against the Steady-State theory.

The fate of the Steady-State theory appeared to be finally sealed by the discovery in 1965 of the Cosmic Microwave Background which was interpreted as the relic energy of the Big Bang, now thought to have occurred 13.8 billion years ago. But the last word may yet to be said in relation to how it all began. Multiverses, eternal inflation, oscillating universes alternating between expansion and contractions still remain in currency - and in some of these models the mathematics of the Steady State universe appears to persist.

Perhaps Fred Hoyle's most daring scientific exploit relates to his 40-year long collaboration with my father Chandra Wickramasinghe on the cosmic origins of life. After identifying the great profusion of complex organic molecules - which are the building blocks of life itself - in interstellar dust in the 1970's, Hoyle and Wickramasinghe became gradually convinced that life is a truly cosmic phenomenon. Their ideas were viewed as being heretical at the timebut Hoyle was never frightened of finding solutions outside the realm of orthodoxy. He turned accepted precepts on their head, stating that the cosmic nature of biology will seem as obvious to future generations as the Sun being the centre of the Universe seems obvious to the present generation.

 Up to the time of his death in 2001 evidence in support of this point of view has accumulated from fields as diverse as space science, microbiology, geology and genetics. The holy grail of biology that life began on Earth is now under serious threat, and science is slowly beginning to admit this in various ways. The discovery of planets similar to Earth in great profusion in the Milky Way (an estimate of 140 billion has recently been mentioned) adds to the possibility that we live in vast connected biospheres. These views are only gradually and somewhat reluctantly being conceded at the present time. But the trend is clear. A major paradigm shift is in sight, and Fred Hoyle's contribution in this area of science will perhaps shine as a guiding star.